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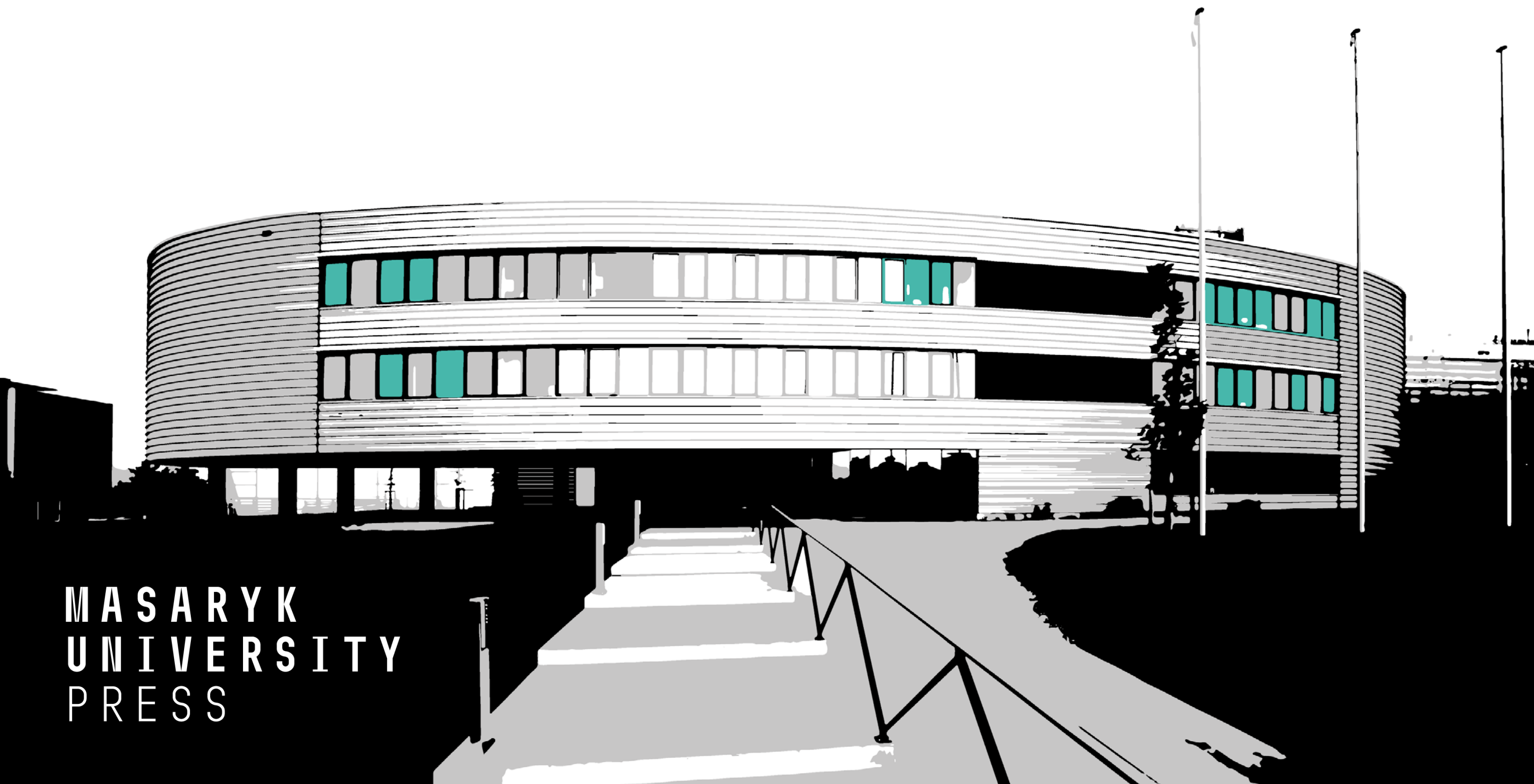

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Maja Ban[1], Tomislav Đurković[2], Nenad Marelić[2]

[1]*PhD student at Faculty of Kinesiology, University of Zagreb, Croatia*
[2]*Faculty of Kinesiology, University of Zagreb, Croatia*

ABSTRACT

Purpose: The main goal of this study is to determine possible differences in the range and quality of movement between senior male and female volleyball players of HAOK Mladost. *Methods:* Respondents, all right-handed and healthy, were members of the senior volleyball team of HAOK Mladost (female n=24, male n=17). The testing was conducted during the transition period, between the first and second competition period. We used seven tests, all part of standard FMS protocol: Deep Squat (DS), Hurdle Step (HS), In-Line Lunge (ILL), Shoulder Mobility (SM), Active Straight Leg Raise (ASLR), Trunk Stability Push-up (TSPU), Rotary Stability (RS), with 12 measured variables (left and right side for five bilateral tests plus DS and TSPU). Educated staff at the Faculty of Kinesiology, University of Zagreb conducted the testing. The examination of significance of the differences between senior male and female volleyball players was conducted by using the nonparametric ***Mann-Whitney U*** test.

Results: Statistical analysis showed significant difference in three tests: In – Line Lunge Left (ILLL), z= -2,11, p=0,03, with moderate effect size (r=0.33), Active Straight Leg Raise Left (ASLRL), z= -2,58, p=0,01, with moderate to strong effect size (r=0.4) and Stability Push-up (TSPU) z= -3,68, p=0,00, with strong effect size (r=0.58).

Conclusion: Statistically significant difference was determined in the range and quality of movement in three measured variables. Male volleyball players achieved better results in two tests: In-Line Lunge Left (ILLL) and Stability Push-up (TSPU). That addresses to a higher ability to keep the balance during lunges (reaction on short balls during reception or defence phase of the game) and considerably higher ability to maintain the stability of the trunk in the transfer of force from the upper extremities to the lower (during block) and vice versa (during spike). It is interesting to note that female volleyball players achieved a significantly better rating in the Active Straight Leg Raise Left (ASLRL) test, suggesting a better flexibility of the left hamstrings and better right hip mobility which enables higher capacity in performing elements which require extension, which include almost all volleyball elements (hitting, serve receive and transition into offense, defence and transition into counterattack and blocking, smashing and jump serve).

Keywords: stability; mobility; FMS; volleyball skills; female; male

Introduction

A number of factors can affect the level of training of an individual player or an entire volleyball team, thus also the competitive results that a player (and team) achieve. Health status and good motor and functional abilities represent basic anthropological characteristics of volleyball players which enable them to be well trained, while also prerequisites for specific technical-tactical performance that can be more or less efficient. Gambetta defines athleticism as “the result of movement skills development that involves learning proper techniques for agility, balance, coordination, flexibility, metabolic training, power, reaction time, speed, strength, and strength endurance” (Ransdell et al., 2016). Generally, the implementation of a successful individual and team tactics primarily depends on technical capacities of individual players. Optimal execution of technical elements in volleyball requires knowledge – “skills”, and a certain level of morphological characteristics and motor and functional abilities. In order for all the mentioned factors to be unified in “producing” correct technical performances, it is thus required to possess mobility and stability of different regions of the body. The correct, i.e. most effective, performance of technique is at the same time the best possible prevention from injury. Reduced mobility and stability of certain regions of the body can result in incorrect movement mechanisms that can ultimately lead to a variety of chronic difficulties. Although volleyball seems as a sport with symmetric load on the athlete’s body, a series of research have registered mechanisms which may cause asymmetries in the range and quality of movements, and eventually also injuries (Kugler et al., 1996; Wang & Cochrane, 2001; Salci et al., 2004; Tillman et al., 2004; Markou & Vagenas 2006; Lobietti et al., 2010; Cuckova & Suss, 2014; Zohreh & Ashraf, 2016). According to the authors of the mentioned research, such asymmetries are primarily generated by unilateral smashing and serving techniques, unilateral landings following smashes, jump serves and blocks or take-off phase prior to a smash or a jump rotation serve (Khan & Bahr, 2003).

Cook developed the functional movement screen (FMS) as a means to qualitatively assess functional movement. The FMS is a series of 7 movements that are scored on a 4-point scale of 0–3, based on the execution of the specific movement pattern (Cook, 2010). In order to determine stability and mobility, each test is numerically evaluated using grades between zero and 3, which means that an examinee can achieve a maximum result of 21 points. When an athlete is unable to perform (injury), he scores zero points. When scoring 1 point, an athlete does not have a functional base of stability and mobility, indicating that a sports physician should further assess flexibility and strength in more detail. A score of 2 points does not necessarily require an examination by a sports physician, but a physical conditioning coach creates special training programs in order to improve stability and (or) mobility of the desired part of the body. An assessment of 3 points indicates optimal stability and mobility in particular joints (Cook, 2010). The FMS has good to excellent intra-rater reliability and is recommended for use during pre-participation screening to identify asymptomatic athletes who may benefit from injury prevention training (Anderson et al, 2015). Some authors found that players with a score of 14 or less have a substantially greater chance of injury (Kiesel et al., 2007; Chorba, 2010). This methodology was also used for research in different team sports games: volleyball, basketball, soccer and handball (Cuckova & Suss, 2014; Shojaedin et al., 2014; Slodownik et al., 2014; Sprague et al., 2014; Đurković et al. 2017).

Table 1 demonstrates the potential implications of the measurement for each test in the FMS protocol on the performance of volleyball technique.

Table 1 *Potential implications of the measurement for each test in the FMS protocol on the performance of volleyball technique*

IMPLICATION ON VOLLEYBALL TECHNIQUES	
DEEP SQUAT	It is manifested during the execution of all volleyball elements, particularly those which require a quick reaction – in the preparation phase of serve receive and defence (explosive first step, forward lunge, side lunge), as well as in extreme movements while performing defensive elements of technique (“sprawl”, “dive” in male or roll in female volleyball). Mobility of the upper part of the body become noticeable during the preparation phase for a smash (or a jump spin serve) where there is a substantial extension and lateral flexion of the trunk. Mobility of the shoulders is also relevant in the performance of overhand and forearm passes (inability to connect the forearms), smashing, serving and blocking. Mobility of the hips, knees and ankle joints is important in the final phase of the smash, as there is a jump landing which is, according to certain research, performed as much as 50% on only one foot.
HURDLE STEP	It is manifested as the ability to execute a lunge of greater amplitude in all directions (mostly forward and diagonally forward) and it becomes noticeable in the preparation phase for serve receive (in short serves) or for defence.
IN-LINE LUNGE	As the performance of this test requires mobility and stability of the joint ankle, a greater ability of dorsiflexion (better angle) contributes primarily to a better execution of the preparation phase for a smash and jump serve.
SHOULDER MOBILITY	It is manifested in the preparation phase, basic phase (contact with the ball) and final phase for a smash (serve). As the smash (serve) technique includes various solutions from different zones (straight shot, shot with an emphasis on internal rotation, shot with an emphasis on external rotation), in addition to considerable angular speed at the shoulder joint, good mobility of the shoulder and the shoulder blade are a prerequisite for a good technical performance of a shot, as well as for the ability to generate maximum force (which is manifested by the speed of the ball).
ACTIVE STRAIGHT LEG RAISE	In volleyball practice injuries often occur as a result of an unfavourable relationship between strength and flexibility of both hamstrings when strength and flexibility are dominant in the front hamstring (very often in volleyball). Muscles of the upper leg back hamstring also assist in extending the trunk from the position of a forward bend (preparation phase for smashing, serving and blocking), as well as affect the stability of the lower part of the back.
TRUNK STABILITY PUSH-UP	Considering that during this test the trunk stabilizers symmetrically transfer strength from the upper towards the lower towards the lower extremities, and vice versa, this is manifested in volleyball as the correct position for a player during blocking (active block). During smashes and serves, by correctly “overlapping” the ball, trunk muscles are activated, and force generated from the entire body is thus transferred to the smash/serve arm.
ROTATORY STABILITY	A quality performance of this test allows for a complex movement of transferring energy from one segment of the body to another, through the trunk. This requires trunk stability through all the axis of the body during the joint movement of the upper and lower extremities. It can be manifested in the game in all volleyball techniques: smashing, blocking, digging, serving, overhand and forearm hits.

The main goal of this study is to determine possible differences in the range and quality of movement between senior male and female volleyball players of HAOK Mladost with possible implications on volleyball performance.

Methods

Educated personnel at the Faculty of Kinesiology, University of Zagreb conducted the testing. All examinees signed an informed consent form for the implemented measurements. The sample of examinees included 24 women and 17 men Premier league volleyball players who are members of the HAOK Mladost Zagreb. For the purpose of this research were used all 7 tests that are part of the FMS screening tool protocol; Deep Squat (DS), Hurdle Step (HS), In-Line Lunge (ILL), Shoulder Mobility (SM), Active Straight Leg Raise (ASLR), Trunk Stability Push-up (TSPU), Rotary Stability (RS), with total of 12 measured variables (left and right side for five bilateral tests plus DS and TSPU).

Results

Table 2 demonstrates the descriptive indicators for FMS tests in male and female volleyball players. Arithmetic mean, number of examinees, standard deviation for all tested variables is presented for all tested variables.

Table 2 *Descriptive statistical parameters*

		DS	HS_L	HS_R	ILL_L	ILL_R	SM_L	SM_R	ASLR_L	ASLR_R	TSPU	RS_L	RS_R
FEMALE	M	1,63	2,04	2,08	2,00	2,00	2,50	2,79	2,54	2,21	2,25	2,04	2,04
	N	24	24	24	24	24	24	24	24	24	24	24	24
	SD	0,58	0,62	0,50	0,29	0,59	0,72	0,41	0,59	0,72	0,53	0,46	0,46
MALE	M	1,94	1,82	2,06	2,29	2,12	2,29	2,59	1,94	2,18	2,88	2,00	2,00
	N	17	17	17	17	17	17	17	17	17	17	17	17
	SD	0,56	0,39	0,56	0,59	0,49	0,59	0,51	0,75	0,64	0,33	0,00	0,00

M=arithmetic mean; N=number of examinees; SD=standard deviation; Deep Squat (DS), Hurdle Step (HS), In-Line Lunge (ILL), Shoulder Mobility (SM), Active Straight Leg Raise (ASLR), Trunk Stability Push-up (TSPU), Rotary Stability (RS)

Table 3 shows the results of the Mann-Whitney U test for the measured variables among the groups of male and female volleyball players. Mann-Whitney U test, Wilcoxon W, Z value and two-sided – level of the statistical significance was calculated in order to compare female and male volleyball players.

Table 3 *Results of the Mann-Whitney U test for the measured variables among the groups of male and female volleyball players*

	DS	HS_L	HS_R	ILL_L	ILL_R	SM_L	SM_R	ASL-R_L	ASL-R_R	TSPU	RS_L	RS_R
MWU	148,00	167,00	200,00	146,50	184,00	160,50	162,50	114,50	196,50	82,50	195,50	195,50
WW	448,00	320,00	353,00	446,50	484,00	313,50	315,50	267,50	349,50	382,50	348,50	348,50
Z	-1,72	-1,22	-0,14	-2,11	-0,66	-1,28	-1,39	-2,58	-0,22	-3,68	-0,40	-0,40
p	0,09	0,22	0,89	***0,03***	0,51	0,20	0,16	***0,01***	0,83	***0,00***	0,69	0,69

*MWU – result of the Mann-Whitney U test, Wilcoxon W – result of the Wilcoxon W, Z – Z value, p – two-sided – level of the statistical significance of the test, *indicates statistical significance (p <0.05)*

Out of the 12 tests that were conducted on male and female volleyball players, a statistically significant difference was demonstrated in 3 tests. The Mann-Whitney U test registered a statistically significant difference in the In-Line Lunge Left (ILL_L) variable with higher results of male volleyball players, in the Active Straight Leg Raise Left (ASLR_L) variable, with higher results of female volleyball players and in the Trunk Stability Push-up (TSPU) variable, with higher results of male volleyball players.

Discussion

The Mann-Whitney U test registered a statistically significant difference (p = 0,03) in the In-Line Lunge Left (ILL_L) variable, with higher results of male volleyball players (M = 2,29, n = 17) in comparison to female players (M = 2,00, n = 24), U = 146,50, z = -2,11, with a medium effect according to the Cohen criterion (r = 0,33). The obtained results indicate a lower mobility in the hip area of female volleyball players, a somewhat less stable joint ankle and knee of the landing (right) leg, as well as a possible misbalance in the relationship of adductors and abductors in both or only one hip. The possible implications on the performance of technique are an improved ability to maintain balance while performing lunges (in the phase of defending the court and receiving short serves), as well as a more efficient and coordinated transfer into offensive activities (spikers) or protection of offensive activities (libero players).

The Mann-Whitney U test registered a statistically significant difference (p = 0,01) in the Active Straight Leg Raise Left (ASLR_L) variable, with higher results of female volleyball players (M = 2,54, n = 24) in comparison to male players (M = 1,94, n = 17), U = 114,50, z = -2,58, with a medium effect according to the Cohen criterion (r = 0,4). The obtained results indicate an unfavourable relationship in hamstring flexibility, which can be caused by a large number of take-offs, one-leg landings and long-term performance of volleyball stances. The misbalance in the relationship between the front and back hamstring in male volleyball players results even in chronic and acute injuries (Sommer, 1998; Kibler et al., 1998). In order to achieve a good result in this test, a player should have flexible back hamstrings and hips (particularly of the opposite, passive leg), as well as stability of the lower part of the abdomen. Considering the lower results of male players in this test, in addition to the fact that the muscles of the rear part of the upper leg assist in extending the trunk from a forward bend, the possible manifestations during the game include limitation in performing elements which require extension, while this includes almost all volleyball elements (hitting, serve receive and transition into offense, defence and transition into counterattack and blocking, smashing and jump serve).

The Mann-Whitney U test registered a statistically significant difference (p = 0,00) in the Trunk Stability Push-up (TSPU) variable, with higher results of male volleyball players (M = 2,88, n = 17) in comparison to female players (M = 2,25, n = 24), U= 82,50, z = -3,68, with a large effect according to the Cohen criterion (r = 0,58). Upon considering the obtained results, the conclusion can be made that the most significant difference between male and female volleyball players was registered in this variable. The results of this study suggest that male volleyball players have a stronger upper body and better trunk stability than female volleyball players. Schneider et al. (2011), Agresta et al. (2014) found the same results in adult population, while Kuzuhara et al. (2018) determined it in child population. Stability of the trunk shall assist during the symmetrical transfer of force from the upper extremities towards the lower extremities (block), or vice versa (overhand and forearm hitting and smashing). Better results in this test can be manifested in the performance of an active block, enhanced control (overhand and forearm hitting), more precise and stronger hitting (passing the ball for a smash), and perhaps most in the ball speed of smashes.

Conclusion

The main goal of this study is to determine possible differences in the range and quality of movement between senior male and female volleyball players of HAOK Mladost. A statistically significant difference was registered in 3 tests: In-Line Lunge Left (ILLL_L), Active Straight Leg Raise Left (ASLR_L) and Stability Push-up (TSPU). The most intensive movements in volleyball technique are those which are executed with one arm (smash and serve) or one leg (frequent one-leg landings or smashing after one-leg take-offs in women’s volleyball), which on the one hand results in muscle hypertrophy on the dominant side. The jump serve and smash are biomechanically the most demanding volleyball elements in both male and female players. The results obtained in this study indicate that male volleyball players are statistically significantly better in performing the In-Line Lunge Left (ILL_L) and the Stability Push-up (TSPU) tests, which points to the ability to produce greater forces, i.e. a stronger performance of jumps and more developed and stronger extremities, which thus enables achieving higher speed during smashing or serving. Female volleyball players achieved significantly better results in the Active Straight Leg Raise Left (ASLR_L) test, which points to a better flexibility of the left back hamstring and a better mobility of the right hip. After considering the obtained results of the FMS, it is necessary to give attention in physical conditioning to the segments which showed dysfunction within the movement patterns in order to reduce and maximally minimize them. The training process must be specific and directed in accordance to gender and playing positions.

In order to improve the result on the In-Line Lunge Left test of female volleyball players, it is recommended to put emphasis on working with the left leg as part of a preventive programme. Trainings should include foam rolling and upper leg muscle stretching, mobility of the joint ankle and hip of the left leg from a kneeling position, unilateral exercises for strengthening the muscles of the left leg and exercises for enhancing the balance of the joint ankle and the knee.

Upon considering the results of the Active Straight Leg Raise Left (ASLR_L) test, trainings for female volleyball players should be focusing on muscle flexibility of the left upper leg and calves, as well as on hip mobility of the opposite leg by applying foam rolling exercises for the left back hamstring and for the upper leg and hip flexors of the right leg. In addition to flexibility exercises, due to the disproportion between the muscles of the front and back upper leg muscles, it should also be insisted on focusing towards strengthening the back hamstring, particularly of the left leg. Corrective exercises should likewise be performed unilaterally in order to activate a certain group of muscles on one side and to additionally emphasize the activation of trunk muscles.

According to the obtained results in the Trunk Stability Push-up (TSPU) test, trainings for female volleyball players should be directed towards strengthening the muscles of upper extremities, as well as exercises for trunk stability. In order to improve the results in this test, trainings should primarily include a series of exercises in plank position (walking on hands, various endurance combinations), exercises in kneeling position and from an elevated position, as well as pushing and pulling of the body or of an external load. Unilateral exercises should likewise be incorporated, while elastic and TRX (suspension) bands and can also serve as an excellent supplementary tool.

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SPECIFICITY OF THE ANTHROPOMETRIC CHARACTERISTICS AND FITNESS ABILITIES OF MALE VOLLEYBALL PLAYERS

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Tomislav Đurković[1], Nenad Marelić[1], Robert Zekić[2]

[1]*Faculty of Kinesiology, University of Zagreb, Croatia*
[2]*PhD student at Faculty of Kinesiology, University of Zagreb, Croatia*

ABSTRACT

Purpose: The main goal of this study is to analyze possible differences in the space of anthropometric characteristics, motoric and functional capabilities on the sample of senior male volleyball players with different playing roles. On the base of obtained data normative and modal values could be established eventually helping coaches to perform secondary selection – so called volleyball specialization (at the age of 15–16), pointing young players to certain roles where they will be able to achieve maximum results in the volleyball career.
Methods: The research was conducted on 74 senior volleyball players all members of Croatian premier league teams. Players were categorized as setters (n = 11), central players (n = 17), receivers – attackers (n = 20), opposite hitters (n = 16), and liberos (n = 10). The sample of independent variables consisted of 4 anthropometric measures (body height, body weight, one hand standing reach and two hand standing reach. Ten standardized were used for the assessment of motor skills: lateral agility, starting acceleration, spike and block reach, general flexibility, explosive strength of arms and shoulders, spiking speed, repetitive strength of trunk flexors, static strength of trunk extensor and repetitive strength of chest, arm and shoulders. For the estimation of functional abilities, the relative maximal oxygen consumption was used. Dependent variable – playing role – is numerically defined and represents the affiliation of a player to a specific group: (1) setters, (2) central players, (3) receivers – attackers, (4) opposite hitters and (5) libero players. A one-way analysis of variance (ANOVA) with Tukey HSD post-hoc test was used to determine possible significant differences among groups of players. The level of significance was set at 0.05.
Results: Significant differences ($p < 0{,}05$) were detected for 8 of 16 measured variables – all four anthropometric measures and four measures for the assessment of specific speed – strength capacities.
Conclusion: Based on the obtained results, it is possible to identify the grouping of players in two subgroups, subgroup of attacking players (central players, receivers – attackers and opposite hitters) and the subgroup of the other players (setters and libero players). The main goal of the attackers is to win points with spiking blocking and serving actions for which they need certain anthropometric characteristics (height, weight, and arm span) and capabilities that enable high reaches during those actions. Extremely important is the ability to generate high spiking and serving speeds to prevent the reaction of the opponent block, defense, and service reception. For the second subgroup it can be said that they are not necessarily concentrated on winning points but on the preparation activities before spike in attack or counterattack like service reception (libero), defense (libero and setter) or setting (setter and libero) in the attack and counterattack complex for which body height, body weight and specific speed – strength capacities are not crucial (setter) or they are completely irrelevant (libero). Based on the obtained results the experts in the training process can direct the players toward specific role and develop very skills that are highly correlated with the specific situational efficiency in the game.

Keywords: volleyball; anthropometry; condition; specialization; playing role

Introduction

Success in sport and high-level sports results are accomplished in conditions with a planned, programmed, and controlled training process. In order for an athlete or team to be able to approach the field of top-level sports results and remain in the top primarily on a national and then international level, one needs to be capable to use expert analyses and results of scientific research by applying them into the training process. Furthermore, it is necessary to determine the level of certain motor skills, characteristics, and motor abilities responsible for achieving success in sport, as well as to transform them in training operators towards the modal values for a specific playing position. Basic anthropologic characteristics, an athlete's specific abilities, situational efficiency parameters and sports results, as the ultimate measure of an athlete's performance, form a set whole which differs regarding the unique structure of a particular sport. Volleyball is a sports game dominated by various forms of movement, which is, according to Janković and Marelić (1995), defined as a polystructural complex sport which requires the players to possess high-level performance indicators of technique, tactics, motor abilities and psychological preparedness. Success in volleyball depends on technical, tactical, physical, psychological, and anthropometric parameters (Bompa, 1999; Grosser & Neumaier, 1986). Identically as other sports games, volleyball can be classified as a multi-subject complex sports activity (Milanović, 2010). Volleyball also belongs to the group of highly intensive intermittent sports games which are dominated by multiple short periods of explosive movements, separated by periods of short rest, during which the player recovers to a varying degree. Basic complex polystructural movements in volleyball that are highly correlated with success are as follows: ball hitting, jumps, short sprints, changes of direction of movement, acrobatic throws, static endurance in low positions and hitting the ball when serving and smashing. Basic motor abilities, which are a constituent part of the equation specification in a sport, for success in volleyball include various forms of explosive strength, speed, agility, coordination, endurance, flexibility, balance and precision, and they represent the basis for the development of specific motor abilities which can be improved only in situational training conditions. Volleyball is predominated by a narrow specialization according to the playing position (setter, receiver-attacker, opposite hitters, middle blocker and libero), and therefore it is to be expected that players also possess various highly developed specific motor abilities, such as the ability to jump after a specific type of movement for smashing and blocking, the ability to jump from place, agility, explosive strength abilities such as hitting the ball and alactic endurance. Previous studies indicate the existence of differences in the field of anthropometric characteristics in relation to playing positions in younger players (Ciccarone, Fontani, Albert et al. 2005), whereas a similar research was repeated by Ciccarone, Croisier, Fontani et al. (2008) on a sample of senior players, which confirmed the findings of Duncan, Woodfield and al-Nakeeb (2006), while Marques et al. (2009) corroborated the distinction between players according to the playing position in the field of longitudinal dimensionality of the skeleton in such a way that taller player are also stronger. Đurković et al. (2012) isolated the longitudinal dimensionality of the skeleton as the main distinguishing factor, whereas Sattler et al. (2015) confirmed the differences in the performance of the vertical jump between receiver-attackers and setters. The aim of this research is to analyze the differences in the field of anthropometric characteristics, as well as motor and functional abilities in volleyball players depending on the playing position in order to use the data to determine normative and modal values that shall enable secondary selection, i.e. volleyball specialization, and thus facilitate guiding younger players towards the roles in the game that shall allow them to achieve maximum results in the long run.

Methods

The research was implemented with 74 volleyball players from the 1st division league. The tested volleyball players are members of top-level Croatian volleyball teams competing on the highest national competitive level. At the moment of conducting the tests, all the players were in good health and without signs of injuries. Considering the aim of this study, the players were divided into groups according to their playing positions, as follows: 11 setters, 17 middle blockers, 20 receiver-attackers, 16 opposite hitters and 10 libero players. For the assessment of anthropometric characteristics, the players were measured for body height – BH and body weight – BW in accordance with the recommendations of the International Biological Program – IBP (Mišigoj et al., 1995), as well as for standing spike reach – SSR and standing block reach – SBR (adjusted according to Đurković, 2009). For the assessment of motor abilities, the following standardized tests were used: lateral steps – LA, starting acceleration to 20m – SA20M, spike and block reach – SR and BR, seat and reach – SAR, medical ball throwing 1kg – MBT1KG, spiking speed – SPS, sit-ups in 1 minute – SU60SECMIN, isometric back strength test – IBST, push-ups in 60 SEC – PU60SEC (according to Đurković, 2009). For the assessment of functional abilities, the relative maximum oxygen consumption – RMOC was used, which was calculated by using the standard protocol implemented at the Human Performance Laboratory of the Faculty of Kinesiology University of Zagreb. The list of independent variables is presented in Table 1. For the purpose of determining the differences in the field of anthropometric characteristics and motor and functional abilities between the different groups of volleyball players, a dependent (criteria) variable – ***Group*** – was isolated for indicating the numerically determined affiliation of the players to the groups of different playing positions: (1) setters, (2) middle blockers, (3) receiver-attackers, (4) opposite hitters and (5) libero players. Central and dispersive indicators of the measured variables was also determined, whereas the significance of the differences in the field of anthropometric characteristics and motor and functional abilities between the groups of volleyball players with different playing roles was tested by using the Univariate variance analysis and the Tukey HSD post-hoc test. Statistical significance was set at $p < 0,05$.

Table 1 *Sample of variables*

	Abbreviation	Variable	Unit
Anthropometry	BH	Body height	kg
	BW	Body weight	cm
	SSR	Standing spike reach	cm
	SBR	Standing block reach	cm
Motor abilities	LA	Lateral agility	sec
	SA20M	Starting acceleration 20 meters	sec
	SR	Spike reach	cm
	BR	Block reach	cm
	SAR	Seat and reach	cm
	MBT1KG	Medical ball throwing 1 kg	m
	SPS	Spiking speed	km/h
	SU60SEC	Sit – ups in 60 SEC	rep
	IBST	Isometric back strength test	sec
	PU60SEC	Push – ups in 60 SEC	rep
Functional abilities	RMOC	Relative maximal oxygen consumption	VO_2max/kg^{-1}

For the purpose of determining the differences in the field of anthropometric characteristics and motor and functional abilities between the different groups of volleyball players, a dependent (criteria) variable – ***Group*** – was isolated for indicating the numerically determined affiliation of the players to the groups of different playing positions: (1) setters, (2) middle blockers, (3) receiver-attackers, (4) opposite hitters and (5) libero players. Central and dispersive indicators of the measured variables was also determined, whereas the significance of the differences in the field of anthropometric characteristics and motor and functional abilities between the groups of volleyball players with different playing roles was tested by using the Univariate variance analysis and the Tukey HSD post-hoc test. Statistical significance was set at $p < 0,05$.

Results

Table 2 demonstrated the descriptive parameters for each tested group in the selected variables. The group with the best results in a certain variable is emphasized in bold letters.

Table 2 *Descriptive parameters*

	Setters n = 11	Middle blockers n = 17	Receivers – attackers n = 20	Opposite attackers n = 16	Liberos n = 10	All tested players n = 74
BH	190,91 ± 5,99	**197,35 ± 4,96**	190,40 ± 5,37	192,38 ± 4,75	180,92 ± 7,17	191,22 ± 7,25
BW	84,59 ± 8,56	**93,71 ± 6,54**	83,66 ± 11,13	89,36 ± 6,71	76,05 ± 12,36	86,31 ± 10,55
SSR	248,45 ± 6,41	**259,24 ± 6,04**	249,65 ± 8,54	253,00 ± 7,41	236,90 ± 8,27	250,68 ± 9,88
SBR	246,36 ± 5,68	**255,88 ± 6,26**	247,50 ± 8,58	251,25 ± 6,72	224,50 ± 37,87	246,96 ± 17,61
LA	7,53 ± 0,52	7,39 ± 0,42	**7,37 ± 0,36**	7,46 ± 0,45	7,42 ± 0,44	7,42 ± 0,42
SA20M	3,64 ± 0,19	3,59 ± 0,12	**3,54 ± 0,08**	3,58 ± 0,09	3,55 ± 0,12	3,58 ± 0,12
SR	315,42 ± 9,15	323,96 ± 28,76	324,98 ± 10,53	**326,42 ± 12,43**	307,90 ± 8,77	321,33 ± 17,43
BR	295,82 ± 9,07	**311,57 ± 7,62**	302,98 ± 9,37	307,85 ± 8,73	287,90 ± 8,10	302,91 ± 11,48
SAR	5,58 ± 6,82	8,57 ± 7,57	10,69 ± 7,18	**13,10 ± 6,39**	11,87 ± 5,41	10,12 ± 7,10
MBT1KG	14,37 ± 1,04	**15,98 ± 1,56**	15,26 ± 1,62	15,59 ± 1,47	14,30 ± 2,06	15,26 ± 1,64
SPS	92,27 ± 8,17	**96,73 ± 5,22**	96,68 ± 7,20	95,74 ± 8,99	88,15 ± 6,20	94,77 ± 7,66
SU60SEC	53,00 ± 7,09	52,53 ± 5,91	**54,35 ± 7,71**	51,06 ± 8,21	53,60 ± 7,04	52,92 ± 7,17
IBST	93,03 ± 22,54	98,26 ± 31,18	104,50 ± 25,94	98,14 ± 31,05	**105,15 ± 29,23**	100,17 ± 27,97
PU60SEC	33,20 ± 9,59	34,47 ± 9,15	37,55 ± 10,30	34,50 ± 10,91	**41,78 ± 7,07**	36,07 ± 9,84
RMOC	54,63 ± 4,66	52,44 ± 4,11	55,17 ± 5,87	53,63 ± 3,99	**56,77 ± 4,74**	54,37 ± 4,86

All variables are reported as mean ± standard deviation. n-number of tested players

Based on the ANOVA results demonstrated in Table 3, the conclusion can be made that there are statistically significant differences in 8 of the 15 measured variables. Statistically significant differences are also present in all 4 variables that are used for assessment in the field of anthropometry, as well as in 4 variables which are used for assessment in the field of specific explosive strength in vertical jump (reach) in spike and block, specific explosive strength in spike and specific explosive strength of the arms and the shoulder belt.

Table 3 *Results of ANOVA for tested variables*

Variable	F	p	Variable	F	p
BH	**14,23**	**0,00***	SAR	2,38	0,06
BW	**6,83**	**0,00***	**MBT1KG**	**2,72**	**0,04***
SSR	**14,94**	**0,00***	**SPS**	**2,91**	**0,03***
SBR	**7,26**	**0,00***	SU60SEC	0,49	0,74
LA	0,29	0,89	IBST	0,39	0,82
SA20M	1,28	0,29	PU60SEC	1,32	0,27
SR	**2,69**	**0,04***	RMOC	1,50	0,21
BR	**14,98**	**0,00***			

*p – two-sided – level of the statistical significance of the test, *indicates statistical significance ($p < 0.05$)*

Table 4 shows the results of the HSD post-hoc test for the variables that proved to be statistically significantly different.

Table 4 *Results of HSD post hoc test*

BH	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,03	1,00	0,96	0,00
middle blockers	0,03		0,00	0,08	0,00
receiver attackers	1,00	0,00		0,82	0,00
opposite hitters	0,96	0,08	0,82		0,00
libero	0,00	0,00	0,00	0,00	
BW	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,09	1,00	0,68	0,22
middle blockers	0,09		0,01	0,65	0,00
receiver attackers	1,00	0,01		0,35	0,22
opposite hitters	0,68	0,65	0,35		0,01
libero	0,22	0,00	0,22	0,01	
SSR	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,00	0,99	0,53	0,01
middle blockers	0,00		0,00	0,13	0,00
receiver attackers	0,99	0,00		0,67	0,00
opposite hitters	0,53	0,13	0,67		
libero	0,01	0,00	0,00	0,00	
SBR	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,49	1,00	0,92	0,01
middle blockers	0,49		0,46	0,91	0,00
receiver attackers	1,00	0,46		0,95	0,00
opposite hitters	0,92	0,91	0,95		0,00
libero	0,01	0,00	0,00	0,00	
SR	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,68	0,55	0,45	0,84
middle blockers	0,68		1,00	0,99	0,12
receiver attackers	0,55	1,00		1,00	0,07
opposite hitters	0,45	0,99	1,00		0,06
libero	0,84	0,12	0,07	0,06	
BR	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,00	0,19	0,01	0,23
middle blockers	0,00		0,03	0,73	0,00
receiver attackers	0,19	0,03		0,45	0,00
opposite hitters	0,01	0,73	0,45		0,00
libero	0,23	0,00	0,00	0,00	

MBT1KG	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,09	0,59	0,31	1,00
middle blockers	0,09		0,64	0,96	0,08
receiver attackers	0,59	0,64		0,97	0,56
opposite hitters	0,31	0,96	0,97		0,29
libero	1,00	0,08	0,56	0,29	
SPS	setters	middle blockers	receiver attackers	opposite hitters	libero
setters		0,51	0,49	0,74	0,72
middle blockers	0,51		1,00	1,00	0,04
receiver attackers	0,49	1,00		1,00	0,04
opposite hitters	0,74	1,00	1,00		0,10
libero	0,72	0,04	0,04	0,10	

Discussion

Upon referring to Table 2 which demonstrates descriptive parameters, it can be observed that the group of middle blockers achieved the highest results in as much as 7 (all 4 variables that assess anthropometry) of the 15 measured variables. The group of receiver-attackers achieved the best results in 3 of the 15 measured variables, however, also above-average results in as much as 13 of the 15 measured variables. The group of opposite hitters achieve the highest results in 2 tests, above-average results in 10 tests, however, also the lowest results in as much as 5 tests. The group of libero players accomplished the best results in 3 tests, yet also the lowest results in all tests for assessing anthropometric characteristics or the tests in which anthropometric characteristics condition a high level of success (Vint, 1994), such as spike and block reach and spiking speed. The group of setters represents the biggest surprise as it did not achieve the best result in any of the measured variables, while it has as much as 13 below-average results of the 15 measured variables. The group of middle blockers accomplished the best results in all 4 variables for assessing anthropometry. It is recognized that an increase in body height is accompanied by an increase of body weight, as well as an expected high correlation with maximum reach with one and both hand from place. Similar results, except for the body height of the setters, were also confirmed by Marques et al. (2009), as well as by Sheppard et al. (2009). Considering the high impact of anthropometric characteristics on spike and block reach (Vint, 1994), it is logical that the mentioned group had the highest results in block reach and an above-average result in spike reach. Regarding the rules and structure of volleyball, middle blockers play in K1 and K2 in the middle of the net. Their primary role is to win points with fast balls, as well as successful blocking in the block phase, so that the height of the player is a major factor for game efficiency, as the length of the arm allows them to make up for the delay in lateral movement when assembling for a group block or in defensive vertical jumps in fast offense situations or offense with a second ball by the opposing setter. The group of libero players are substantially lower than all the other groups, they have the lowest average body weight and significantly lower results in reach with one and both hand from place. As these are players who play at the highest national level of competition and they have gone through a multi-year selection process, it can be concluded that the anthropometric indicators which assess the longitudinal dimensionality of the skeleton are not relevant for the selection of libero players, since these are players who primarily play in the receiving and court defensive phases, while according to the rules they are not allowed to serve, block or smash. The only significant deviation in the group of setters when considering the anthropometric variables is in their body height and one-hand reach from place, where they demonstrated substantially lower results than middle blockers. They are somewhat lower than opposite hitters, while they are of similar height as the receiver-attackers. Receiver-attackers and middle blockers stand out in the lateral agility test. It can be assumed that with regard to the increasingly faster serves in volleyball (in top-level volleyball, the speed of strong rotational serves reaches up to between 120–130 km/h), receiver-attackers must be particularly agile considering the short reaction time in the reception phase, as well as in the possibility of transferring into offense after receiving such a serve. High results by middle blockers are presumably conditioned by their specific movements which they perform from the middle of the net towards the left and right side in the preparation phase for the formation of a group block. The best results in the starting acceleration test were accomplished by the groups of setters and libero players. Like libero players, setters are also expected to show a high level of anticipation and reading of the game, as well as quick decision making in addition to a high level of agility and aptitude in the game (Fattahi et al., 2012). Motor tests for the assessment of explosive strength in vertical jumps clearly indicate that the groups of "offensive" players (opposite hitters, middle blockers and receiver-attackers) accomplished the best results in spike reach – SR and block reach – BR, as well as in the test for assessing explosive strength of the arms and the shoulder belt – MBT1KG and spiking speed – SPS (middle blockers), while straight close to them were also opposite hitters, as the main offensive player who in addition to their excepted efficiency, besides their height, also have to demonstrate great strength and speed while hitting the ball, which is also indicated by the results achieved in MBT1KG and SPS tests, while similar results were also observed in research conducted by Hubbard et al. (2001) and van den Tillaar et al. (2004). As a result of the favorable relationship between body height and lever lengths, the group of libero players accomplished the highest results in tests for assessing static and repetitive strength – IBST and PU60SEC60. The group of libero players also achieved the best results in the test for the assessment of functional abilities – RMOC. The univariate variance analysis was used for testing the differences between arithmetic means of all the variables in relation to all the groups of players and it confirmed the presence of statistically significant differences with an error of reasoning $p = 0.05$. Table 3 demonstrates the results which indicate that the groups of players are substantially different in all anthropometric measurements. The explosive strength indicators in the vertical jump which were manifested by both specific tests – SR and BR – showed statistical difference, which is partly due to the body height of the volleyball players (Vint, 1994). Motor tests for the assessment of explosive strength of the upper extremities – MBT1KG and specific explosive strength in spiking speed – SPS, confirmed the differences between the "offensive" group of players who win points by smashing after receiving the ball from both setters and libero players. Namely, both setters and libero players demonstrated lower explosive strength of the upper part of the body than all the other playing positions, which can be assigned to the specificities of playing positions in the game, i.e. to the lack of need to perform the element of smash (setters) or smash and serve (libero players), which is also confirmed by the findings of Marques et al. (2009) and . Upon considering the results of the post-hoc analysis (Table 4), it can be concluded that in the field of anthropometric characteristics of longitudinal dimensionality of the skeleton – BH, BW, SSR and SBR – libero players show a statistically significant difference in relation to all the other groups of players, which is in accordance with these results, as well as with the tests for assessing explosive strength in vertical jump. Libero players are also different from all three groups of players for whom play at the net with repetitive and high jumps is an important factor for success. Aside from manifestations of explosive strength aimed at achieving maximum reach and hitting the ball in the highest position, the group of offensive players must also be able to perform a strong hit at the ball in order for it to be fast enough to make it difficult for the opponents to play in defense, and this is also demonstrated by the differences between these groups in the variable SPS.

Conclusion

The aim of this research was to determine the differences in certain anthropometric characteristics and motor and functional abilities between different playing positions in volleyball. The research included 75 volleyball players, and based on the obtained data and its processing, it was confirmed that there are persistent and statistically significant differences. Generally, it can be argued, with reservations, that there are two types of players – the group of spikers (middle blockers, receiver-attackers, and opposite hitters). The mentioned group of players plays at the net with the primary goal of winning points by using high jumps in blocking and smashing, whereas for the other group of players, playing at the net does not necessarily include focus on winning points (setters), and their play on the court is based on preparatory activities for the offensive and counterattack phase. Thus middle blockers, along with opposite hitters and receiver-attackers, are the tallest and heaviest players who are capable of demonstrating the highest reach while jumping, as well as generating the greatest power manifested in the speed of a spiked ball, while the setters and receiver-attackers, are particularly agile and nimble, so that they could synthetize the reception of the serve and offensive play, as well as fast transition into counterattack. The practical value of this research is represented in the obtained parameters that separate different playing positions, and based on which expert professionals in the training process can direct players towards particular roles and develop precisely those abilities that are highly correlated with situational efficiency in the game.

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DETERMINATION OF LOWER LIMBS LOADING DURING BALANCE BEAM EXERCISE

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Petr Hedbávný, Miriam Kalichová, Michal Rabenseifner, Adam Borek

Masaryk University, Faculty of Sport Studies, Brno, Czech Republic

ABSTRACT

In women's artistic gymnastics, the balance beam belongs among the disciplines with the heaviest lower limbs load. The aim of our research was to disclose a lower limbs weekly load volume regarding load asymmetry, and to determine the take-off and landing reaction forces between landing ground and foot in selected gymnastic elements. In 9 female artistic gymnasts of junior and senior category one training week was video-recorded and analysed. The reaction forces were measured using 5 Bertec force plates in one female Czech national team member. Based on the training video recordings 12 jump and acrobatic elements were analysed. Among the total of 422 recorded take-offs and landings 41% were performed from both legs, (BL), 44.5% from one lower limb (HL) and 14.5% from the other lower limb (LL). The maximum reaction force of the landing ground during take-offs was 2.4 BW in average, 3.1 BW in landings. In asymmetrical elements, one leg was loaded three times more (538.3 BW) than the other (174.1 BW) in one training day in total. We recommend to record the load asymmetry in the course of the gymnastic trainings in order to choose and personalise the appropriate regeneration process and compensational exercise.

Keywords: artistic gymnastics; asymmetry; landing; reaction forces; take-off

Introduction

In artistic gymnastics, the balance beam is both attractive and challenging tool in research of mechanical load of lower limbs. The balance beam exercise has a long-run evolution, from originally basic exercises to the most difficult routines with maximal movement flexibility; its exquisite character stems from the floor exercise-based compositions being performed on a strictly demarked space that conducts the movement technique (Tůma, Zítko & Libra, 2004). Regarding the more detailed monitoring of training process in artistic gymnastics, there is only a few studies dealing with this issue. Gymnasts at an international level train from 22–26 hours a week. More precise data can be brought from active training time, which was in junior gymnasts dealt with by Kalichová, Hedbávný, Chrenko, Kopřiva and Kasovič (2018). For female gymnasts the data is not available in (Potop & Timnea, 2017). Authors warn of asymmetrical load during gymnastic exercises as asymmetric force load on body increases the risk of injury, both acute and chronic (Bradshaw & Hume, 2012; Moresi, Bradshaw, Thomas, Greene, & Braybon, 2013; Campbell, Bradshaw, Ball, Hunter, & Spratford, 2019). Structure of many gymnastic elements is asymmetric from the point of view of load of upper and lower limbs or rotations. However, even the elements which are symmetrical in their temporospatial structure can cause asymmetric load on body parts during take-offs and landings, as found by Exell, Robinson and Irwin (2016) or Campbell et al. (2019), who also adds that intra-limb loading variability is very individual for each element and each gymnast. The routine on the balance beam in elite gymnasts is a sequence of repeated take-offs with subsequent landings derived from the explosive leg strength. The higher the mechanical energy necessary for a realisation of the demanding gymnastic element, the higher the mechanical load is affecting the biological structures necessary for its production, transmission and/or absorption (Brüggemann, 2005). Frequent repetitions of these elements produce the ground reaction forces that could cause severe injury.

Many studies have shown the most injuries in artistic gymnastics occur during landing (up to 52%) when the biggest forces are being absorbed (Harringe, Renström & Werner, 2007). The big forces affecting the gymnast's body in combination with the highly frequential and voluminous training load is attributed as the principal injury cause also by Farana, Zahradník, Uchytil and Jandačka (2013). From the aforementioned reasons the necessity of recording of both volume and frequency of the absorbed forces is accented by Bradshaw and Hume (2012). The aim of this paper focusing on beam exercise is to monitor load of lower limbs in female artistic gymnasts of Czech national team during a week-long training cycle. Based on the aim we lay following questions:

1. How does number of attempts affect the load of lower limbs during take-off and landing phases of acrobatic and jump elements?
2. To what extent the week training affects the load of lower limbs and its asymmetry?
3. What is the size of reaction forces of landing ground acting on lower limbs during selected jump and acrobatic elements?

Methods

Subjects' characteristics

For the research, 9 female artistic gymnasts were evaluated, all of them belong among the high-level national competitors in either junior or senior category. Their training takes place 5–8 times a week, whereas the balance beam training takes place 4–6 times a week.

Data collection and processing

The balance beam video recording took place during a week training cycle on a GoPro Hero5 Session camera (GoPro Ltd. Iceland) in HD resolution (720 × 1280) with a frame rate of 30 frames per second. From the record, the dynamic elements were evaluated *id est* the jump and acrobatic elements, by two independent observers. In total, 12 elements included in the rules of female artistic gymnastics during the recording week were evaluated: 1. split leap forward (fwd), leg separation 180° (Split leap), 2. leap fwd with leg change, free leg swing to 45°, to cross split, 180° separation after leg change (Switch leap), 3. split jump, leg separation 180°, from cross position (Split jump), 4.side split jump from cross position (Sd split jump), 5. handspring fwd with flight to land on one leg (Handspring fwd), 6. flic-flac with step-out (Flic-flac), 7.salto fwd tucked to cross stand (Salto fwd), 8. salto backward (bwd) tucked, or stretched, step out (Salto bwd), 9. salto sideward (swd) tucked take off from one leg to side stand (Salto swd), 10. salto bwd stretched, step out (Salto bwd st), 11. free/aerial walkover fwd, landing on one or both feet (Walkover), 12. free/aerial cartwheel – landing in cross or side position (Aerial).

The common steps as well as more complex choreographic elements were excluded from the analyses. The data of interest comprised frequency of the selected elements and take-off and landing leg in single-leg jumps. Parallelly to the training evaluations, in a biomotorics laboratory 6 selected elements were analysed in one female Czech national artistic gymnastics representant of a senior category. The gymnast was rated as experienced due to her participating in artistic gymnastics for over 15 years and regularly undergoing 4–8 trainings per week. The weight of the gymnast was 57.9 kg, the height was 161 cm and BMI was 22.3. For the kinetic analysis of take-off and landing phases we chose elements representing these three categories: leap/jump, handspring and salto. In the same time, regarding the asymmetrical load, the elements with single-leg take-off and landing were selected: Switch leap, Johnson, Handspring fwd, Flic-flac, Aerial and Salto swd. Before the recording the gymnast performed warm-up as she is used to before each training. Every element was recorded 3 times, between the attempts there was a minimal break of 30 seconds. Individual elements were performed in order as listed above. In total 18 valid attempts were recorded, using 5 dynamometric plates Bertec Force Plate FP6090-15 (MIE Medical Research Ltd. United Kingdom) (each of dimension 60 × 90 cm and load capacity of 10 000 N). The recording of the process of reaction forces of the landing ground was used to evaluate the maximum force during noth take-off and landing phase.

Statistica 12 software and following statistical methods were used to evaluate the data: Kruskal-Wallis multiple comparison test, Friedman ANOVA analysis and post-hoc Wilcoxon test, all calculated at 5% level of statistical significance.

Results and Discussion

Question 1: Training monitoring

The results show that during a weekly training session a female gymnast performs 211 ± 59 acrobatic and jumping elements in average. Regarding the individual elements, jumping elements are performed equally in all gymnasts. In average there are 85 jumping elements for one gymnast, i.e. 21 attempts for each jumping element. In acrobatic elements the number are bigger, in average it is 126 elements a week in each gymnast (Table 1). This number is probably affected by the fact that the amount of observed acrobatic elements (8) is higher than jumping elements (4).

Table 1 *Amounts of jump and acrobatic elements on balance beam during one week in 9 female artistic gymnasts (G)*

	G1	G2	G3	G4	G5	G6	G7	G8	G9
Elements in total	243	149	289	288	275	138	161	169	188
SD	21	15	25	28	16	11	11	13	15
min	0	0	0	0	0	0	0	0	0
max	73	50	90	104	45	39	30	40	50

The most frequently performed jumping element in our research was switch leap (average/gym = 24), which was included in each gymnast´s training (Table 2). This corresponds to results by Kalinski, Božanić and Atiković (2011), who found out that this jump was found in almost every junior balance beam exercise. According to the authors this is caused by simplicity of the element, despite the fact that according to Code of Points 2017–2020 (FIG, 2017) it is valued by a quite high C difficulty value, as well as by its suitability of binding it with other elements to gain extra points.

Regarding the fact that our research group included female gymnasts belonging to high-level national competitors in either junior or senior category, acrobatic flights are regular part of their competition routines, therefore also their trainings. The most frequently performed was flic-flac or back handspring (54±28 attempts in average), B-level skill (FIG, 2017) which was also recorded all observed gymnasts. It is an element which is taught early in a gymnast´s carrier (Sands, & McNeal, 2006) and is an essential part of routines in more disciplines (Payne, & Barker, 1976). As flic-flac can be easily bound to other artistic elements, it is essential to perform it perfectly so that gymnast is capable of creating optimal conditions for performance of the whole movement structure and thus gain bonus awards by connecting two or more elements in one routine.

Table 2 *Number of attempts for individual elements (an average for one female gymnast per week)*

elements	**Split leap**	**Switch leap**	**Sd split jump**	**Split jump**	**Handspring fwd**	**Flic-flac**	**Salto swd**	**Aerial**	**F walkover**	**Salto fwd**	**Salto bwd**	**Salto bwd st**
average	21	24	20	20	4	54	5	15	17	5	3	24
SD	11	7	6	6	3	28	12	10	14	10	6	20
Min	0	14	9	9	0	18	0	0	0	0	0	0
max	40	38	31	31	8	104	38	31	43	30	18	54
CV	53	30	33	33	71	51	242	70	83	205	204	85

The second most frequently performed artistic element was salto bwd st with a difficulty value C (24 ± 20 attempts in average). The gymnasts who did not train this element at all substituted it with a different variant of salto of the same difficulty value C , i.e. salto fwd or salto bwd. This is in correspondence with the Code of Points, there must be one acrobatic series consisting of at least two flight elements, and one must be a salto (Kelly, 2014).

We may summarise that female gymnasts do not train all observed jumping and acrobatic elements at once. Each gymnast trains 8–9 selected elements. If a gymnast includes an element into her training, she performs approximately 24 attempts of the element a week. However, when looking at the results in more detail, there are significant differences among the gymnasts themselves as well as among individual elements. The lowest number of elements was performed by G6 with 138, the most intensive, on the other hand, by G3 who performed 289 elements. Due to the performance level of our gymnasts, more acrobatic elements was trained than jumping ones, with flic-flac as the basic acrobatic flight being the most frequently performed, the least frequently performed elements salto bwd, handspring, salto fwd and salto swd, as can be seen in Table 2. These differences are statistically significant, as proved by the results of Multiple comparison p values ($p = 0.00–0.034$).

Question 2: Load asymmetry

There is another risk accompanying an intense training: an asymmetry of frequent unilateral load could lead to musculoskeletal imbalances. Our research revealed that on the balance beam the dynamic exercises burden the lower limbs unilaterally, especially in the landing phase. Among the 12 recorded jump and acrobatic elements 6 were initiated by single leg take-off and 6 by double leg take-off, overall 8 spatially asymmetrical.

In our work it is not important whether it is right or left leg, but which one is more used during take-off and landing phases. Therefore we use division into lower limb that experiences higher load (HL) and lower load (LL) calculated from the total load during take-offs and landings (Campbell et al., 2019), in case both legs are used during take-off or landing we use "both limbs" (BL).

Training asymmetry was assessed as the amount of elements performed with asymmetrical load on the lower limbs during take-off and landing phase. Among the total of 211 take-off elements 86 were single leg take-offs (68 HL and 17 LL) and 125 were double leg take-offs. On contrary, the landing elements mostly comprised single leg landing (121 HL and 43 LL), whereas the double leg landings were of rather a minor occurrence (47). Table 3 presents also a percentual expression of the take-offs from HL leg (32%) and LL leg (8%) and from both legs simultaneously (60%), as well as the landings to HL (57 %) and LL (21%) and to both legs simultaneously (22%). These differences were proved to be statistically significant based on calculations of Friedman ANOVA and following Wilcoxon paired test, the results are significant for both take-offs and landings ($p = 0.008–0.021$). Only in landings there was no difference between less loaded leg and double leg landings ($p = 0.767$).

Table 3 *The take-offs and landings as performed on a single or both legs*

	Take-off HL	Take-off LL	Take-off BL	Landing-HL	Land-ingLL	Landing-BL	Take-offs overall	Landings overall
$\bar{x}$	68	17	125	121	43	47	211	211
SD	29	12	46	47	31	20	59	59
min	34	0	63	59	7	23	138	138
max	132	33	200	200	111	95	289	289
%	32	8	60	57	21	22	100	100

The overall evaluation of asymmetry shows that HL is loaded in 44,5%, LL in 14,5% and BL in 41%. A related study was executed by Pajek, Hedbávný, Kalichová and Čuk (2016) who studied asymmetrical loads in lower limbs during a balance beam competition of World Cup in Ljubljana, 2014. The study reported that during routines the right leg was loaded in 42.87% of the total routine time, the left leg was loaded in 29.08% of the total routine time and the both legs simultaneously were loaded in 28.05% of the total routine time. These results comply with our results as both indicate high unilateral load put on the lower limbs. However, Pajek et al. (2016) evaluated the load duration and our working group evaluated the number of loading elements, both studies detected higher load in one lower limb.

Question 3: Dynamic measurements of ground reaction forces

Based on the dynamometric force plates recordings the maximal value of particular X (anterior-posterior axis), Y (mediolateral axis) and Z (vertical axis) components of the resultant reaction force were evaluated, in take-off and landing phase. Table 4 presents the average values of the three valid attempts of every element in multiples of body weight (BW).

Table 4 *Ground reaction forces during take-off and landing phases in multiples of body weight (BW). Red colour stands for right leg, green for left and blue for both legs*

	vertical axis Z		anterior-posterior axis Y		mediolateral axis X		resultant force	
	Take-off (BW)	Landing (BW)	Take-off (BW)	Landing (BW)	Take-off (BW)	Landing (BW)	Take-off (BW)	Landing (BW)
Switch leap	2.8	3.5	0.5	0.7	0.1	0.3	2.8	3.6
Johnson	3	3.6	0.8	0.9	-0.2	-0.8	3.1	3.8
Handspring fwd	1.1	3	0.3	0.7	0	-0.3	1.1	3.1
Flic-flac	1.7	1.8	-0.5	0.3	-0.1	0.1	1.8	1.8
Aerial	2.7	3.2	0.5	1.2	0.2	-0.4	2.8	3.4
Salto swd	2.8	2.7	0.7	0.5	0.2	-0.6	2.9	2.8

According to our results, when the non-acrobatic, handspring and salto group elements were compared, it was revealed that the non-acrobatic and salto elements evince similar force in the take-off phase. The reason is, we assume, a similar take-off technique, stemming from the fast single leg take-off. The reaction forces in handspring elements were half, compared to the non-acrobatic and salto elements. It is, however, necessary to take into consideration the different take-off technique in Flic-flac (double leg take-off) and Handspring forward (single leg take-off). The vertical reaction forces in landing were 13–50% lower in the salto and handspring elements than in the non-acrobatic elements. In jump elements Switch leap and Johnson there was force of more than 3.6 BW affecting the lower limb.

Burt, Naughton and Landeo (2007) compared the forces acting on a balance beam and floor and state that ground reaction forces on the beam apparatus ranged from 1.80 to 5.59 BW for the lower limbs, floor apparatus ground reaction forces applied to the lower limbs varied from 3.30 to 8.46 BW. Our results vary from 1.1–3.1 BW for take-offs and 1.8–3.8 BW for landings, i.e. our results mostly correspond with the results of Burt et al. (2007). Similar results were published by Kew-Wan, Young and Kyoung-Kyu (2012), who performed the kinetic analysis of tucked backward salto on the balance beam. A ground reaction force appeared more than twice the weight at the moment that showed the power of motion to all subject. Our study, as well as other similar ones, observed the forces in elements performed separately. However, when more elements are bound in a routine, the reaction forces are expected to double, as could be seen in results of Potop and Timnea (2017), who analysed acrobatic elements on balance beam executed separately, in connection of 2-3 acrobatic elements and in mixed series.

Based on our dynamometric measurements we can state that the average take-off force on beam has a value of 2.4 BW, in landing 3.1 BW. If we consider asymmetry in load of lower limbs, i.e. HL, LL and BL in take-offs and landings and use the measured values, we can gain an overview of the total load asymmetry. We find out that HL was in total loaded by 538.3 BW, the other lower limb LL 174.1 BW and during take-offs and landings double legs the total forces were 445.7 BW (Table 5). Not considering the fact that during double legs take-offs and landings the forces may not be distributed equally between the lower limbs, we observe triple difference in loads between the lower limbs during unilateral loading.

Table 5 *Approximate calculations of forces acting on lower limbs during weekly training*

	HL		LL		BL	
	Take-off	**Landing**	**Take-off**	**Landing**	**Take-off**	**Landing**
number of attempts	68	121	17	43	125	47
F range (BW)	1.1–3.1	1.8–3.8	1.1–3.1	1.8–3.8	1.1–3.1	1.8–3.8
F average (BW)	2.4	3.1	2.4	3.1	2.4	3.1
F (BW)	163.2	375.1	40.8	133.3	300	145.7
F (BW)	**538.3**		**174.1**		**445.7**	

Artistic gymnasts as well as their coaches should not only try to achieve maximum performance, but also should attempt to protect their bodies against possible injuries. The quality and quantity of take-offs and landings may affect health problems significantly. Therefore it is important to minimise forces overloading musculoskeletal system, mainly in case of unilateral distribution of load.

Conclusion

In our research we assessed the level of the mechanical load in selected gymnastic elements, however, the mechanical load resistance threshold is an individual variable. In following studies training loads should be monitored using unified methods so that the results could be compiled and compared. We are of an opinion that it would be optimal to perform registration of executed elements and then further analyse: number of take-offs and landings on upper and lower limbs and asymmetry in load on landing ground, whether the elements were with or without rotation, number of successful and unsuccessful (fall) attempts, whether the elements were isolated or bound in a series. These results then further synthetize with results of dynamic measurements of impacts either using force platforms, pads or accelerometers. We are convinced that such monitoring increases not only training effectiveness, but may also help to optimise load so that overloading and overtraining is prevented leading to decrease in risk of injury and side disbalances of musculoskeletal system.

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THE EFFECT OF CLASSICAL BALLET, SLOVAKIAN FOLKLORE DANCE AND SPORT DANCE ON STATIC POSTURAL CONTROL IN FEMALE AND MALE DANCERS

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Marta Gimunová, Tomáš Vodička, Kristián Jánsky, Miriam Kalichová, Antonín Zderčík, Alena Skotáková, Petr Hedbávný, Kateřina Kolářová

Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

ABSTRACT

Purpose: Classical ballet, Slovakian folklore dance, and sport dance training differ in their way how to master the art of dance; however, postural control is essential for the correct execution of complex movements used in all types of dance. The aim of this study was to analyse the differences in static postural control between classical ballet dancers, Slovakian folklore dancers and sport dancers and to analyse the effect of body mass, body height and toe grip strength on postural control.

Methods: 68 dancers, between 17 to 28 years of age, participated in this study: 21 dancers from Slovakian folklore dance group VSLPT Poľana Brno (12 females, 9 males), 22 dancers from Brno Dance conservatory (16 females, 6 males) and 25 sport dancers competing at Brno Dance Open 2019 (12 females, 13 males). All participants were asked to stand upright, barefooted, arms along the body, both feet on the Emed-at platform (Novel GmbH, Germany) for 10 seconds with their eyes open to obtain the length of COP line (cm), average velocity of COP (cm/s), the elliptic area (mm^2) and numerical eccentricity of the ellipse. The toe grip strength was measured for each foot when sitting using toe grip dynamometer (Takei Scientific Instruments, Niigata, Japan). To analyse the effect of dance style, to grip strength, body mass, body height, and gender on postural control variables, Kruskal Wallis test, and Spearman Rank Order Correlation were used.

Results: A better postural stability measured by the length and average velocity of COP was observed in sport dancers, compared to classical ballet and Slovakian folklore dancers. Sport dancers are used to a greater load on the forefoot and to a special foot roll-of pattern when dancing, which may lead together with a constantly changing environment during competitions to their enhanced postural stability. Despite the differences in dance training and dance footwear of female and male dancers (high-heel shoes in sport and Slovakian folklore female dancers, pointe shoes in female ballet dancers), no statistically significant difference in postural variables between genders was observed. Similarly, in analysed dancers, no effect of age, body mass, and body weight on postural control were observed. The toe grip strength was not observed to affect the postural variables in this study. The greatest toe grip strength was observed in female ballet dancers, despite their younger age. Ballet dance training includes repetitive exercises focused on foot and toes such as *battement tendu* or *demi-pointe* and *en pointe* positions probably resulting in the greater strength of the toes.

Conclusion: In this study, better postural stability measured by the length and average velocity of COP was observed in sport dancers, compared to classical ballet and Slovakian folklore dancers. In analysed dancers, no effect of body mass, body weight, gender, and toe grip strength on postural control variables was observed. Future studies focused on postural stability changes in non-dancers after a sport dance, classical ballet and Slovakian folklore dance training program would provide additional knowledge about the process how each type of dance enhance the balance and other coordinative skills.

Keywords: postural stability; dance; length of COP; the average velocity of COP; toe grip strength

Introduction

Dancers have enhanced balance skills (Gerbino, Griffin & Zurakowski, 2007; da Silveira Costa, de Sá Ferreira & Ramiro Felicio, 2013). However, different types of dance such as ballet, Slovakian folklore dance, and sport dance differ in their demands put on the dancer, which may result in different balance control. Balance, or static postural control, minimize the centre of gravity displacement during quiet standing (Perrin, Deviterne, Hugel & Perrot, 2002). The postural control is affected by the somatosensory, visual, and vestibular system, joint range of motion, and strength (Ricotti, 2011). Furthermore, the previous study shows that postural stability is also affected by body mass and gender (Ku, Abu Osman, Yusof & Wan Abas, 2012).

Classical ballet dancing involves both static balance and dynamic choreographic figures for which the balance control is essential as the female dancers dance *en pointe* using the pointe shoes. Additionally, ballet consists of extreme ranges of motion, especially seen in the ankle plantar flexion and hip extension. On the other hand, ballet dancers perform in a stable environment on a stage or in front of a mirror where no unexpected disturbances occur (Perrin et al., 2002; Lin, Lee, Liao, Wu & Su, 2011; Hugel, Cadopi, Kohler & Perrin, 1999).

Slovakian folklore dance is a part of the Central and Eastern European dancing folklore, has been formed since the 5th century and influenced during the period of the Austria-Hungarian Empire by different ethnic groups (Matúš, 2016). Slovakian dance folklore includes *chorovody* and *kolesá (karičky),* girls' round dances, in 2/4 and 4/4 time, characterized by a slow, resting part and a faster part with more difficult steps turning the circle in increased tempo. Men's dance includes *odzemok* and *verbunk* characterized by jumps and squats. Couple turning dances, *krútivé tance*, usually consist of four parts: the man singing to the musicians the song he wants to play, man solo dance, couple dance when man and women turn as a pair, and man and women separate dance. Čardáš, a Hungarian couple turning dance, is also one of the Slovakian couple turning dances (Giertlová, 2014).

Sport Dance express emotions provoked by a different type of music of ballroom or Latin-American dances (Lukić, Bijelić, Zagorc & Zuhrić-Šebić, 2011). During the competition, sport dancers pairs present their program at a simultaneous presentation in a constantly changing environment in which they must anticipate the movement of other competitors and preserve the space for their own presentation (Kuczyński, Szymańska & Bieć, 2011).

The classical ballet, Slovakian folklore dance, and sport dance training differ in their way how to master the art of dance; however, postural control is essential for the correct execution of complex movements used in all types of dance and also serves as a protection against injuries (Ricotti, 2011). The aim of this study was (i) to analyse the differences in static postural control between classical ballet dancers, Slovakian folklore dancers and sport dancers; (ii) to analyse the effect of gender, age, body mass and body height on postural control; and (iii) to analyse the effect of toe grip strength on postural control.

Methods

68 dancers, between 17 to 28 years of age, participated in this study: 21 dancers from Slovakian folklore dance group VSLPT Poľana Brno (12 females, 9 males), 22 dancers from Brno Dance conservatory (16 females, 6 males) and 25 sport dancers competing at Brno Dance Open 2019 (12 females, 13 males). Their body mass, body height, and age are shown in Table 1. Informed consent was provided by all participants or their caregivers prior to the data collection.

Table 1 *Dancers characteristic: age (years), body mass (kg), and body height (cm)*

		n	Age	Body mass	Body height
Slovakian folklore dance	female	12	22,58 ± 2,47	55,73 ± 7,28	167,07 ± 6,34
	male	9	22,44 ± 1,67	74,43 ± 8,93	179,89 ± 1,67
Classical ballet	female	16	18,06 ± 1,00	54,83 ± 5,96	166,69 ± 5,46
	male	6	18,00 ± 1,26	64,13 ± 6,68	172,92 ± 6,48
Dance sport	female	12	20,33 ± 2,67	56,47 ± 6,76	164,63 ± 5,02
	male	13	20,69 ± 2,87	69,93 ± 9,04	179,52 ± 7,64

All participants were asked to stand upright, barefooted, arms along the body, both feet on the Emed-at platform (Novel GmbH, Germany) for 10 seconds with their eyes open, looking straight ahead to obtain the length of COP line (cm), average velocity of COP (cm/s), the elliptic area (mm^2) and numerical eccentricity of the ellipse. The toe grip strength was measured twice for each foot when sitting using a toe grip dynamometer (Takei Scientific Instruments, Niigata, Japan), and the higher value was used for further analysis.

To analyse the effect of dance style on postural control variables, the Kruskal Wallis test was used. The correlation between to grip strength, age, body mass, body height, postural control variables, and dance style was analysed by Spearman Rank Order Correlation. Additionally, the gender differences in postural variables were analysed using an unpaired t-test.

Results

The mean toe grip strength (N), length of COP line (cm), the average velocity of COP (cm/s), elliptic area (mm^2) and numerical eccentricity are shown in Table 2.

Table 2 *Mean toe grip strength (kg), length of COP line (cm), the average velocity of COP (cm/s), elliptic area (mm^2) and numerical eccentricity of female and male Slovakian folklore, classical ballet and sport dancers*

		Toe grip strength		Length of COP	Average velocity of COP	Elliptic area	Numerical eccentricity
		Dominant	**Non -dominant**				
Slovakian folklore dance	**female**	19,27 ± 4,24	20,09 ± 5,67	35,12 ± 7,42	3,58 ± 0,68	155,36 ± 129,50	76,37 ± 20,72
	male	29,97 ± 9,51	30,73 ± 11,35	38,26 ± 11,65	3,82 ± 1,17	326,37 ± 353,80	80,29 ± 18,28
Classical ballet	**female**	27,48 ± 5,76	25,54 ± 5,53	33,74 ± 7,68	3,38 ± 0,77	161,62 ± 239,10	79,02 ± 12,36
	male	29,67 ± 5,78	29,92 ± 7,36	35,37 ± 4,64	3,54 ± 0,47	114,93 ± 91,37	83,79 ± 7,97
Dance sport	**female**	23,93 ± 8,68	24,36 ± 7,37	31,20 ± 4,36	3,12 ± 0,44	184,12 ± 92,36	81,82 ± 7,81
	male	31,51 ± 6,88	31,11 ± 6,25	32,34 ± 4,26	3,24 ± 0,43	176,67 ± 102,22	80,92 ± 13,46

Classical ballet, Slovakian folklore, and sport dancers differences

Results of Kruskal Wallis test show no statistically significant difference between classical ballet, sport dance and Slovakian folklore dance in the length of COP ($p = 0{,}085$), the average velocity of COP ($p = 0{,}055$), elliptic area ($p = 0{,}041$), nor the numerical eccentricity ($p = 0{,}900$).

The Spearman Rank Order Correlation showed a small correlation between the dance type and toe grip strength (0,239 and 0,231 for dominant and non-dominant foot, respectively), length of COP

(-0,266) and average velocity (-0,298), showing increased to grip strength and decreased length of COP and average velocity of COP in sport dancers compared to classical ballet dancers or Slovakian folklore dancers.

Additionally, the Spearman Rank Order Correlation showed a large correlation between length of COP and average velocity of COP (0,986), a medium correlation between length of COP and numerical eccentricity (0,410), average velocity and numerical eccentricity (0,390) and a small correlation between length of COP and elliptic area (0,281) and average velocity and elliptic area (0,276).

The effect of gender, age, body mass and body height on postural control

Results of Spearman Rank Order Correlation show no effect of age on toe grip strength or postural variables. The effect of gender was observed only in toe grip strength of dominant and non-dominant foot (0,419 and 0,432, respectively), body height (0,661) and body mass (0,674). Similarly, unpaired t-test showed no statistically significant gender differences in postural variables. Body mass showed a statistically significant correlation with toe grip strength (0,415 and 0,422 for dominant and non-dominant foot, respectively), gender, and body height (0,765). Body height was observed to correlate with body mass, age, gender, and toe grip strength (0,462 and 0,425 for dominant and non-dominant foot, respectively).

The effect of toe grip strength on postural control

The results of Spearman Rank Order Correlation show a large correlation between dominant and non-dominant foot toe grip strength (0,807), medium correlation between toe grip strength and gender (0,419 and 0,432 for dominant and non-dominant foot, respectively), body height (0,462 and 0,425 for dominant and non-dominant foot, respectively) and body mass (0,415 and 0,422 for dominant and non-dominant foot, respectively) and a small correlation with dance type (0,239 and 0,231 for dominant and non-dominant foot, respectively).

Discussion

The purpose of this study was to analyse the differences in static postural control between classical ballet dancers, Slovakian folklore dancers, and sport dancers and to analyse the effect of age, body mass, body height and toe grip strength on postural control variables.

In this study, a large correlation between the length of COP and average velocity of COP was observed as the velocity is a division of the length of COP by trial time. In previous studies, the average velocity of COP was observed to be a postural control variable with the greatest reliability when a smaller velocity indicates better postural control (Paillard & Noé, 2015; Jančová Všetečková & Drey, 2013; Prieto, Myklebust, Hoffmann, Lovett & Myklebust, 1996). A medium correlation was observed between the length and average velocity of COP and numerical eccentricity of the ellipse in this study. The numerical eccentricity describes the shape of the ellipse when “0” is a perfect circle, “100” is an elongated, narrow ellipse. The elliptic area quantifies the 95% of the area covered by medio-lateral and anterior-posterior excursions of COP. Similarly to the length and average velocity of COP, the smaller is the elliptic area, the better postural control, and a small correlation between the elliptic area and the length and average velocity of COP was observed in this study (Paillard & Noé, 2015).

The results of this study showed a smaller length and average velocity of COP in sport dancers, compared to classical ballet and Slovakian folklore dancers. Sport dancers are used to a greater load on the forefoot and to a special foot roll-of pattern when dancing, which may lead together with a constantly changing environment during competitions to the enhanced postural stability. Previous studies show better postural control in dancers compared to other athletes or control groups (Gerbino et al., 2007; da Silveira Costa et al., 2013). However, no previous study focused on postural stability in different types of dance is known to the authors.

Despite the differences in dance training and dance footwear of female and male dancers (high-heel shoes in sport and Slovakian folklore female dancers, pointe shoes in female ballet dancers), no statistically significant difference in postural variables between genders was observed. Similarly, no effect of body mass, body height and age on postural variables was observed in this study and was probably caused by the similar body shape characteristics of all dancers as in the general population, the effect of body mass and gender on postural stability was described (Greve, Alonso, Bordini & Camanho, 2007; Hue et al., 2007; Lee & Lin, 2007).

The toe grip strength was not observed to affect the postural variables in this study. An interesting observation was made in female dancers when female sport dancers and Slovakian folklore dancers were observed to have a greater strength in a non-dominant foot (left in most of the dancers), which may be a result of the asymmetrical use of the left and right leg in sport and Slovakian folklore dance. The greatest toe grip strength was observed in female ballet dancers, despite their younger age, who performed better with their dominant foot. Previous study focused on ballet dancers found no statically significant difference in balance when landing from ballet jumps between the self-described stronger and weaker leg (Mertz & Docherty, 2012) as ballet dancers practice symmetrically demanding repetitive exercises focused on foot and toes work such as *battement tendu* or *demi-pointe* and *en pointe* positions (Nihal et al., 2002).

In dancing, most of the injuries are caused by overuse and not by trauma as the movement is choreographed (Gerbino et al., 2007; Teitz, 2000). Previous studies show that lower postural stability increases the risk of injury and can be improved by a special exercise program (Witchalls, Blanch, Waddington, & Adams, 2012; Struhár & Dovrtělová, 2014). Future studies focused on postural stability changes in non-dancers after a sport dance, classical ballet and Slovakian folklore dance training program would provide additional knowledge about the process how each type of dance enhance the balance and other coordinative skills.

Conclusions

This study, focused on postural stability and toe grip strength in dancers, show better postural stability measured by the length and average velocity of COP in sport dancers, compared to classical ballet and Slovakian folklore dancers. In analysed dancers, no effect of age, body mass, body weight, or gender on postural control was observed. Similarly, the toe grip strength was not observed to affect the postural variables in this study, probably because of the enhanced postural stability skills in all three analysed types of dance.

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THE APPLICATION OF FUZZY LOGIC IN THE DIAGNOSTICS OF PERFORMANCE PRECONDITIONS IN TENNIS

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Antonín Zderčík[1], Jiří Nykodým[1], Jana Talašová[2], Pavel Holeček[2], Michal Bozděch[1]

[1]*Masaryk University, Faculty of Sport Studies, Brno, Czech Republic*

[2]*Palacky University in Olomouc, Olomouc, Czech Republic*

ABSTRACT

Sports performance is influenced by a many of factors that can be characterised as its relatively independent – although synergetic – components. The most frequently mentioned are the fitness, somatic, tactical, mental and technical factors of sports performance. The subject of interest in sport is the process of monitoring and evaluating the level of these individual factors, i.e. the diagnostics of sports performance. When diagnosing the level of performance prerequisite for tennis, it is recommended to use those diagnostic methods that focus on tennis-specific performance prerequisites. Analyses of modern tennis show speed (reaction, action), strength (explosive), strength endurance and specific coordination abilities to be the most important motor prerequisites. Diagnostics of the motor prerequisites of an athlete are often performed in practice employing motor tests and test batteries. Methods of evaluating the results obtained are generally based on the probability approach, though an alternative is provided by a method based on the theory of fuzzy logic. The aim of the research was to use the theory of fuzzy logic in evaluating the level of performance prerequisites and compare evaluation results by using of a classical discrete approach and a fuzzy approach. The two approaches are evaluated and compared using the results of testing of a group of 15–16-year old tennis players (n = 203, age M ± SD = 15.97 ± 0.57 years, height M ± SD = 181.9 ± 6.8 cm, weight M ± SD = 71.6 ± 8.6 kg) who took part in regular testing conducted by the Czech Tennis Association in the years 2000–2018 using the TENDIAG1 test battery. STATISTICA 12 software was used for the analysis of data using a probability approach. FuzzME software was used for analysis using of a fuzzy approach. The testing of research data (the Kolmogorov-Smirnov test) demonstrated the normal distribution of the frequency of the results of individual tests in the test battery. The level of agreement of the results (the Pearson correlation coefficient) obtained by the two approaches (the discrete and the fuzzy approaches) was high both from the effect size (ES, large) and statistical significance points of view (r = 0.89, p = 0.05). The evaluation of the effect size (ES) of the differences between the mean values of the results obtained by the two approaches using the Cohen's *d* did not demonstrate any substantively significant difference (d = 0.16). For a more detailed analysis, two subsets were selected from the original group of tennis players. They consisted of players with an overall evaluation (probability approach) of 4–5 points and 8–9 points, respectively. The level of agreement between the results in the subgroup with the evaluation 4–5 points was low from both the effect size (ES, small) and statistical significance points of view (r = 0.15, p = 0.05), while the agreement in the subgroup with the evaluation of 8–9 points was at a medium level in terms of the effect size (ES, medium) and statistically insignificant (r = 0.47, p = 0.05). The effect size (ES) assessment of the differences between mean values of the results obtained by the two approaches did not demonstrate any effect (d = 0.12) in the group with the overall score of 4–5 points, and a large effect (d = 0.89, large) in the group with an overall score of 8–9 points. Despite the similarity of the results obtained by the probability and fuzzy methods, it was shown that the fuzzy approach enables a finer differentiation of the level of fitness prerequisites in players on the evaluation boundaries. Since that the results for individual items in the TENDIAG1 test battery indicate the level of individual performance prerequisites, the use of different weighting criteria may be considered for future evaluation using the fuzzy approach. For this approach, the use of the point method, a paired comparison method or the Saaty method can be considered for the identification and calculation of individual subtests weighting.

Keywords: diagnostics; fuzzy logic; FuzzME; probability approach; TENDIAG1 test battery

Introduction

In the area of sports science, one of the basic concepts is sports performance and its structure. The basic factors of sports performance are somatic, fitness, technical, tactical and mental factors (Dovalil et al., 2012; Hohmann, 2007). Different sports require different levels of individual factors, and it is therefore important to diagnose those factors that significantly affect sports performance - these are referred to as sport-specific factors. Contemporary tennis is characterized by a powerful, fast and aggressive style, and places high demands on the players' fitness. Players must also be highly technically and tactically mature (Filipčič & Filipčič, 2005). According to Schönborn (2008), sport-specific factors in tennis can be divided into limiting factors, which are important but not compensable, and influencing factors, which are important but can be compensated for by other qualities. Based on a retrospective theory, Hohmann et al. (2010) concluded that successful adult athletes exhibited a high level of certain specific performance prerequisites already in their youth. For that reason, early identification of talented individuals, for which motor tests and test batteries are frequently used, plays such an important role in sports. To diagnose physical and motor performance prerequisites for tennis, the TENDIAG1 test battery has been developed in the Czech Republic by Zháněl et al., (2000).

In everyday life, there often arise situations when human thinking creates concepts that cannot be described unambiguously by the rules of classical set theory, which assumes sharp boundaries between sets, that is to say a specific element either belongs or does not belong to a set. Fuzzy theory, which can model uncertainties and fuzziness, is associated with the name of L. A. Zadeh, who in 1965 proposed the basic principles of the so-called fuzzy sets. In fuzzy theory, each element is assigned a degree of membership in the range [0; 1]. Thus, an element either does not belong to the set (degree of membership 0), or it certainly belongs to the set (degree of membership 1) or belongs to the set only partly (degree of membership ranging between zero and one (0; 1)). Fuzzy theory is used in many different fields, e.g. in engineering, the building industry, transport and electrical engineering. economics, banking and personal logistics (Hubacek et al., 2015). The first application of fuzzy theory in sports dates back to the 1990s. For instance Zháněl et al. (2006) give examples of its applications in learning to ride a bike, analyzing diagnostic data in speed skating, skiing, gymnastics, and sports games. Other examples of fuzzy theory applications are found in table tennis (Acharjee & Chaudhuri, 2012), strength training (Novatchkov & Baca, 2013), as well as in the diagnosing of sports talent, specifically in triathlon (Bottoni et al., 2011), football (Tavana et al., 2013), volleyball (Noori & Sadeghi, 2017), badminton (Ağılönü & Balli, 2009), tennis (Hubáček et al., 2015, Zderčík et al., 2018) and others.

Methods

The present paper aim is to propose the possibilities of using the fuzzy approach for the evaluation of the results of tennis players obtained with by the TENDIAG1 test battery, and for the comparison of evaluation results obtained using the classical probability approach and the fuzzy approach. Three research questions were formulated based on of the knowledge synthesis and the objectives of the research study:

1. How can the level of performance prerequisites be evaluated using a probability approach?
2. How can the level of performance prerequisites be evaluated using a fuzzy approach?
3. Is it possible to demonstrate significant differences between the results of the performance prerequisites evaluation obtained using the probability approach and the fuzzy approach?

The research group consisted of male tennis players aged 15–16 (U16, n=203, age M ± SD = 15.97 ± 0.57 years, height 181.9 ± 6.8 cm, weight 71.6 ± 8.6 kg), who participated in regular testing of the Czech Tennis Association. The research data are the result of long-term monitoring (2000–2018) using the same diagnostic procedures, tests and instruments. The TENDIAG1 test battery contains a total of 9 tests divided into three areas (physical prerequisites, fitness skills and coordination abilities) with three subtest each (12 tests in total).

The results of individual tests in fitness skills and coordination abilities (physical prerequisites were not scored) are evaluated on a point scale of 0–2 (0 = low level, 1 = medium level, 2 = high level). The evaluation of the results (the standard) is based on the classical probability approach and basic statistical characteristics (M and s) for individual age categories of players. The total score of the TENDIAG1 test battery is the sum of the points obtained in each evaluated test (6 tests) in the interval 0-12 points. The research data have the character of physical quantities or dimensionless index-type variables. MS Excel and Statistica 12 software were used for the analysis. FuzzME software (Holeček & Talašová, 2010) was used to analyse individual tests evaluated using the fuzzy approach. The degree of agreement between results obtained using the classical probability approach and the fuzzy approach was assessed using the Pearson correlation coefficient. Because a deliberate selection of elements of the research group was used, the effect size (ES) of the results was evaluated using the Cohen's *d* value (Cohen, 1988), which can be expressed in word form as follows: small effect (*d* = .20), medium effect (*d* =. 50) and large effect (*d* = .80).

Results

Basic statistical characteristics of the research group of tennis players (n=203) in the age category 15–16 years are given in Table 1

Table 1 *List of basic statistical characteristics*

Test	Test parameter	M	SD	Min	Max
A	Age	15.97	0.57	15.00	16.90
H	Height	181.89	6.79	166.0	195.50
W	Weight	71.62	8.56	38.90	90.00
T1	Dominant arm strength	46.00	6.21	32.40	63.40
T2	Running speed	13.25	0.66	11.64	15.24
T3	Medium-term endurance	136.50	7.02	117.80	155.15
T4	Arm reaction time	0.46	0.05	0.35	0.60
T5	Leg reaction time	0.39	0.04	0.27	0.49
T6	Trunk agility	42.24	3.72	31.00	54.00

Note. M = mean; SD = standard deviation, Min = minimum value, Max = maximum value

Probability approach

When scoring the results of individual tests using a probability (discrete) approach, the participants scored points from the set {0, 1, 2} in each test. Conversion of the test results to the point score was carried out in Microsoft Excel using pre-developed standards.

The athletes were therefore able to earn a total of 0–12 points in the six tests. An example of point score calculations in individual subtests of selected athletes in the research group is given in Table 2.

Table 2 *An example of a conversion of result in individual subtest to a point score*

No.	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	Total
1.	35.1	14.00	143.0	0.56	0.39	41	0	0	0	0	1	0	1
2.	36.0	13.90	145.0	0.47	0.36	44	1	0	0	2	1	1	5
…	…	…	…	…	…	…	…	…	…	…	…	…	…
202.	57.9	13.50	130.3	0.49	0.40	38	2	0	2	1	1	0	6
203.	50.7	16.60	145.3	0.51	0.43	38	2	0	0	1	0	0	3

Note. M = mean; SD = standard deviation, Min = minimum value, Max = maximum value

Fuzzy approach

In the first step of point scoring the results of individual tests using the fuzzy approach, a membership function for each TENDIAG1 test battery item was selected. Because of the character of individual tests, the S-shape and Z-shape membership functions were used. The S-shape membership function was used in tests in which the point score increased with an increase in the numerical value of the test results, e.g. in the dominant arm strength test. The Z-shape function, on the other hand, was used in tests where the point score decreases with an increasing numerical value of the test result (e.g. in the running speed test). There are two important points along the S- and Z-shape membership function curves, the so-called break points, which divide these functions into three performance level intervals. The S-shape membership function can be defined as follows:

$$A(v_i, a_i, b_i) = \begin{cases} 0 & \text{for } v_i \leq a_i \\ \frac{v_i - a_i}{b_i - a_i} & \text{for } a_i < v_i < b_i \\ 1 & \text{for } v_i \geq b_i \end{cases}$$

where v_i is the participant's result in the i-th test, a_i is a completely unsatisfactory value in the i-th test, and b_i is a completely satisfactory value in the i-th test. The completely unsatisfactory value a_i and the completely satisfactory value b_i in the i-th test correspond to the value of M - SD and M + SD, respectively. Similarly, the Z-shape function can be defined as follows:

$$A(v_i, d_i, c_i) = \begin{cases} 1 & \text{for } v_i \leq c_i \\ \frac{d_i - v_i}{d_i - c_i} & \text{for } c_i < v_i < d_i \\ 0 & \text{for } v_i \geq d_i \end{cases}$$

where v_i is the participant's result in the i-th test, c_i is a completely satisfactory value in the i-th test, and d_i is a completely unsatisfactory value in the i-th test. The completely satisfactory value c_i and the completely unsatisfactory value d_i in the i-th test correspond to the value of M - SD and M + SD, respectively. Table 3 lists the membership function types for each test and the mean level of performance standards for athletes in the 15–16-year age group.

Table 3 *Overview of membership functions and their mean values (1 point)*

Code	Membership function shape	Mean values interval	Units
T1	S	39.8–52.2	kp
T2	Z	12.59–13.91	s
T3	Z	129.8–143.84	s
T4	Z	0.41–0.51	s
T5	Z	0.35–0.43	s
T6	S	38.52–45.69	number

Note. M = mean; SD = standard deviation, Min = minimum value, Max = maximum value

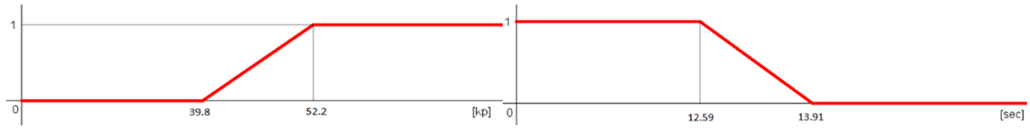

Figure 1 *Examples of S-shape (test T1) and Z-shape functions (test T2)*

The Z-shape function is constant below the lower limit of the mean value interval (degree of membership 1) and above the upper limit of the mean value interval (membership degree 0). Within the mean value interval, the Z-shape function is linearly decreasing. Table 4 gives examples of result evaluations in individual T1-T6 tests (participants 1, 2, 202 and 203), and the overall evaluation of the results of the TENDIAG1 test battery using the FuzzME software.

Table 4 *Fuzzy evaluation of individual test of selected participants*

Participant/test	T1	T2	T3	T4	T5	T6	Total
1.	0	0	0.06	0	0.05	0.333	0.893
2.	0	0.008	0	0.4	0.875	0.737	2.02
…	…	…	…	…	…	…	…
202.	1	0.311	0.964	0.2	0.375	0	2.85
203.	0.879	0.235	0	0	0	0	1.114

Note. M = mean; SD = standard deviation, Min = minimum value, Max = maximum value

Comparison between the probability and the fuzzy approach

When point scores are used to evaluate test results using the probability approach, athletes are scored on a 0–2 point scale. In the fuzzy approach-based scoring, athletes can in each test be scored either 0 (completely unsatisfactory or 1 (completely satisfactory), or any value from the interval (0; 1). For a comparison of results obtained using the probability and the fuzzy approaches, it is necessary to multiply the total sum of fuzzy evaluations by 2. Table 5 shows the evaluation of selected participants using the fuzzy approach (multiplied by 2), and using the probability approach. The last column shows the differences between results obtained using the two approaches, where the positive difference indicates a higher rating using the fuzzy approach, a negative difference indicates a higher rating using the probability approach.

Table 5 *Comparison between point and fuzzy evaluation*

Participant	FA	PA	Diff
1.	1.786	1	+ 0.786
2.	4.04	5	- 0.96
…	…	…	…
202.	5.7	6	- 0.3
203.	2.228	3	- 0.772

Note. FA = fuzzy approach, PA = probability approach, Diff = difference

When assessing the level of agreement between evaluation results of the entire group of 15 to 16-year old tennis players (n=203) using the probability and the fuzzy approach, a high level of agreement was found both in terms of the effect size and statistical significance (large, $r = 0.89$, $p = 0.05$). The assessment of the effect size of differences in mean result values obtained by the two approaches using Cohen's *d* showed small effect ($d = 0.16$). Therefore, we can conclude that evaluation results obtained in the group of 15 to 16-year-old tennis players (n = 203) using the two approaches show no significant differences. For a more detailed analysis, two subgroups consisting of participants with borderline results in probability evaluation were selected from the total research group, i.e. participants who scored 4–5 points (S1, n=47) or 8–9 points (S2, n=53). For subgroups S1 and S2, the degree of agreement of evaluation results obtained by the two approaches as well as the assessment of the effect size of differences in mean values of results was again assessed. The degree of agreement between results in the S1 subgroup was insignificant from both the effect size and statistical importance points of view ($r = 0.15$, $p> 0.05$, small). In the S2 subgroup, the agreement reached a medium degree in terms of the effect size but was statistically insignificant ($r = 0.47$, $p > 0.05$, medium). The difference in mean values of the results obtained by the two approaches was highly significant from both the effect size and the statistical importance points of view ($d = 0.89$, $p < 0.05$, large).

Discussion

The results of our research (in which we found significant agreement from the effect size and statistical importance points of view in the results of a group of tennis players aged 15–16 years, $r = 0.89$, $p < 0.05$, large) were compared with the results of similar studies. In a research study evaluating the results of tennis players aged 11–12 years, Hubáček et al. (2015) demonstrated significant dependence of evaluation results obtained by the two approaches from the effect size and the statistical importance points of view ($r = 0.92$, $p <0.05$, large). Zderčík et al. (2018, 13-14-year-old tennis players, n=211) also demonstrated a significant degree of dependence from both the effect size and statistical importance points of view ($r = 0.94$, $p <0.05$, large) between evaluation results obtained by the two approaches. The same authors found only trivial differences in the mean values of evaluation by the two approaches ($d = 0.36$, small). These findings indicate that evaluation results obtained by the two approaches in different groups of tennis players do not differ significantly. To obtain a more detailed comparison of the results of the two approaches, we evaluated two subgroups of players who scored 4-5 points or 8–9 points in probability evaluation, i.e. scored at the borderlines of performance categories low/medium, and medium/high, respectively. In contrast to Hubáček et al. (2015, tennis players 11–12 years, n=88), who found large effect size in the subgroup that scored 4-5 points ($r = 0.68$, large), we found only small effect size of dependences ($r = 0.15$, small). In the other subgroup, Hubáček et al. (2015) again found a highly significant effect size of the dependence between the results of the two approaches ($r = 0.65$, large) while in our research we found a medium effect size ($r = 0.47$, medium). The results of this more detailed analysis partly corroborate the assumption that the fuzzy approach allows for a finer and more accurate differentiation between the levels of performance prerequisites. Also Bottoni et al. (2011) state that the triathlon talent model based on fuzzy logic is somewhat better than the classical evaluation methods.

The fuzzy expert system for identification of sports talents in various sports (Papič, Rogulj & Pleština, 2008) has demonstrated high accuracy, reliability and agreement of its results with experts' opinions on individual sports. In a majority of the above studies, evaluation of the results of individual tests with equal weights set for all subtests was used. However, some methods assign different weights to different tests according to their importance, which have already been applied in sports, e.g. in badminton (Ağılönü & Balli, 2009).

Conclusions

The result section describes the method of evaluating test results of using the classical probability approach, including an example of individual tests evaluation and the overall score of the TENDIAG1 test battery of selected participants from the research group. The next section dealing with the fuzzy approach gives a detailed description of the methods of constructing S- and Z-shape membership functions, including the reasons for using a particular type of the membership function in subtests from the TENDIAG1 test battery. Next, the method of evaluating the results of testing using the fuzzy approach and the FuzzME software was presented. When comparing the results obtained using the probability approach and the fuzzy approach, a significant agreement between results was found from both the effect size and the statistical importance points of view ($r = 0.89$, $p < 0.05$, large). An assessment of the effect size of differences between the means of results obtained by the two approaches showed only a small effect ($d = 0.16$, small). A more detailed analysis of the results of two subgroups that scored 4-5 points and 8-9 points, respectively, showed that the degree of agreement between the results obtained by the two approaches in the former subgroup is insignificant from both the effect size and statistical importance ($r = 0.15$, small) and moderately significant in the latter subgroup ($r = 0.47$, medium). An assessment of the effect size of the differences between the means of results obtained by the two approaches in the two subgroups showed no effect ($d = 0.12$, small) and large effect ($d = 0.89$, large), respectively. Application of methods for the calculation of different weights for individual subtests from the TENDIAG1 test battery, the subsequent comparison of these methods and the use of the Saaty method could be the subject matter of future research studies.

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DIFFERENCES IN SELF-ASSESSMENT OF PREPAREDNESS OF WRESTLERS BEFORE COMPETITION

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Kristijan Slačanac[1], Nenad Žugaj[2]

[1]*Central State Office for sport, Zagreb, Croatia*
[2]*Faculty of kinesiology, University of Zagreb, Zagreb, Croatia*

ABSTRACT

Purpose: The main goal of this research was to establish differences in self-assessment of preparedness of Greco-Roman wrestlers in different age groups before a competition.
Methods: The sample of subjects consisted of Greco-Roman wrestlers (n=223) divided into three age groups (cadets n=76; juniors n=69; seniors n=78). Self-assessment of preparedness was determined immediately before official weighing (approximately 16 hours before official weighing) using a survey questionnaire on the Likert scale of 1 to 5. Descriptive statistic parameters were present. The wrestlers' success was determined by analysis of official bulletin from national championships. The correlation between self-assessment of preparedness and success was determined by a linear regression analysis. Statistically significant differences between the groups were determined by the Mann-Whitney test.
Results: Most cadets (35.5% of subjects) estimate that they are completely prepared for a competition comparing to juniors. Seniors and juniors carefully evaluated preparedness for a competition. Seniors (42.3% of subjects) estimate that they are somewhat prepared, while juniors (43.5% of subjects) estimate that they are highly prepared for a competition. Furthermore, results of linear regression indicate relation ($R = 0.203$; $p = 0.002$) between self-assessment and success of Greco-Roman wrestlers. In addition, statistically significant differences between cadets and juniors ($p = 0.033$) were confirmed as well as between cadets and seniors ($p = 0.001$) in variable self-assessment of preparedness for a competition.
Conclusion: Statistically significant relation between self-assessment and success indicates that wrestlers with a high level of self-assessment have better success as well as self-confidence in wrestling competition. The differences between age groups of Greco-Roman wrestlers in variable self-assessment of preparedness emphasize importance of realistic and achievable goals in young age groups of wrestlers. Setting unrealistic goals can lead to frustrations or giving up on practicing wrestling. Therefore, individual approach to the mental preparedness of young wrestlers before a competition is very important, especially setting and realization of achievable goals. In this way, positive experience from a competition will raise the level of self-confidence in young age wrestlers.

Keywords: wrestling; Greco-Roman; focus; self-confidence; motivation; success

Introduction

According to international rules (UWW, 2019), wrestlers are competing in different age groups (boys, cadets, juniors, and seniors). In wrestling as a sport with three Olympic disciplines, it is important to have the strength and mental preparedness for a competition. Under the preparation period of wrestlers for a competition, there are lot of factors that affect the best results such as strength, coordination, speed, agility, flexibility, etc. What is important for success in wrestling is not only a high level of strength preparedness but also a good mental preparation. In the field of psychological preparedness of wrestlers, there are scientific papers about goal orientation (Bahrami & Yousefi, 2014; 2015; Han, 2008; Karninčić, Baić & Slačanac, 2016; Slačanac, 2017; Slačanac, Karninčić & Baić, 2017).

The main problem in practice is the absence of mental preparedness or insufficient knowledge in the field of mental preparedness. This is especially evident in young age wrestlers, which results in angry behavior after a defeat and has a hindering impact on competition placement as well as not achieving the set goals (Karninčić et all, 2018). To prevent the appearance of negative emotional states or frustration and withdrawal from practicing wrestling, it is important to know the importance of self-assessment of preparedness and their relation with success in wrestling. Also, it is very important to know the differences between the age group so that we can access the individual mental preparation of the wrestler for a competition.

This research focuses on two issues. The primary goal of this study was to determine differences in self-assessment preparedness for a competition of wrestlers between different age groups. Therefore, the second goal was to establish a relation between self-assessment preparedness and success of Greco-Roman wrestlers.

Methods

The data for this survey are part of Ph.D. research "Relation between rapid weight loss and competitive efficiency of wrestlers" (Slačanac, 2017). The sample of subjects consisted of 223 wrestlers, who participated in the Croatian National Greco-Roman wrestling championship. The subjects were divided into three age groups according to international wrestling rules (UWW, 2019); the first group refers to cadets (n=76), the second group refers to juniors (n=69) and the third group refers to seniors (n=78). The sample of variables comprises variables of anthropometric characteristics, wrestlers experience self-assessment of preparedness and success on a competition. Self-assessment of preparedness before a competition was estimated with the occasional questionnaire in the Croatian language. The survey of subjects was conducted immediately before official weighing (approximately 16 hours before a competition). The question for estimating self-assessment of preparedness for the competition was: "for this competition I am ready?". Subjects estimated their own preparedness on Likert scale by answers offered from 1–5 (1 – not prepared; 2 – little prepared; 3 – somewhat prepared; 4 – very prepared; 5 – completely prepared). Preparedness means physical condition, technical and tactical as well as mental preparedness for a wrestling competition. Wrestlers' success was determined by analysis of official reports from the competition (CWF, 2014a, 2014b, 2014c).

In this paper, basic statistic parameters (mean, standard deviation, minimum and maximum) are presented. The relation between self-assessment and success is established by linear regression analysis, whereas statistically significant differences between the groups were determined by the Mann-Whitney test. All the data were analyzed using IBM SPSS Statistics, version 20.0 (IBM SPSS Inc., Chicago, IL).

Results

Observing frequencies (Table 1), self-assessment of preparedness varies depending on the age group. Most cadets (35.5% of subjects) estimate that they are completely prepared for a competition compared to juniors. Seniors and juniors carefully evaluated preparedness for competition. Seniors (42.3% of subjects) estimate that they are somewhat prepared, while juniors (43.5% of subjects) estimate that they are very prepared for a competition.

Table 1 *Frequencies table and descriptive analysis of results*

PREPAREDNESS	cadets		juniors		seniors	
	n=76		n=69		n=78	
	f	%	f	%	f	%
not prepared	0	0	1	1.4	1	1.3
little prepared	6	7.9	6	8.7	5	6.4
somewhat prepared	14	18.4	19	27.5	33	42.3
very prepared	29	38.2	30	43.5	28	35.9
completely prepared	27	35.5	13	18.8	11	14.1
Min–Max	2.0–5.0		1.0–5.0		1.0–5.0	
Mean ± SD	4.0 ± 0.9		3.7 ± 0.9		3.6 ± 0.9	

The descriptive parameters variable for self-assessment of preparedness and ranking are presented in Table 2. The results indicate that cadets have the largest average values in variable self-assessment compared to juniors and seniors. The values range in the variable ranking from 1st–18th. Average values of anthropometrical characteristics of juniors and seniors is referred in body mass and body height as well as experience compared to cadets.

Table 2 *Descriptive statistics*

Variables	cadets (n=76)		juniors (n=69)		seniors (n=78)	
	Mean ± SD	Min–Max	Mean ± SD	Min–Max	Mean ± SD	Min–Max
Age (years)	15.6 ± 0.9	14.1–17.1	18.1 ± 1.1	16.1–20.2	22.7 ± 4.5	17.1–41.4
Body mass (kg)	64.0 ± 12.8	40.8–98.0	73.3 ± 6.1	49.5–119.5	77.9 ± 15.0	56.7–129.7
Body height (cm)	173.8 ± 7.9	148.0–190.0	176.4 ± 6.1	160.0–190.0	177.5 ± 93	140.0–199.0
Experience (years)	5.1 ± 2.5	1.0–11.0	7.4 ± 2.6	2.0–14.0	10.7 ± 5.1	1.5–27.0
Ranking	5.8 ± 3.9	1.0–17.0	6.3 ± 4.5	1.0–16.0	6.6 ± 4.1	1.0–18.0
Self-assessment	4.0 ± 0.9	2.0–5.0	3.7 ± 0.9	1.0–5.0	3.6 ± 0.9	1.0–5.0

Results of linear regression (Table 3) indicate statistically significant correlation ($p = 0.002$) between self-assessment and the success of wrestlers. The correlation coefficient is $R = 0.203$, while determination coefficient is $R^2 = 0.041$(4% of variance). The standardized coefficient ($\beta = -0.203$) indicates linear changes in value of self-assessment and success.

Table 3 *Linear regression results*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Std. Coeffic.	p-level
1	.203	.041	.037	.907	-.203	**.002**

Note: Unstandardized coefficients B = -.909 + 9.626

Differences between groups were determined by the Mann-Whitney test. The results of the Mann-Whitney test (Table 4) confirm statistically significant differences between cadets and juniors ($p = 0.033$) in self-assessment of preparedness before a competition as well as cadets and seniors ($p = 0.001$). Differences between juniors and seniors were not confirmed. Besides, statistically significant differences were determined in the variables of age, body weight and experience among cadets, juniors, and seniors.

Table 4 *Mann-Whitney test results*

Variables	Cadets vs Juniors			Juniors vs Seniors			Seniors vs Cadets		
	U	Z	p	U	Z	p	U	Z	p
Age (years)	150.5	-9.8	**.000**	749.5	-7.5	**.000**	0.0	-10.7	**.000**
Body mass (kg)	1679.0	-3.7	**.000**	2150.5	-2.1	**.036**	1372.5	-5.8	**.000**
Body height (cm)	2091.0	-2.1	**.035**	2371.5	-1.2	.214	2142.0	-3.0	**.003**
Experience (years)	1208.5	-4.7	**.000**	1549.5	-4.2	**.000**	822.5	-7.1	**.000**
Ranking	2519.5	-0.4	.682	2518.0	-0.7	.499	2618.5	-1.3	.208
Self-assessment	2112.5	-2.1	**.033**	2400.5	-1.2	.232	2097.5	-3.3	**.001**

Discussion

Statistically significant differences between groups were determined in variables anthropometric characteristics, age, experience and self-assessment of preparedness for a competition. By comparing results of descriptive parameters in variable experience it can be concluded that cadets start with wrestling practicing at the age of 10.5 and juniors at the age of 10.7. The finding complies with previous research (Baić, Karninčić & Šprem. 2014). Wrestlers with more experience have a great mental as well as conditional preparedness (Han, 2008) and train 15.09 years before they won their first medal on Olympic games or World championship (Karninčić, Baić & Šprem, 2017).

Optimal strength preparation is necessary for success in wrestling. Using the long-distance running contributes to develop specific endurance as well as focus and mental endurance. Through proper conditioning preparation wrestlers can optimally reduce their body mass, keep their weight and achieve some benefits: to be the highest and have greater weight. Mental preparedness is important, so military preparedness of wrestlers is characterized by an optimal level of pre-competitive excitement (Marić, 1985) as well as focus (task orientation) on task (Han, 2008) and positive self-speech. Together they have a positive impact on psychological skills and performance in wrestling (Zakaria, 2012). Depending on experience, seniors have more intrinsic motivation and experience emotional stimulation in that way (Grushko at all., 2016).

Results of linear regression analysis confirm that wrestlers with great self-assessment of preparedness achieve better sports result. Wrestlers with great perceptive competence are more interested, have a higher level of confidence as well as better task orientation. Successful wrestlers are more confident than the less successful wrestlers (Slačanac, 2017). Authors Karninčić, Baić & Slačanac (2017) determined that wrestlers during moderate weight loss have high levels of intrinsic motivation and high value of interest/enjoyment. Competition-induced stress, as well as positive psychological skills that contribute to a state of self-esteem are important for better self-esteem (He, 2014), which can be improved by forgetting defeat, developing positive affirmation towards one's work, documenting success, visualization, etc. (Čerenšek, 2017). It can be said that task orientation during weight loss produces much more satisfaction, leading to better performance at competitions (Farkhondeh & Maghaddam, 2015), and it is logical that 87% of wrestlers tend to be task-oriented (Bahrams and Yousefi, 2004) and despite weight loss more task-oriented (Slačanac, Karninčić & Baić, 2017). The task orientation can be developed and influenced by the level of training, fitness, stress tolerance, attitude and approach, perceptual abilities, patience, anxiety, etc. (Čerenšek, 2017). In contrast, ego-oriented athletes will have a greater degree of arousal (Halvari, 1990), so competitive pressure on the body of young wrestlers will significantly reduce physical capacity (Korjenevsy & Podlivaev, 2011).

In this research, statistically significant differences between cadets and seniors in variable self-assessment of preparedness for competition were determined. The largest differences are visible in numerical values of self-assessment of preparedness. This means that more cadets express that they are very or completely prepared compared to seniors. This relation can be described by more experience, better knowledge of their capabilities, competition in the tournament and giving greater importance to the competition (Karninčić, Baić and Slačanac, 2016). Wrong self-assessment of preparedness in younger age groups (older boys and cadets) or failure to achieve a goal can lead to frustration, anger or even quitting practicing wrestling. That is especially important if we know the fact that wrestlers won their first medal on Olympic games or World championship after 15.09 years of training (Karninčić, Baić & Šprem, 2017). Therefore, it is very important to set realistic and achievable goals, which is a very important factor in preventing disappointment and frustration, especially for younger age groups of wrestlers.

By achieving goals, it is possible to develop positive experiences related to an event, so that wrestlers develop a sense of security in themselves and increase their confidence. Therefore, goal setting is very important in the process of confidence development. Goal setting should be SMART - specific, measurable, achievable, realistic and timed (Čerenšek, 2017).

Conclusion

Differences in anthropometric characteristics may be important in terms of manifestation of maximal power, but also of greater appearance, and may affect the psychological state, that is, they may have a positive effect on the level of wrestling. Fitness training and athletic training, mental pre-competition preparation is also important, especially in relation to intrinsic motivation and goal orientation. It is assumed that, because of previous competition experience, confidence, and proper goal setting, seniors better evaluate their pre-competition status than cadets. The relation between self-assessment of preparedness and placement indicates a statistical correlation ($p = 0.002$), so wrestlers with a higher level of self-assessment preparedness achieve better placement. This indicates a high level of perceived competence, confidence, and task orientation in pre-competition wrestlers. Statistically significant differences between groups of wrestlers are reflected in setting realistic and achievable goals in seniors then cadets. Setting unrealistic goals in younger age groups of wrestlers can cause negative emotional states (anger, frustration, etc.) and even giving up practicing wrestling. Therefore, it is very important to individually (mentally) prepare young wrestlers before the competition, especially when setting and achieving realistic goals, thus developing positive competing experiences and raising self-confidence.

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THE EFFECTS OF COMMERCIALLY AVAILABLE ENERGY DRINK ON COGNITIVE PERFORMANCE

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Michal Kumstát[1], Martin Sebera[1] Michal Vičar[2]

[1]*Masaryk University, Faculty of sport studies, Brno, Czech Republic*
[2]*Palacký University Olomouc, Faculty Of Physical Culture, Olomouc, Czech Republic*

ABSTRACT

Energy drinks are frequently purported as a non-alcoholic beverage food commodity to improve cognitive function and concentration and as such is marketed especially on vulnerable populations such as professional drivers, students, managers. We aimed to explore the acute dose-effect of commercially available multi-ingredient beverage on cognitive performance.
Twenty adult university students, caffeine-deprived received two 500 ml non-alcoholic, glucose-free, multi-herbal extract drinks differing in ingredients dose: $DRINK_{100}$, threefold higher concentration dosage ($DRINK_{300}$) and ingredients-free, flavored-matched placebo (PLA) in a double-blind, three-way cross over, randomized order, separated by a 7-day wash-out period. Cognitive functions, autonomous nervous system activity, and specific mental performance were assessed. Drinks were consumed in the late evening (20 p.m.). Standardized psychomotor vigilance task (PVT) to detect reaction time, lapses and the total score and spectral analysis of heart rate variability (software-driven, standing/lying down with ~300 beats recorded in each position, relative change in total power score between consecutive measurements was used) took place immediately prior and 60, 120 and 180 min post-drink consumption (post-drink). Thirty minutes of the cognitively demanding task (continuous manual text transcription) was commenced immediately and in 90, and 150 min post-drink. Total word counts were used in assessing mental performance changes. The ecologically valid methodology was used to mimic typical students time of drink consumption.
During the 60min post-drink, the level of alertness decreased independently of the drink category, however, $DRINK_{300}$ increased correct: lapsus ratio in 120 min and this remained elevated until the end of testing. No significant effect of $DRINK_{100}$ over PLA on vigilance was present. $DRINK_{300}$ led to an increase in autonomic nervous system activity after drink administration in 60–90 minutes post-drink with a clear decline observed in PLA. This corresponds with a significant increase in the number of words transcripted in the corresponding time in $DRINK_{300}$, however, not sustained in 180 min post-drink.
We demonstrate an acute and transitional dose-effect of multi-herbal caffeine-containing non-energetic beverage on cognitive and autonomous nervous system performance. The effect appears to be evident immediately (< 30 min) post-drink. A beverage containing guarana equivalent to 120 mg of caffeine reduce cognitive performance impairment and this is sustained over ~180 min.

Keywords: caffeine; herbal extract; psychomotor vigilance task; heart rate variability

Introduction

Energy drinks are frequently purported as a non-alcoholic beverage food commodity to improve cognitive function and concentration and as such is marketed especially on vulnerable populations such as professional drivers, students, managers. Their most common active ingredient is caffeine, often in the form of Guarana extract. In addition to stimulants (caffeine), they often contain other ingredients such as Ginkgo Biloba, taurine, vitamins, and others, and these drinks are the subject of studies (McLellan & Lieberman, 2012; Mora-Rodriguez & Pallarés, 2014). The stimulating effect on the body in most energy drinks is mediated by caffeine (Giles et al., 2012). Caffeine in energy drinks leads to a demonstrable reduction of physical and mental fatigue, increased mental abilities and maintain alertness and concentration (van den Eynde, van Baelen, Portzky, & Audenaert, 2008). Similar effects affecting memory and cognitive function are also shown by Ginkgo Biloba, Panax ginseng (Ginseng) is the subject of extensive research, investigating its effect on various diseases, weakening and promoting metabolic functions via so-called apoptogenic effect. Adaptogens are compounds that increase the body's defence against exogenous stress factors (environmental factors, toxic substances) and eliminate the risk of damage caused by these factors (Winston, 2011). The effects are mainly related to the hypothalamus-pituitary-adrenal axis and this axis is part of the stress system and plays an important role in the body's response to repeated stress.

To determine cognitive performance and effects of active ingredients psychomotor vigilance task (PVT) or spectral analysis of heart rate variability (SA HRV) has been widely used for evaluating wake-promoting food-based substances (Wesensten, Belenky, Thorne, Kautz, & Balkin, 2004). It was shown that various nutritional factors (e.g. caffeine intake) (Zahn & Rapoport, 1987), health factors (e.g. presence of illness) (Kapounková et al., 2019) and/or experimental manipulations affect the sympathetic nervous system explaining high prevalence of methods used in determining sympatho-vagal disturbances (Acheson, 1993).

Various drinks containing a combination of active naturally-based substances are marketed for a range of people. As described above, there is no doubt of a performance-enhancing potential of isolated substances. However multi-component drinks become increasingly popular, namely among students with high cognitive-performance demands (García et al., 2017; Majori et al., 2018). Therefore, we aimed to explore the effect of commercially available multi-ingredient beverage on cognitive performance in university students.

Methods

Study design

Twenty adult university students (23 ± 3,5 yrs), caffeine-deprived received three drinks in a double-blind, three-way cross over, randomized order, separated by a 7-day wash-out period. Two 500 ml non-alcoholic, glucose-free, multi-herbal extract drinks differing in ingredients dose: $DRINK_{100}$ (Guarana 395mg, Ginko Biloba 45 mg, Lecithin 90 mg, Schizandra 55 mg, Ginseng 45 mg, Matcha Tea 45 mg), threefold higher concentration dosage ($DRINK_{300}$) and ingredients-free, flavored-matched placebo (PLA) were administered. The amount of administered substances was in accordance with the Czech legislation and the opinion of the European Food Safety Authority on caffeine consumption in 2015 and the drink does not pose any health risk for the consumer („Scientific Opinion on the safety of caffeine", 2015).

The study was spread into 3 weeks with one day in every week (experimental day) a randomly assigned drink was ingested and followed by ~3 h period in which the test of cognitive functions, autonomous nervous system activity (ANS), and specific mental performance were realized. Standardized psychomotor vigilance task (PVT), spectral analysis of heart rate variability (SA HRV) and the cognitively demanding task (continuous manual text transcription (TEXT) were used to identify a post-drink effect (Figure1). participants were educated to be familiar with all the testing procedures, received complete information of the course of the experiment and were trained in manipulation with the measuring device.

As far as the drinks were consumed in the late evening (20 p.m.), the ecologically valid methodology was intentionally used to mimic typical students time of drink consumption. Each participant signed informed consent. The research was approved by the Scientific ethical board of Masaryk University.

Description of the PVT

Standard 10-min form of PVT was used to assess the level of alertness and ability to keep attention (Dinges & Powell, 1985). The participants have to react to a red-light spot that appears on a black background for 10 minutes at irregular intervals. The participants were prompted to respond by pressing the key immediately after the red dot appears. The participants responded on average to 80 stimuli. The accurate, delayed or premature reactions were examined. The correct reaction was evaluated as a sufficiently rapid response to occur within 0,5 s of the red dot appeared. A premature reaction was considered to occur before the red dot appears and the delayed reaction was considered as a lapsus, a reaction that takes place more than 0,5 s after the red dot appears and overall success defined as the score was calculated as the ratio between correct reactions and delayed reactions. The testing was carried out on desktop computers with free software described by Khitrov et al. (2014). Each participant underwent a total of 12 tests (4 within an experimental day). The principle of PVT test was blinded to the participants.

Description of the SA HRV

The heart rate variability was assessed by measuring the length of R-R intervals using the frequency-domain spectral analysis method based on Fourier transformation (Stejskal & Salinger, 1996). A mySASY software (mySASY a.s.) was used. Each participant received a chest belt to measure heart rate variability and installed a mobile application on own mobile phone for monitoring ANS via mySASY app. The measurement was audio assisted by the installed application and follows standard protocol (Stejskal & Salinger, 1996). All participants underwent ANS standardization measurements period to assess the individual level of the ANS activity, which consisted of morning and evening measurements of ANS activity during the 5 days preceding the experiment. The duration of the each ANS measurement was 15 minutes, with the first 5 minutes of the proband remaining in the lying position, the second 5 minutes of the proband remaining in the standing position, the last 5 minutes of the proband remaining in the lying position. On the experimental days, participants underwent morning standardization measurement. In the evening (at the time of the experiment), they underwent four experimental measurements (pre- and post-drink). We focused on total spectral power that reflects overall autonomic activity where the sympathetic activity is a primary contributor (Zahn & Rapoport, 1987).

Description of the TEXT transcription

Specific mental performance task consisted of three 30min continuous manual text transcription. It commenced immediately (TEXT I) and in 60 (TEXT II), and 120 (TEXT III) min post-drink. Total word counts were used to assess mental performance changes. The printed book was selected for text rewriting. All participants were asked to start manually rewriting the given part of the text. The transcription took exactly 30 min. Time was measured with a stopwatch, started and ended with oral instruction. Three different parts of the text were selected for transcript. Individual transcribed parts (highlighted in the printed book) were then converted to the number of words using MS Word as the book was available in the *docx.* form. This procedure was used to objectively replicate real mental activity, as the number of transcripted words allows for quantification of the work done.

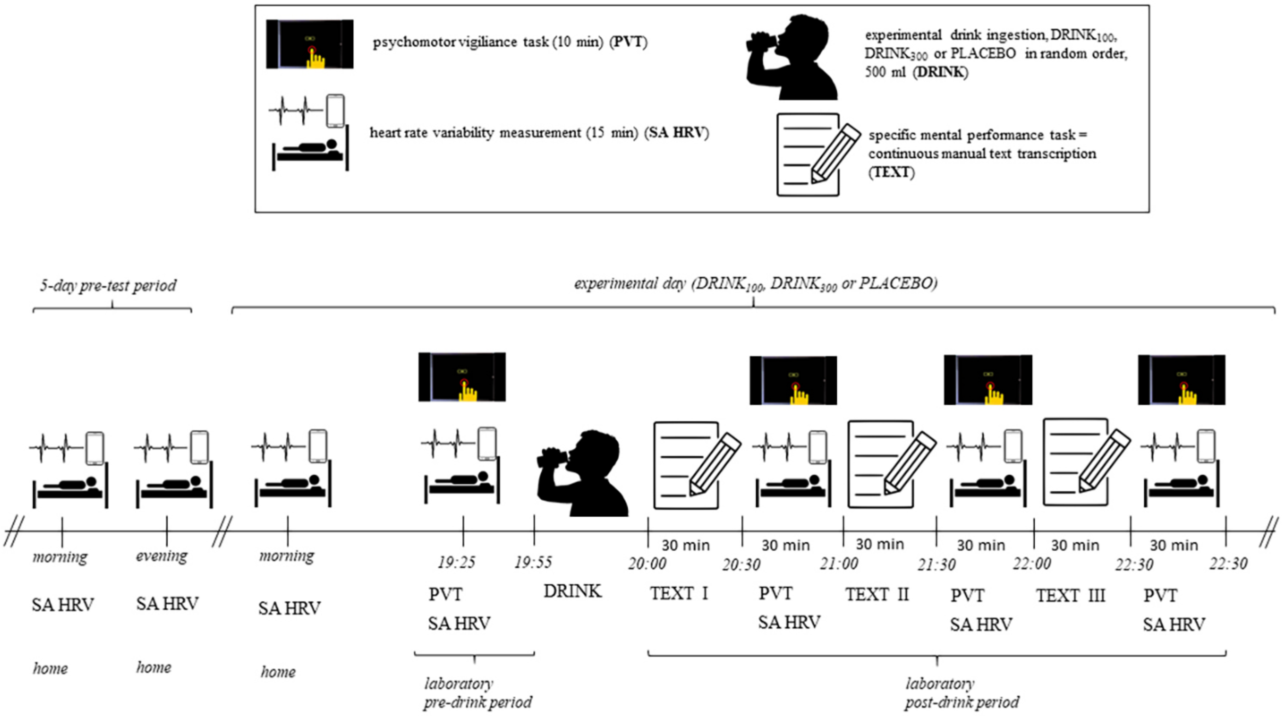

Figure 1 *Illustration of the experimental design*

Statistical analysis

The results of PVT are presented as a median of the “overall score” parameter (the ratio between correct reactions and delayed reactions.) in order to take into account, the high degree of inter-individual variability (mean CV in the overall score 9,75 ± 3,9%). To show ANS changes, total power was used to show total spectral power that reflects the overall autonomic activity. Due to the high variability of baseline total power values in individual probands, the relative change in ANS activity was evaluated between successive measurements. The number of words transcripted was used as a marker of a specific mental performance task. Analysis of variance with repeated measurements was used to detect the time and the groups’ differences. This method tests the consistency of mean values for recurrent measurements, including the detection of statistically significant changes. Effect size is described using Cohen´s d coefficient.

Results

Vigilance decreased during the first hour after the testing began. A $DRINK_{300}$ increased alertness as depicted by the ratio between correct reactions and delayed reactions and maintained the condition until the end of the testing period (Figure 2). No significant time interaction was found in either experimental situation. However, a significant effect of $DRINK_{300}$ on the difference between the overall score over $DRINK_{100}$ was evident in 150–180 min post-drink period ($p = 0,005$). The effect of $DRINK_{300}$ is consistent as the interindividual CV in the 150–180 min post-drink was the lowest (5 %) in comparison to the $DRINK_{100}$ and PLA (14% and 11%, respectively).

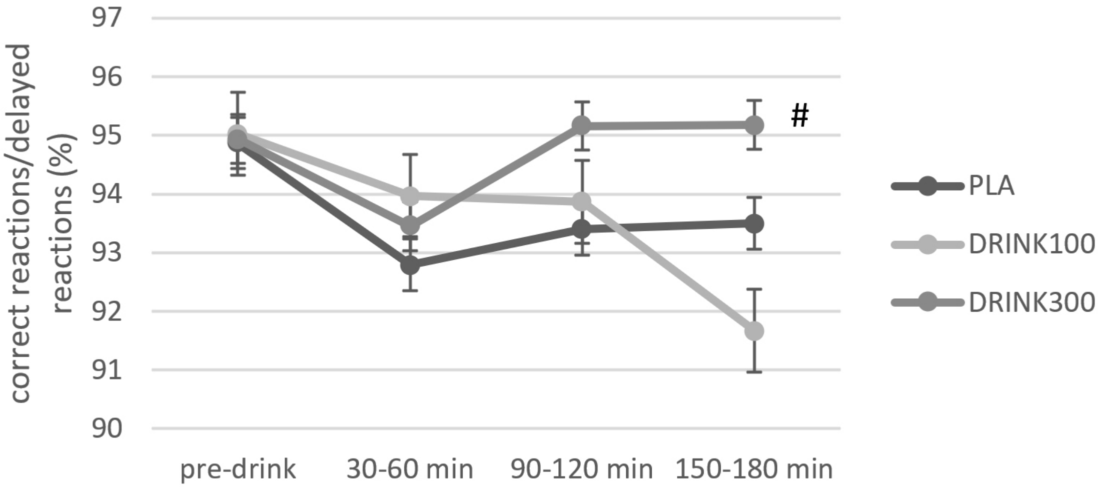

Figure 2 *Overall score in PVT 30-180 min post-drink (ratio between correct reactions and delayed reactions) (%) (no significant time interaction was found; # significantly different from DRINK$_{100}$)*

After 180 minutes, the number of transcribed words decreased in all experimental situations (Figure 3). The effect of drink consumption on the cognitive work done (amount of words transcripted) did not appear immediately after the drink was consumed as there was no difference between situations. Throughout the post-drink period (3 h), DRINKS$_{100,300}$ increased the performance at 60–90 minutes after consumption, with clear but not-significant effect especially at the DRINK$_{300}$ dose over PLA and DRINK$_{100}$ (p = 0,09 and 0,08, respectively). No significant time effect was found, but the trend was strong for DRINK$_{300}$ (p = 0,05).

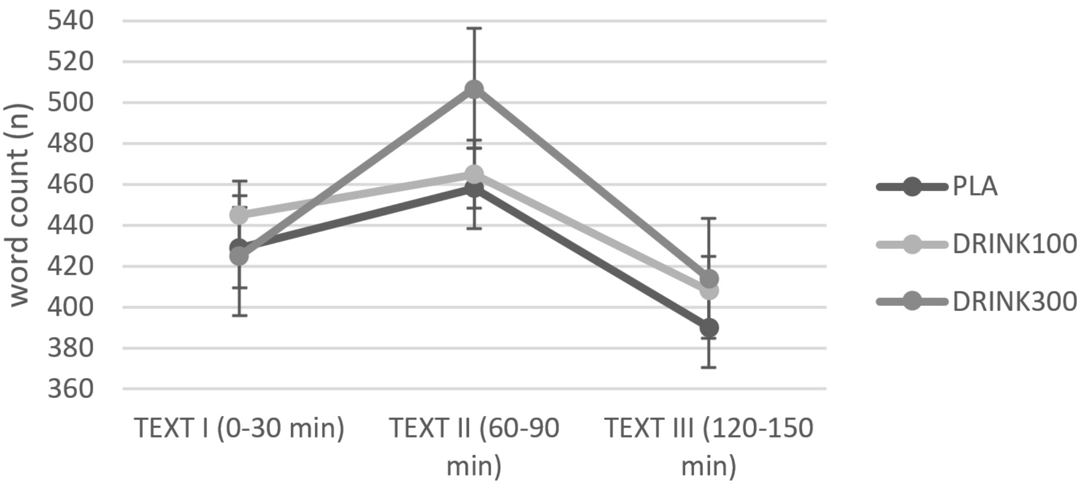

Figure 3 *Total word count during the post-drink manual text transcription*

Figure 4 shows the difference in spectral power at 30–180 min post-drink. The results show a trend in the influence of DRINK$_{100}$ and DRINK$_{300}$ on the overall spectral performance of participants. This is mainly due to the extreme increase in the activity of the autonomic nervous system after serving the drink and maintaining it for about 90 minutes after use. Placebo has no significant impact. The differences are not statistically significant (p_{PLA} = 0,92; p_{100} = 0,41; p_{300} = 0,26). Interpretation of effect sizes (Cohen´s d) can classify small effect of 100% and 300% (d_{PLA} = 0,28; d_{100} = 0,35; d_{300} = 0,38).

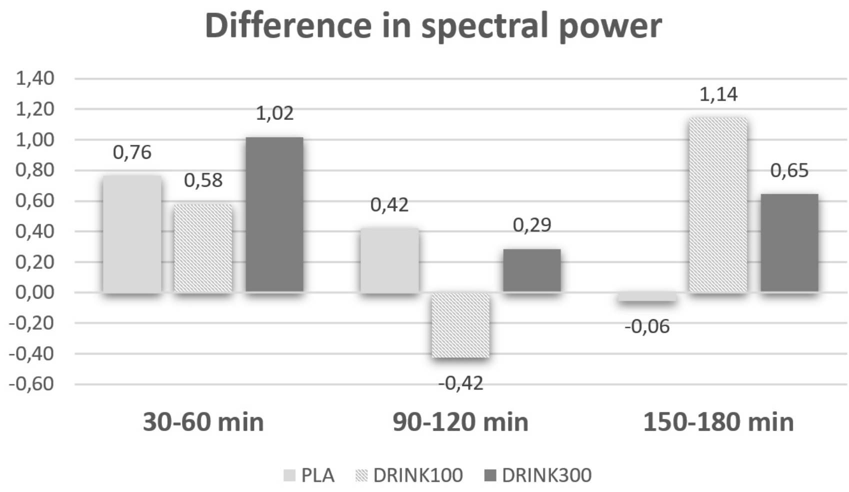

Figure 4 *Differences in ANS spectral power during the post-drink period*

Discussion

We aimed to assess the acute effect of commercially available non-energetic herbal blended drink on selected parameters of cognitive performance. The ecologically valid methodology with the drink administration was set at 20:00 p.m. and the post-drink period ended at midnight was intentionally used to mimic the typical time of the drink consumption by the vulnerable groups (eg. students, drivers, managers, etc.). We used standardized PVT test to detect cognitive impairments, continuous manual text transcription to measure real-work performance and ANS activity measurement. Most importantly we demonstrate an immediate dose-effect of caffeine-containing non-energetic beverage on cognitive and ANS performance.

An important aspect of caffeine-containing drink consumption is the health aspect. Mayo Clinic experts draw attention to the acute effect of such beverages on heart rate, blood pressure without changes in heart rhythm. They conclude that there is no link between long-term caffeine consumption and the risk of hypertension, and cardiovascular disease in the case of consumption of coffee and other sources of food caffeine (Higgins, Tuttle, & Higgins, 2010). Similarly, EFSA reports a safe daily dose of the caffeine of 400 mg/day and a single 200 mg dose („Scientific Opinion on the safety of caffeine", 2015). In our research, 0, 395 and 1185 mg of guarana (equivalent to ~0, 40 and 120 mg of caffeine) were administered.

The vast majority of studies, with 50–250 mg of caffeine to be usually administered, show a positive effect on cognitive abilities. The effect always occurs after a single, acute use, with an effect lasting up to several hours, with a different time effect after administration (Heatherley, Hayward, Seers, & Rogers, 2005; van Duinen, Lorist, & Zijdewind, 2005).

The effect of guarana is not only explained by caffeine, but a possible synergistic action with other ingredients such as ginseng is questioned. Kennedy, Haskell, Wesnes, & Scholey (2004) administered 75 mg guarana and/or 200 mg ginseng and observed the acute effect of the administered active ingredients 1-6h after administration on various computer-controlled cognitive abilities (similar to PVT). The positive effects of an acute dose of ginseng on cognitive abilities and mood 1–6h after administration was first presented by Kennedy, Scholey, & Wesnes (2001). The authors administered higher doses and observed a beneficial effect already at doses of 200 mg in attention and response rate indicators and the effect persisted for up to 6 hours. In the research, 0 and lower doses of 45 mg or 135 mg were administered. The acute effect of schizandra on attention (standardized d2 attention test) at 100mg, ie the amount corresponding to the dose administered by us (55 or 165 mg) was observed 2 hours after administration of the combined plant extract (Aslanyan et al., 2010). A synergistic effect of caffeine on cognitive abilities has also been observed with L-theanine, the active ingredient with similar effects to caffeine, present in green tea such as Matcha tea, at a dose of 50 mg caffeine and 100 mg L-theanine (Owen, Parnell, De Bruin, & Rycroft, 2008). L-theanine interferes with the production of dopamine and serotonin, known as fatigue inducers.

A high rate of delayed or premature reactions in PVT as the testing period progressed indicates lower alertness, intense concentration, fatigue and possible sleep deficit (Table 1). The *time × lapsus* effect was positively correlated ($r = 0,85$). Caffeine was shown to improve concentration and motor coordination. The desired effects persist for about three to four hours (Nehlig, 2010) which was confirmed by the effects of DRINK$_{300}$ in a reduction of cognitive performance impairment seen as the post-drink time progressed. The average number of lapses in PVT within 3h post-DRINK$_{300}$ discontinue to increase in contrast to the DRINK$_{100}$ and PLA and was significantly lower (10,1 vs. 14,2 and 13,4, respectively) ($p < 0,01$).

Table 1 *Correct and delayed responses in PVT (average)*

PLA		Correct (n)			Lapsus (n)		
		DRINK$_{100}$	**DRINK$_{300}$**	**PLA**	**DRINK$_{100}$**	**DRINK$_{300}$**	
Pre-drink		74,2	71,7	74,7	8,2	9,7	8,2
Post drink	*30–60 min*	70,3	72,2	70,6	10,3	9,8	8,6
	90–120 min	70,6	70,0	70,4	11,3	10,8	10,3
	150–180 min	69,0	67,1	72,5	13,4	14,2	10,1

Our results correspond with findings by Giles et al. (2012). The vigilance and the reaction ability test outcomes significantly improved 30 and 60 minutes after administration of 200 mg caffeine. Interestingly, there was no superior effect when glucose (50 g) was administered. The immediate effect of beverages, even without energy, was therefore predominantly mediated by effective stimulants (caffeine). This conclusion supports the positive properties of the glucose-free beverage.

Despite the fact that the number of words transcribed period decreased significantly towards the end of the post-drink period (180 min) from ~433 to ~404 words ($p = 0,003$), the DRINK$_{300}$ even improved the word-count and therefore specific mental performance by 19% in the 60–90 min post-drink (~507 words). This was strongly correlated with an overall score in PVT ($r = 0,69$) supporting the fact that a number of words method was sensitive enough in the determination of real cognitive performance. The effect of DRINK$_{300}$ on ANS does not correspond with the cognitive task. The DRINK$_{100}$ effect on total spectral power (expressed as the difference in two consecutive time-point measurements, eg. 30–60 min vs. 90–120 min) revealed the most prolonged stimulation of ANS as the spectral power increased.

The above discussion objectively justifies the inclusion of a combination of active substances and given dosages in the researched beverage as psychoactive effects of tested substances were widely confirmed. Besides, we may speculate to what extent the blended substances can interact and strengthen the effect as this remained to be established.

Conclusions

We demonstrate an acute, transitional dose-effect of multi-herbal caffeine-containing non-energetic beverage on cognitive and autonomous nervous system performance. The effect appears to be evident immediately (< 30 min) post-drink. A beverage containing guarana equivalent to 120 mg of caffeine reduce cognitive performance impairment and this is sustained over ~180 min.

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HIERARCHICAL CLASSIFICATION OF EXPERT MODELS OF EXERCISES DESIGNED TO ELIMINATE SPECIFIC MISTAKES OCCURRING IN SHORT SKI TURN

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Danijela Kuna[1], Matej Babić[1], Mateja Očić[2]

[1]*Faculty of Kinesiology, University of Split, Croatia*

[2]*University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia*

ABSTRACT

The aim of the present study was to examine the structure of an expert model of exercises designed to eliminate the *Lack of specific ski movement* mistake in short ski turn, as well as offer a hierarchical classification of the expert model. For this purpose, a two-stage research was conducted. During the first stage of the research the exercises with the purpose of *Lack of specific ski movement* mistake elimination were designed by 20 skiing experts aged 25 to 45. By means of email and coordinated by the paper author, the experts first designed a model of 14 methodical exercises and subsequently selected the five most relevant ones, ranking them on a scale from 1 to 5. A nonparametric chi - square test (χ^2) was used. The research showed there was no significant variation across the experts' evaluation of the five most important methodical exercises (χ^2 = 21,69; p = 0,06). The expert model of the most important methodical exercises for the *Lack of specific ski movement* mistake correction thus includes the following: *Holding a ski stick under the handle, Jump turns, Hands on hips, Unbuttoned ski boots and Ski poles in vertical position in forwards*. 307 skiing professionals of various levels of expertise participated in the second stage of the research, whose aim was to classify the *Lack of specific ski movement* mistake elimination exercises. The participants' task was to rank the exercises based on their relevance. Total amounts of rank sums (ΣR) were calculated, the Kruskal-Wallis test (H-test) was carried out, and the corresponding levels of significance (p) were recorded, for the purpose of comparing the significance of diversity between rank sums and the expert model. The statistically significant difference was found between the rank sums (ΣR) of the most efficient exercises for the *Lack of specific ski movement* mistake correction (H = 198,19; p < 0,001). The results obtained in the two stages of the research provide valuable insights regarding the methods of short ski turns. The hierarchical classification of the most important methodical corrective exercises obtained from ski teachers and professionals with different levels of education and expertise yields accurate and precise data about corrective methodical exercises in the process of studying short ski turn. Any further research regarding the same object should evaluate the designed expert model of the most important methodical exercises, as well as their hierarchical classification, across different groups of participants.

Keywords: Expert evaluation; alpine skiing; methodical exercises; short ski turns

Introduction

The successful performance in alpine skiing depends on the quality and the nature of the skiing equipment used, but mostly on the level of skiing education, experience and way of teaching employed by skiing experts. The skiing skill acquisition can be defined as the process of systematic adoption and perfection of specific structure of dynamic movement, with the aim of efficient performance in various conditions and types of ski slopes. Ski school programmes are especially significant in the process of alpine skiers' instruction and training. The principle of progression in ski schools means that learners shift from easy activities designed to guarantee safety and progression towards the more advanced skills, for example, from the snow plough to the parallel ski. The skiing school programme models enable and accelerate the process of skiing skill acquisition (Jurković & Jurković, 2005; Matković et al. 2004; Lešnik & Žvan 2010). The basis of the programme facilitates the adoption of various techniques of alpine skiing and secures the gradual progress of skiing skill acquisition. All the mentioned factors are the result of specific divisions and formations of different skiing school programme models (Feinberg-Densmore, 2000; John, 2006; Murovec, 2006; Anderson, 2007; Puškarić, 2010; Božidar et al. 2010). In relation to the mentioned and with the aim of rational performance and lower energy consumption, the skiing elements and methodological exercises should follow one another in a logical methodological order (Franjko, 2007; Kuna et al. 2013). Furthermore, when coordinating actions, good skiers use optimal amount of energy for transit across a slope compared to those with lower levels of skiing expertise (Bucher et al. 2014; Maleš et al. 2013). Moreover, good skiers require less energy in order to perform any of these elements than the skiers of lower skiing proficiency level. Skiing technique changes also depend on the skier's fitness level, such as the ability to produce power by the upper and lower limbs, equipment and snow quality, height and weight, as well as tactical aspects and individual preferences based on earlier experience (Hausken, 2017.)

The key factor in the process of skiing skill acquisition and advancement is professional and high-quality guidance provided by ski experts, teachers and instructors. To be able to provide adequate instruction, a skiing teacher or trainer should be highly knowledgeable in skiing theory and practice. Not only that, but he/she should also understand the methodological and didactic principles of training process as well as the basics of psychology. We must accept the fact that potential students differ substantially regarding the level and the degree of anthropological abilities and personal traits (Emeterio & González-Badillo 2010; Malliou et al. 2004). To be able to plan and execute an adequate training process ski instructors should acknowledge the athletes' diverse maturity levels and growth rates, especially so as to prevent late maturing athletes from sustaining injuries (Müller, Hildebrandt, Müller, Fink et al., 2017). Therefore, it is essential that skiing teachers and instructors understand the dynamics of motor skills acquisition process and other concepts pertaining to motor development. Without these preconditions, skiing instructors will not apply an adequate teaching method, which may decelerate the learners' progress or even be dangerous.

All this applies to short ski turn acquisition, which is taught in Croatian advanced skiing school programme. Short ski turn is a dynamic technical element, which primarily consists of pronounced creasing and stretching of the body with minimal rotation of the trunk, and almost constant skiing on the edges of the skies. The second important matter is constant control of speed, which is done by dynamic and rhythmic turn shifting, from the right side to the left side. Constant shifting between sides is enabled by means of lateral deflections of the body. Indeed, turning produces centrifugal force, which leads to an increased effective weight of the skier and hence higher normal reaction and friction forces compared to the case of fall-line gliding. As the centrifugal force depends on the speed and local radius of the skier's trajectory, it varies during the run and its overall effect cannot be estimated easily (Komissarov, 2018.). Short ski turns are an exception in that case because every turn is approximately equal, so the skier can efficiently control the speed. The pressure translocation from the forefoot (at the beginning of the turn) towards the heel (at the end of the turn) is still a feature of short ski turn (Falda-Buscaiot et al. 2017). The variables of the ideal-carving equation are the velocity of the skier, the angle between the trajectory of the skier and the horizontal, and the instantaneous curvature radius of the skier's trajectory (Jentschura & O`Fahrbach, 2003.).

Previous research on the matter (Kuna, 2013) has defined the expert model for teaching dynamic short ski turns, the typical mistakes occurring in the process, and the most important exercises used for their elimination. Research on the matter is aimed at a detailed elaboration of methodical approach to short ski turn instruction to improve the quality of the acquisition process.

Since one of the typical mistakes in short ski turns is *Lack of specific ski movement,* this research had two objectives: a) To form an expert model of the most important corrective methodical exercises used for the elimination of the *Lack of specific ski movement* mistake, manifested through the execution of short ski turn, b) To form a hierarchical classification of expert models of most important exercises for elimination of the *Lack of specific ski movement* mistake through execution of short ski turn.

Methods

- *Participants and procedure*

Data was collected in order to form an expert model of the most important corrective exercises used for *Lack of specific ski movement* mistake elimination; a mistake that most often occurs during the execution of short ski turn. The sample comprised of twenty state ski demonstrators. There were eight ski demonstrators from Croatian team, six ski demonstrators from Slovenian team and six from Bosnia and Herzegovina team. Following the request of the research authors, and with the approval of the president and the members of the executive council of HZUTS Croatia, ZUTS Slovenia and ATUS Bosnia and Herzegovina, the state ski demonstrators agreed to take part in designing the expert model for elimination of the *Lack of specific ski movement* mistake; a mistake that occurs during the execution of short ski turn. Participation requests were sent to the participants via email, along with the descriptions of each of the elements and their role in the research. The experts devised a model of the most important corrective methodical exercises for the *Lack of specific ski movement* mistake elimination. They had to choose between fourteen corrective exercises which are: *Short turn to one side - STOS, From snowplough turn cross to the short ski turn - FSTCST, From parallel ski turn cross to the short ski turn - FPSTCST, Short ski turn in sideling direction - STISD, Hands on hips - HOH, Ski poles behind in the back - SPBIB, Ski poles in vertical position with arms forward - SPIVPAF, Hands on the thighs - HOT, Switching the ski poles around the body - STSAB, Ski poles in parallel position with arms in forwards - SPPAF, Unbuttoned ski boots - USB, Jump turns - JT, Sting both ski poles under the outside ski - SBSPUOS, Holding a ski poles under the hands- HSPUH.*

Once the expert model was defined, the participants were asked to select/highlight the five most important corrective exercises. In order to make the process more transparent and allow the participants to distinguish between different elements, all exercises were filmed and converted into GIF format. Next, an online poll was created and sent to all participants from the second stage of the research. The sample comprised of four hundred and sixty ski teachers with various levels of expertise from Croatia, Slovenia and Bosnia and Herzegovina. They were required to take the poll, answering all the questions, as well as send their personal data and IP addresses. Having been carefully examined, three hundred and seven results were used in further data analysis. Thus, the final sample of participants consisted of one hundred and eighteen Croatian, one hundred and nine Slovenian and sixty Bosnian ski teachers, aged twenty-five to forty-five.

- *Sample of variables and statistical analysis*

A sample of variables was defined in the first stage of the research, with the expert model of most important corrective exercises used for the *Lack of specific ski movement* mistake elimination consisting of: *Holding a ski stick under the handle, Jump turns, Hands on hips, Unbuttoned ski boots and Ski poles in vertical position in forwards*.

The participants' task was to rank the exercises based on their relevance. The significance level was set to $p < 0,001$. Total amounts of rank sums were calculated, the Kruskal-Wallis test (H-test) was performed, and the corresponding levels of significance were recorded with the purpose of comparing the significance of diversity between rank sums and the expert model**.** Experts first designed a model of 14 methodical exercises and subsequently selected the five most relevant ones, ranking them on a scale from 1 to 5. For the purpose of it nonparametric chi - square test (χ^2) was used. Data analysis was completed with the help of “Statistica Windows 12.0“ program.

Results and Discussion

Table 1 shows total values of the most important corrective methodical exercises ranking. Based on the results, it can be said that although there is no statistically significant difference, the numbers come very close to statistical significance, in the evaluation of five most important corrective methodical exercises for the *Lack of specific ski movement* mistake elimination among the choices made by experts. The reason for this might be the fact that the experts defined too wide a spectrum of methodical exercises which have specific values and contributions to the *Lack of specific ski movement* mistake elimination, so the distribution of their values was dispersed. Nevertheless, according to the results gained from the experts' evaluation of five most important corrective exercises, certain corrective exercises are of higher frequencies. In other words, they were selected more often by the experts than other exercises. And the main reason for this is their collective contribution to the elimination of the *Lack of specific ski movement*; a mistake typically occurring during the execution of short ski turn.

Table 1 *Expert evaluation of the most important corrective exercises used for the elimination of the* ***Lack of specific ski movement*** *mistake occurring during the execution of the short ski turn. Observed (OF) and expected (EF) frequencies of expert evaluation for corrective exercises, value of Chi-square test ($\chi2$) and level of significance (p)*

The most important corrective exercises for the *Lack of specific ski movement* mistake elimination	**OF**	**EF**
STOS	3	4,28
FSTCST	3	4,28
FPSTCST	3	4,28
STISD	2	4,28
HOH	8	4,28
SPBIB	1	4,28
SPIVPAF	8	4,28
HOT	4	4,28
STSAB	4	4,28
SPPAF	1	4,28
USB	6	4,28
JT	9	4,28
SBSPUOS	2	4,28
HSPUH	6	4,28
	χ^2 = 21,69 **p = 0,06**	

By analysing the five most important corrective methodical exercises for the *Lack of specific ski movement* mistake elimination, it becomes clear that the exercise with the highest value is *Jump turns.* The goal of the exercise is to jump from one side to the other, which requires the skier to perform an accentuated vertical motion with a squat. This action can reflect the skier's jump and movement at the same time and set the skis in the direction of the new turn.

The second most relevant exercise according to the expert evaluation of the most important corrective exercises for the *Lack of specific ski movement* mistake elimination is the exercise called *Ski poles in vertical position with arms in forwards* and *Hands on hips*.

During the execution of short ski turns with the help of the *Ski poles in vertical position with arms in forwards* exercise, the skier should be focused on rhythmic and proper timing of ski movement, especially when it comes to vertical and circular moves, as well as maintain the correct gravity centre. These are the main elements that determine the rhythm and the direction of the skier's course. To perform short ski turns in succession, a skier needs to hold his ski sticks vertically in front of him and establish a controlled upright position of the upper body while constantly controlling the speed and the direction. These are the preconditions for the execution of specific ski movements. During the execution of short ski turns with the help of the *Hands on hips* exercise, the skier again has to establish and maintain the correct centre of gravity, and have absolute control of the direction which determines the execution of specific vertical, lateral and circular ski movements.

All the points presented above account for the expert evaluation of those exercises in greater frequencies when it comes to the elimination of the *Lack of specific ski movement* mistake occurring during the execution of short ski turns.

In the third position of expert evaluation of the most important corrective exercises for the *Lack of specific ski movement* mistake elimination is the exercise called *Unbuttoned ski boots* and *Holding a ski poles under the handle.*

During the execution of short ski turn with unbuttoned ski boots, the skier needs to perform a specific ski movement because unbuttoned ski boots do not allow the same movement as skiing with buttoned ski boots. Accordingly, for the skier to move in desired direction and speed, he needs to perform specific short ski turns, otherwise the technique will be incorrect, and the desired direction and speed will not be achieved.

During the execution of short ski turn while holding ski sticks below the holding grip, the skier lowers his centre of gravity, which means that he should perform vertical movements in short ski turns, but also circular and other specific ski movements.

Table 2 *Rank sum of the evaluation of the most efficient corrective methodical exercises for the elimination of the* ***Lack of specific ski movement*** *mistake made during the execution of short ski turn, Kruskal-Wallis test (H-test) and level of significance (p)*

The most efficient corrective exercises for the *Lack of specific ski movement* mistake elimination					
	USB	**SPIVPAF**	**HOH**	**JT**	**ΣR**
USB					628
SPIVPAF	0,00				774
HOH	0,00	1,00			755
JT	0,00	0,00	0,00		1055
HSPUH	1,00	0,00	0,00	0,00	628
H = 198,19**; p** < 0,001					

The analysis of rank sum values for most efficient corrective methodical exercises, obtained from ski teachers with different levels of education (N=307), applying the H-test and p values, shows that there are statistically significant differences (Table 2).

By means of non-parametric post-hoc analysis, it has been found that there is significant difference (p = 0,000) between rank sums of the following methodical corrective exercises: *Unbuttoned ski boots, Ski poles in vertical position with arms in forwards, Hands on hips* and *Holding a ski poles under the handle.* Also, there is statistically significant difference (p = 0,000) between the variables: *Ski poles in vertical position with arms in forwards*, *Jump turns* and *Holding a ski poles under the handle*, as well as between variables: *Hands on hips*, *Jump turns* and *Holding a ski poles under the handle* and between *Jump turns* and *Holding a ski poles under the handle.*

According to the differences between rank sums of corrective methodical exercises as assessed by ski teachers of different levels of education, a hierarchical classification of selected exercises was formed. The corrective methodical exercise with the highest value in efficiency pertaining to the *Lack* *of specific ski movement* mistake elimination is the *Jump turn.* The assessment carried out by ski teachers with different levels of education confirmed the relevance of this exercise as assessed by the experts. The reason for this are the accentuated vertical movements that are required in performance of the exercise *From one side to the other short ski turns. Holding ski poles under the handle* and *Unbuttoned ski boots* are the exercises ranked as second in relevance. The third place belongs to *Ski poles in vertical position with arms in forwards* and *Hands on hips* exercises.

The hierarchical classification of expert models of exercises used for the elimination of typical mistakes made during the execution of short ski turn shows that the exercises of the highest rank are the ones that involve vertical and circular movements, dominant in short ski turn performance. The exercises that involve an upright position of the upper body are of the lowest rank. These exercises are performed without ski sticks because the skiers are required to focus primarily on body movements and skiing rhythm. What needs to be pointed out is the lack of circular and vertical movement, very common among skiers, especially the unexperienced ones. Many skiers do not understand or do not practice the difference between short ski turns, dynamic parallel turns and carving turns, which needs to be improved. In comparison to other sports, very little research has been conducted for the skiing instruction methods. Most researches in alpine skiing are based on the expertise of skiers racing performance (Decroix et al 2017; Černohorski & Pustovrh, 2008). A better understanding of the differences across certain skiing techniques would allow the skiers to gain more experience on ski tracks and reduce their chances of getting injured. The implication for training instructors is that the skills of adapting these five methodical corrective exercises for the elimination of typical mistakes made during the execution of short ski turn aspects to meet individual needs every skier and should also be given due consideration alongside the technical skiing skills.

Conclusion

The results obtained by the research provide a very accurate and valuable insight regarding the most efficient corrective exercises for the elimination of the *Insufficient ski movement* mistake manifested through the execution of short ski turn. In addition to that, we presented the results of the efficiency of expert model of certain corrective exercises in skiing instruction. The hierarchical classification of expert model of most important corrective exercises for the mentioned mistake elimination will help teachers and instructors in the training processes planning and programming. Due to the thriving numbers of recreational and competitive skiers, there is a growing need for precise definition of appropriate exercises to employ in skiing instruction and training to make it as efficient as possible.

We need to consider the fact that most skiers have limited time to spend in instruction, mostly because of the costs included as well as their own everyday activities that prevent them from doing so. These circumstances bring about new challenges for us; namely the need to optimize the skiing instruction and the process of skiing skill acquisition. The beginners often stay on elementary level, because they perceive the advanced techniques as too complicated. The answer to this problem might be to conduct more research on the matter and consider the implications for practice change. This research represents only a part in a sequence of scientific papers with the purpose of forming a hierarchical classification of expert models of most important corrective exercises manifested in all skiing techniques. This fact will determine the direction of our future research as well, to finally arrive at the optimal hierarchical classification which would then be an undeniable methodical foundation for skiing instruction employed across the world.

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Contact Information:

Danijela Kuna, PhD.

University of Split Faculty of Kinesiology

Teslina 6,

21000 Split, Bosnia

Tel: 00387 (063) 524533

E-mail: dankun@kifst.hr

BASIC MOTOR COMPETENCIES IN THE 1ST AND 2ND GRADE ELEMENTARY SCHOOL CHILDREN IN SLOVAKIA

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Peter Mačura[1], Anna Blahutová[1,2], Andrej Hubinák[1], Ján Koštial[1], Peter Krška[1], Nadežda Novotná[3], Jaromír Sedláček[4,1], Mária Hulinková[1]

[1]*Department of Physical Education and Sports, Faculty of Education, Catholic University in Ružomberok, Slovak Republic*

[2]*Department of Outdoor Sports and Swimming, Faculty of Physical Education and Sports, Comenius University in Bratislava, Slovak Republic*

[3]*Department of Pre-school and Elementary Education, Faculty of Education, Catholic University in Ružomberok, Slovak Republic*

[4]*Department of Sport Kinantropology, Faculty of Sports, Prešov University in Prešov, Slovak Republic*

ABSTRACT

A number of youth movement activities, e.g. running, walking, jumping, climbing trees, throwing and catching a ball, has been on a decline in the current European cultural space. The results of this research contribute to broadening the knowledge about the level of basic motor competencies and qualifications of the 1st and 2nd grade elementary children in the Slovak Republic. The primary data on the basic motor competencies and qualifications of the examined group (n=307, age = 7.58 ± 0.69 years) were collected by means of the MOBAK 1–2 test battery (Herrmann et al., 2018b). The significance of differences between boys (n=156, age 7.62 ± 0.69) and girls (n=151, age 7.55 ± 0.70) was evaluated by Student's t-test in two independent groups. The boys in the first grade (n = 97) achieved a significantly better performance in basic motor competency object movements ($\overline{x}$ = 5.17 ± 1.79 points) than their female peers (n=88, $\overline{x}$ = 3.52 ± 1.78). The girls in the second grade did not achieve a statistically better performance in the movement qualifications in throwing, balancing and rolling than the first-graders of the same gender. Knowledge of the level of basic motor competencies and qualifications of the Slovak elementary school children allows the national and European educational and cultural authorities to design and improve the content of physical and sport education classes.

Keywords: basic motor competencies; first-graders; second-graders; elementary school; boys and girls; MOBAK 1-2 test battery

Introduction

Basic motor competencies are defined as functional performance dispositions, which guarantee that children are qualified to participate in sports and exercise (Herrmann et al., 2019).

Unfortunately, the current European culture foster the lifestyle with limited daily physical activities in almost all of its citizens regardless of their age and gender. For example, the parents drive their children to school by car every day and then continue to work. In both cases, they only carry out minimum motor activity. It is unthinkable for many Europeans to walk to school or walk to work...

A similar situation can be observed in children and adolescents. The several-hours-long unorganized physical outdoor activities after coming home from school are a thing of the past. The interest in physical activities organized by schools, sports clubs and non-profit organizations is on a decline. Many young people do not perform any physical activity at all.

Such a behavior has far-reaching society-wide health and economic impacts.

Herrmann and his colleagues (Herrmann et al., 2017a; Herrmann et al., 2018b) set the objective to map the level of basic movement skills and abilities in children of both sexes from kindergarten to the sixth grade of elementary school. They developed the MOBAK-KG test battery for kindergartens (Herrmann et al., 2019), MOBAK 1-2 for the pupils of the first and second grade elementary school (Herrmann and Seelig, 2014, 2017a; Herrmann et al., 2018a), MOBAK 3-4 for the third and fourth grade elementary school (Herrmann & Seelig, 2015; 2017b) and MOBAK 5-6 for the fifth and sixth grade elementary school (Herrmann & Seelig, 2016; Herrmann & Seelig, 2017c).

All four test batteries contain motor tasks targeted at demonstrating the level of children's skills in two areas:

1. object-movement tasks with ball and/or small ball control activities;
2. self-movement tasks with body control activities.

The first group of tasks includes the following tests:

1. throwing a ball at a stationary target;
2. different methods of catching a moving ball or small ball;
3. dribbling the ball by hand/hands;
4. dribbling the ball by foot/feet.

The second group of tests includes:

1. maintaining dynamic balance;
2. various rolling;
3. various jumping;
4. various types of movements (walking, running, shuffle stepping sideways …).

It is clear that the motor tasks in the test items copy a number of spontaneous activities of children:

1. in the yard, for example, the child throws and catches the ball bouncing off the wall, dribbles and kicks the ball;
2. in the nature, for example, the child balances while walking on a tree that fell over the stream, jumps over various natural obstacles, playfully crosses rugged terrain etc.

The creators of the MOBAK test batteries Herrmann & Seelig (2014, 2015, 2016) repeatedly reported that the sets of test tasks were also designed to identify talented children in sports games (ball or small ball control with upper and lower limbs) and select talented children for individual sports, such as athletics or gymnastics (body movement control). [1]

In addition to the methodological approaches, a number of researchers (Tuminaitè, 2016; Mačura et al., 2017; Vrbas, 2017; Herrmann et al., 2018b; Gerlach et al., 2018; Masaryková & Labudová,

1 The importance of examining the basic motor competencies and qualifications of children is also evidenced by the award of a two-year (2018–2019) Erasmus + grant titled *Basic Motor Competencies – EU* (BMC-EU, 2018) by the European Union.

2018; Quitério et al., 2018; Scheuer et al., 2019) have begun publishing the first results of children at the level of basic motor competencies and qualifications.

The main aim of our paper is to improve the understanding of the level of basic motor competencies and qualifications of the first-graders and second-graders in both sexes in the Slovak Republic with a vision of their potential comparison with the peers from other countries from the European Union and worldwide. We identified and compared the level of performance in boys and girls – first-graders and second-graders – at the level of basic motor competencies: object-movement and self-movement.

Method

The primary data on the basic motor competencies and qualifications of the examined groups (Tab. 1) were obtained by means of the MOBAK 1-2 test battery (Herrmann et al., 2018b).

The significance of differences was calculated and evaluated by Student's t-test in two independent groups (Vincent & Weir, 2012). The statistical analyses were done in Excel with the significance levels of $p \leq .05$ and $p \leq .01$. The testing was performed in the second half of the 2018/2019 school year in the period from January to May 2019.

Table 1 *Descriptive parameters of compared groups*

Grade	Gender	n	Decimal age ($\bar{x}$) [years]	Range [years]
1st	♂	97	7.21±0.41	6.31–8.26
1st	♀	88	7.04±0.40	6.33–8.31
1st	♂ + ♀	185	7.13±0.41	6.31–8.31
2nd	♂	59	8.30±0.43	7.22–9.34
2nd	♀	63	8.25±0.29	7.60–8.94
2nd	♂ + ♀	122	8.28±0.37	7.22–9.34
1st + 2nd	♂	156	7.62±0.69	6.33–8.94
1st + 2nd	♀	151	7.55±0.70	6.31–9.34
1st + 2nd	♂ + ♀	307	7.58±0.69	6.31–9.34

Results

Effects of age: As expected, the second-graders (♂ + ♀) had statistically better results both in the object movement and self-movement activities compared to the first-graders (Fig. 1, Tab. 2).

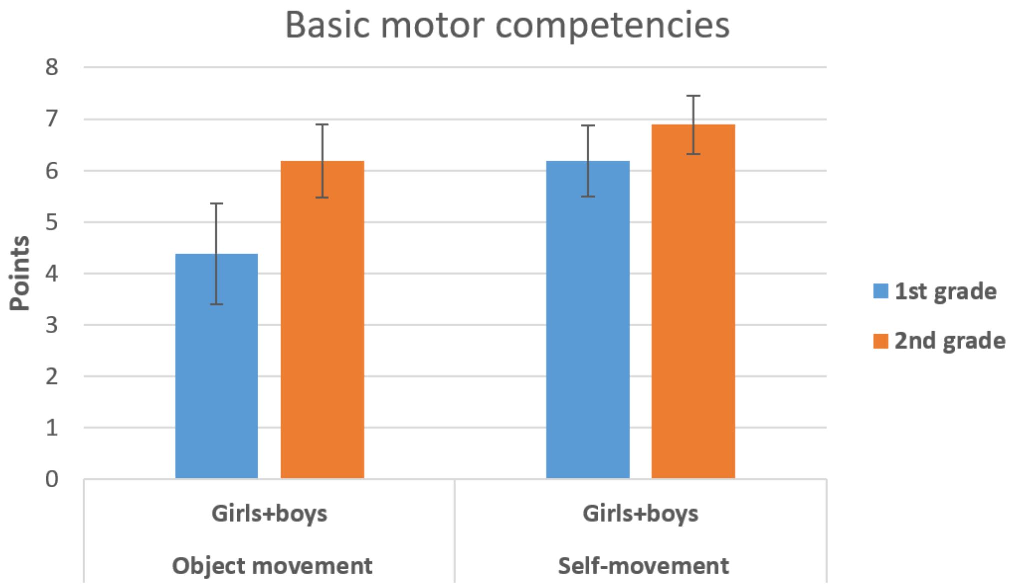

Figure 1 *Comparison of basic motor competencies between first-graders and second-graders in Slovakia*

Table 2 *Basic motor competencies of the compared grade groups regardless of gender (♂ + ♀)*

Grade	Object movement ($\bar{x}$) [points]		Self-movement ($\bar{x}$) [points]	
1st	4.38±1.96		6.19±1.38	
2nd	6.19±1.42	-9.361**	6.89±1.13	-4.679**

** p ≤.01

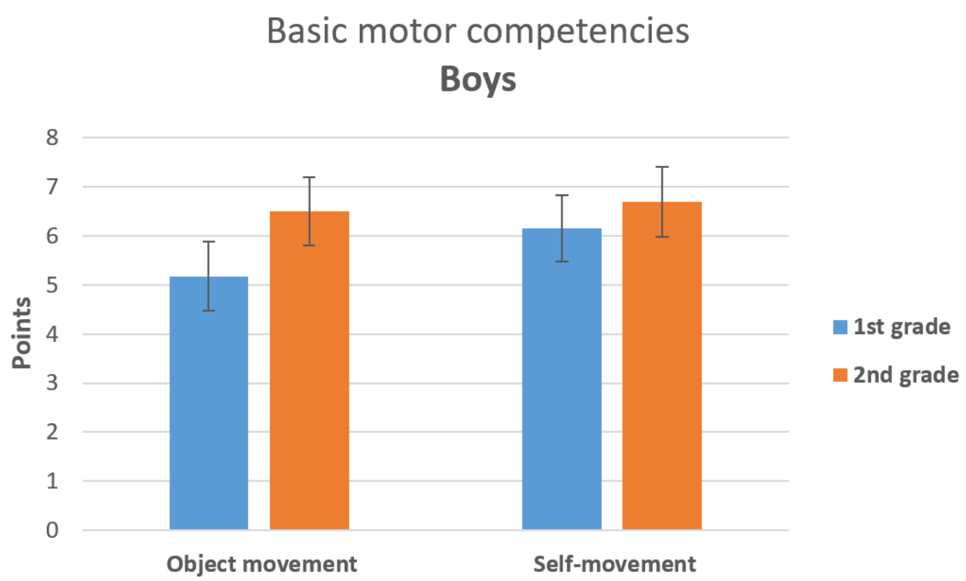

Figure 2 *Comparison of basic motor competencies between first-grade and second-grade boys in Slovakia*

The skill levels in second-grade boys in self-movement activities were indeed higher, but not by a significant margin compared to the first-graders (Fig. 2, Tab. 3). In the ball and small ball control activities (object movement activities) we found statistically higher levels in the second-graders than in the first-graders.

Table 3 *Basic motor competencies of the compared first-grade and second-grade boys*

Grade	Object movement ($\bar{x}$) [points]		Self-movement ($\bar{x}$) [points]	
1st	5.17±1.79		6.14±1.38	
2nd	6.49±1.43	-4.830**	6.68±1.32	-2.385

** p ≤.01

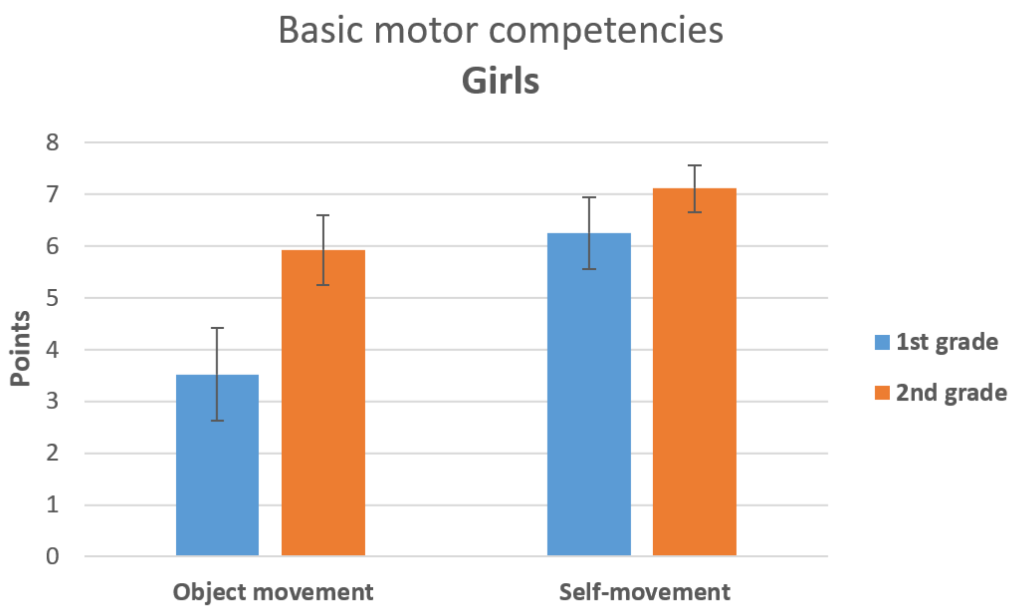

Figure 3 *Comparison of basic motor competencies between first-grade and second-grade girls in Slovakia*

The second-grade girls achieved significantly better results in both basic motor competencies than the younger first-graders (Fig. 3, Tab. 4).

Table 4 *Basic motor competencies of the compared groups of first-grade and second-grade girls*

Grade	Object movement ($\bar{x}$) [points]		Self-movement ($\bar{x}$) [points]	
1st	3.52±1.78		6.24±1,40	
2nd	5.90±1.35	-9.356**	7.10±0.89	-4.588**

** p ≤.01

Effects of gender: Unlike the boys, the older second-grade girls achieved significantly better performance compared to the performance of first-grade girls in movement tasks not only in object movement, but also in self-movement (Fig. 3, Tab. 4).

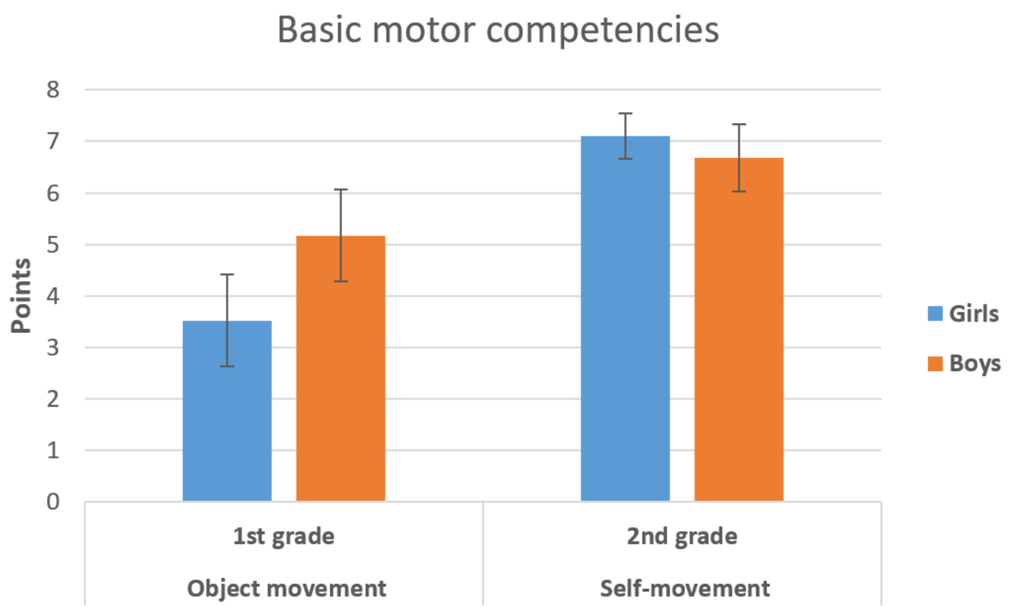

Figure 4 *Comparison of basic motor competencies between the girls and boys in Slovakia*

First-graders: Gender comparison. The first-grade boys had a significantly better performance in object movement than the first-grader girls. In contrast, we found better performance levels of the first-grade girls in self-movement compared to the first-grade boys, but they were not statistically significant (Fig. 4, Tab. 5).

Second-graders: Gender comparison. The second-grade boys were better in object movement activities (p ≤ 1%) compared to the second-grade girls. The situation reversed in the self-movement activities (Fig. 4, Tab. 5).

Gender comparison independent on age. By comparing all the girls and boys from the first and second grade, we found that girls are better at self-movement, but this difference is statistically insignificant when compared to the boys. In object movement, the boys were significantly better than girls (Fig. 4, Tab. 5).

Table 5 *Basic motor competencies of the compared groups of girls and boys in Slovakia*

Grade	Gender	Object movement ($\bar{x}$) [points]		Self-movement ($\bar{x}$) [points]	
1st	♂	5.16±1.79		6.14±1.38	
1st	♀	3.52±1.78	-6.259**	6.24±1,40	1.830
2nd	♂	6.49±1.43		6.68±1.32	
2nd	♀	5.90±1.35	-2.328**	7.10±0.89	-2.033**
1st + 2nd	♂	5.67±1.78		6.35±1.38	
1st + 2nd	♀	4.52±1.99	-5.338**	6.60±1.28	1.645

** p ≤.01

It is obvious that the Slovak first-grade and second-grade boys together are significantly more dexterous in the object movement activities than their female peers. Girls achieved better results in the self-movement activities, which were statistically significant only in the second-graders.

Discussion

When analyzing the testing period during the school year, we found that Herrmann et al. (2018b, p. 45) carried out their testing mostly in the months of October and November. Our testing was carried out in the months of January to May. The Slovak children were older in the testing period ($\overline{x}$ = 7.58 ± 0.69 years) compared to the German and Swiss children ($\overline{x}$ = 6.85 ± 0.42 years), which could be one of the reasons for the better results in basic motor competencies. One of the reasons for this older age of Slovak children during the testing period is the fact that Slovak parents may send their children to the first grade one year later based on the recommendation of the child's physician.

Table 6 *Comparison of basic motor competencies with Herrmann et al. (2018b)*

Grade**	Gender	*Object movement ($\overline{x}$) [points]	**Object movement ($\overline{x}$) [points]	Diff. ($\overline{x}$) [points]	*Self-movement ($\overline{x}$) [points]	**Self-movement ($\overline{x}$) [points]	Diff. ($\overline{x}$) [points]
1st	♂	4.49±1.97	5.17±1.79	0.67	4.83±1.82	6.14±1.38	1.31
1st	♀	3.00±1.78	3.52±1.78	0.52	5.02±1.87	6.24±1,40	1.22
1st	♂+♀	3.73±2.01	4.38±1.96	0.65	4.93±1.85	6.19±1.38	1.26
2nd	♂	5.26±1.95	6.49±1.43	1.23	4.89±2.03	6.68±1.32	1.79
2nd	♀	3.78±1.76	5.90±1.35	2.12	4.99±2.02	7.10±0.89	2.11
2nd	♂+♀	4.63±2.00	6.19±1.42	1.56	4.93±2.02	6.89±1.13	1.96
1st + 2nd	♂	4.77±1.99	5.67±1.78	0.09	4.85±1.90	6.35±1.38	1.50
1st + 2nd	♀	3.23±1.81	4.52±1.99	1.29	5.01±1.92	6.60±1.28	1.59
1st + 2nd	♂+♀	4.03±2.06	5.10±1.97	1.07	4.93±1.91	6.47±1.33	1.54

* Herrmann, Ch. et al. (2018b), ** this research

Tuminaitė (2016) did not find any link between gender and motor skills (n=129, 68 boys – 52.7%, 61 girls – 47.3%). She proposes a broader study to better examine the gender dimensions.

Greek boys (n=73) performed significantly better than girls (n=73) at throwing, bouncing and dribbling, while the girls outperformed the boys at rolling and side stepping. This makes us conclude that the boys were more successful in object movement activities than the girls. In self-movement activities, the success rate of the boys and girls was approximately identical. The second-graders scored significantly higher than the first-graders at catching, bouncing, dribbling and jumping in Greece (Gerlach et al., 2018; p. 83). Interestingly, the one year older children (boys and girls combined) did not achieve a significantly better performance in the self-movement activities such as balancing, rolling, side stepping and object movement activities such as throwing.

The independent sample t-tests revealed significant gender differences (n=204, age 6.7 ± 0.3). The Portuguese boys achieved a higher object movement score (5.7 ± 1.8) than the girls (4.0 ± 1.7). However, the girls were significantly more proficient in the self-movement skills (♂ **=** 5.3 ± 1.8, ♀ = 4.3 ± 1.7) than the boys (Gerlach et al., 2018; p. 88).

The boys (n=122, $\overline{x}_{age}$ = 6.3 years, s_d = 0.4) exhibited better object movement motor competencies than the girls (n=127, $\overline{x}_{age}$ = 6.2 years, s_d = 0.5; boys: $\overline{x}$ = 5.8, s_d = 1.7 points; girls $\overline{x}$ = 4.0,

s_d = 1.7 points; p ≤.001), while the girls were more proficient in the self-movement skills (girls: $\overline{x}$ = 5.1, s_d = 1.8 points; boys: $\overline{x}$ = 4.3, s_d = 1.7 points; p ≤.01) (Quitério et al., 2018). Finally, this study noted no significant links between age and motor competence. These age-related findings are probably explained by the fact that the analyzed population had a very small age range.

Herrmann et al. (2017a) found that age had a positive influence on object movement competency, but not on self-movement one.

The boys exhibited higher object movement motor competencies than the girls (boys: $\overline{x}$ = 5.8, s_d = 1.7; girls $\overline{x}$ = 4.0, s_d = 1.7; p ≤.001), while the girls were more proficient in self-movement skills (girls: $\overline{x}$ = 5.1, s_d = 1.8; boys: $\overline{x}$ = 4.3, s_d = 1.7; p ≤.01) (Quitério et al., 2018).

The validity of the comparisons is sometimes questionable because some authors do not provide accurate information on the children's age (Tuminaitè, 2016; Gerlach et al., 2018) or the school year period in which the testing was conducted (Tuminaitè, 2016; Gerlach et al., 2018; Quitério et al., 2018). Similarly, some authors divide the children into the groups by first- or second-graders, while others divide them according to age with no clear indication of their school grade. Herrmann et al. (2018b) stratifies the compared groups by age and not by the school grade although the test batteries were designed for specific elementary school grades, initially. These facts may be sometimes confusing when interpreting the results.

It is commonly known that some physical performance in sports is determined genetically, and its improvement is only possible through long-term, targeted and intensive training (Horička et al., 2018; Šimonek & Horička, 2020). Therefore, the results do not always confirm the prevailing experience that older children achieve better results than younger children.

Another area for future research is to observe the relation between body height and weight and the performance levels achieved in the motion tasks. Gerlach et al. (2018) found mixed results for BMI in MOBAK-1. Children (n = 923) with a high BMI achieved higher results in locomotion (p. 84). Future research holds the answers even to this question.

Conclusion

The following trends are slowly becoming obvious:

Gender: boys show a higher performance than girls in object movement activities (competency). The situation is inverse in the self-movement activities.

Age: second-graders do not achieve better performance than first-graders in all physical activities in the MOBAK 1-2 test battery. We believe that the performance in some of the tests in this test battery in first-grade and second-grade populations is determined by the factors independent of age.

When justifying the trends in basic motor competencies, a more detailed gender and age comparison of the basic motor qualities will be vital in the future.

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DIFFERENCES IN THE LEVEL OF BODY EQUILIBRIUM BY SEX IN EARLY SCHOOL-AGE CHILDREN

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Sanja Ljubičić, Ljubomir Antekolović, Vedran Dukarić

Faculty of Kinesiology, University of Zagreb, Croatia

ABSTRACT

Equilibrium represents the motor capability responsible for the performance of virtually all functional movements. Thus, the importance of early diagnosis of equilibrium levels in boys and girls was recognized as the key factor for the prevention of motor deficits and muscles misbalances later in life. *Purpose*: The purpose of this paper was to show the difference between boys and girls aged 7–10 years in the level of unilateral static balance of the take-off leg. *Methods***:** Research was conducted at the Kvarner Athletics Club Rijeka, and it involved 80 children aged 7–10 years (38 boys and 42 girls). Measurement of static unilateral equilibrium was obtained using Gyko Inertial System (Microgate, Bolzano, Italy). Three attempts were made in 20 seconds and two motor variables were observed: medio-lateral and antero-posterior trajectories of the body. For both variables, the arithmetic mean, the minimum and maximum score and standard deviation were calculated. Moreover, a non-parametric method of the Mann-Whitney U test was used to determine statistical significance between boys and girls. Statistical significance was set at $p < 0.05$. *Results*: Statistically**,** girls have significantly better results compared to boys, both in the medio-lateral trajectory variable (M_Sumg = 335.1, M_Sumb = 479.34) and the antero-posterior trajectory variable (M_Sumg = 291.14, M_Sumb = 411.71). *Conclusion*: The results of this study showed that girls aged 7–10 years achieved significantly better results compared to boys in observed motor variables (medio-lateral and antero-posterior trajectory of the body), when performing a static unilateral take-off leg balance test. These results are consistent with previous research. Indications for such results stem from different perspectives, among which the most common one refers to the earlier maturation of the systems responsible for postural control in female bodies. Recommendation for further research is to conduct examination on a larger sample of subjects, in younger children (pre-school age) and with both legs.

Keywords: static unilateral balance; early school-age children; take-off leg

Introduction

Quality diagnostics of motor capabilities is the foundation for planning and programing transformation processes. Considering the fact that equilibrium presents a motor capability responsible for the performance of all functional movements, the importance of its diagnostics has been recognized. The ability of maintaining balance presumes the central integration of information coming from several centres, primarily from vestibular system, visual system and various sensory cells from the periphery (Trošt Bobić, 2012). Riach and Hayes (1987) stated that children use visual information for equilibrium control differently than adults and they start approaching the similar use only after the age of 7. The key age for the development of postural control is between the ages of 1 and 7 (Nougier et al., 1998), while Reconsvalles et al. (2005) advocated the extension of that period to the age of 8 or 9. As mentioned by Sá (2018), ability to maintain stable position in children firstly occurred on the visual system, than proprioceptive and finally vestibular system, reaching functional maturity at nine years of age. Milanović (2003) has defined equilibrium as a capability which is manifested in establishing and maintaining the position of balance by successfully resisting the forces which distort it and can further be defined as dynamic and static equilibrium. The evaluation of equilibrium level is rarely conducted in athletic clubs, especially among early school-age children. The deficit in equilibrium level can hinder the performance of different motor performances, while muscle asymmetries can lead to injuries. By the use of timely diagnostics it is possible to act preventively, and consequentially, on the entire motor system through training process. The aim of this study is to present the differences between boys and girls between the ages of 7 and 10 years in the level of unilateral static balance of the take-off leg.

Methods

Sample of participants

The research included 80 children (38 boys and 42 girls) aged 7–10 years. The children were members of the Kvarner Athletics Club from Rijeka. The participants were measured in February 2018. Prior to testing procedure parents were informed about protocol and they gave written consent for their children.

Sample of variables

Two variables were used for the evaluation of equilibrium motor capability: the antero-posterior (AP) and the medio-lateral (ML) trajectory of the body (cm).

Measurement protocol

Prior to the testing, the participants had a 10-minute standardized warm-up which consisted of running, the athletic school of running and stretching and were also introduced to the testing protocol. Static unilateral equilibrium of the take-off leg was measured and Gyko inertial system (Microgate, Bolzano, Italy) was used to obtain data. For the purpose of system calibration, the height of the device was measured on participant's body. The take-off leg was determined during practices prior to the testing. Three attempts were measured, each lasting 20 seconds.

Data processing methods

Statistica 14.0 program package was used for data processing. Basic descriptive indicators were calculated and non-parametric method of Mann-Whitney U test was used for further analysis of differences between the groups.

Results

Table 1 shows the basic descriptive indicators (Mean, Minimum, Maximum, Std. Dev.) obtained from measuring the antero-posterior (AP) and the medio-lateral (ML) trajectory of the body. It is evident from the table that both boys and girls achieved the best results in the first attempt in both variables (ML_G_1 = 101.97, ML_B_1 = 150.20; AP_G_1 = 90.72, AP_B_1 = 130.78). The largest body oscillations in boys were in the third attempt in the ML variable (ML_B_3 = 165.35) and the AP variable (AP_B_3 = 149.67), while the largest oscillations in girls were noted in the third attempt in the ML variable (ML_G_3 = 117.95), and in the second attempt in the AP variable (AP_G_2 = 101.87). In minimum values girls achieved better overall values than boys in both measured variables (SUM_ML_ming = 116.76; SUM_ML_minb = 125.38; SUM_AP_gmin = 116,87; SUM_AP_bmin = 132.00). Both boys and girls demonstrated the smallest oscillations in the ML variable in the third attempt, and the largest in the second attempt (ML_2_ming= 37.66; ML_2_minb= 47.06; ML_3_ming= 33.63; ML_3_minb= 37.39). In maximum values, girls also achieved better total values than boys in both measured variables (SUM_ML_maxg = 1270.62; SUM_ML_maxb = 1846.36; SUM_AP_maxg = 1061.61; SUM_AP_maxb = 1245.18). The greatest changes in body stability were observed in boys in the third attempt in both variables (ML_3_maxb = 737.68; AP_3_maxg = 694.86) and in girls in the MP variable in the third attempt (ML_3_maxg = 659.65) and in the AP variable in the second attempt (AP_2_maxg = 569.30). Standard deviation, i.e. results variability in the ML movements in the first attempt in both sexes exhibited the lowest values (ML_G_1 = 59.23; ML_B_1 = 105.74). Also, the lowest results variability in the first attempt was noted in the AP movement in girls, while in boys it was in the second. Girls had less variability of results in every attempt and overall and also managed to maintain a more stable body position.

Table 1 *Descriptive statistics*

Variable	Descriptive Statistics							
	Me		Min		Max		Std.Dev.	
Sex	G	B	G	B	G	B	G	B
ML_1 (cm)	101.97	150.20	38.02	40.93	307.65	479.18	59.23	105.74
ML_2 (cm)	115.18	163.78	37.66	47.06	638.26	683.80	97.97	145.60
ML_3 (cm)	117.95	165.35	33.62	37.39	659.65	737.68	106.47	131.53
SUM_ML (cm)	335.10	479.34	116.76	125.38	1270.62	1846.36	214.40	362.31
AP_1 (cm)	90.72	130.78	32.96	45.47	259.86	461.84	49.25	79.95
AP_2 (cm)	101.87	131.26	38.00	50.63	569.30	330.48	83.73	69.11
AP_3 (cm)	98.56	149.67	35.68	35.90	476.07	694.86	71.58	110.49
SUM_AP (cm)	291.14	411.71	116.87	132.00	1061.61	1245.18	165.72	230.05

(M- mean, Min- minimum, Max- maximum, G-girls, B-boys, Std.Dev.-standard deviation, Sum-sumarum)

From Table 2 where Mann-Whitney U test was conducted it is evident that the values in both variables in concern are significant in all attempts. Girls achieved significantly better results ($p < 0.05$) in variables ML and AP in the test of unilateral equilibrium of the take-off leg in each of the positions but also in the sum of all three attempts (SUM_ML_U = 571.00; SUM_ML_Z = -2.18; SUM_AP_U = 426.00; SUM_AP_Z = -3.57924).

Table 2 *Mann-Whitney's U-test*

Variable	Mann-Whitney U Test (w/ continuity correction) (Balance) By variable sex Marked tests are significant at p < 0.05				
	Valid N	Valid N	U	Z	p-value
ML_1	42	38	544.00	-2.44	0.02*
ML_2	42	38	587.00	-2.03	0.04*
ML_3	42	38	542.00	-2.46	0.01*
SUM_ML	42	38	571.00	-2.18	0.03*
AP_1	42	38	430.00	-3.54	0.00*
AP_2	42	38	466.00	-3.19	0.00*
AP_3	42	38	389.00	-3.94	0.00*
SUM_AP	42	38	426.00	-3.58	0.00*

* Marked values show statistical significance of differences between groups of participants

Discussion

It is evident from the results in Table 1 that both girls and boys achieved the best results in the first attempt in variables ML and AP. It is also evident that in both variables (except in variable AP_2 in girls) the results became more and more variable with each attempt. This trend in results shows that children manage to maintain the stable body position in the initial attempts of the testing. Every subsequent attempt of maintaining/keeping equilibrium caused lesser concentration and body instability. Also, such results may indicate the occurrence of muscle fatigue. Muscle fatigue is defined as a decrease in the ability to produce force (Wan et al., 2017) and as such, it can hinder motor performances. Johnston et al. (1998) studied whether lower extremities fatigue influences the equilibrium of an individual. The sample included 20 healthy individuals aged 20–39 years. The analysis of the results of equilibrium before and after fatigue showed a significant decrease in performance in all participants. Similar results were obtained by Shimpi Apurva et al. (2014) from which they concluded that fatigue significantly influences the decrease in static equilibrium levels, dynamic equilibrium levels and lumbar core strength. In this research, a statistically significant difference was determined in equilibrium between sexes. Girls achieve significantly better results than boys their age (Smith, Wong and Ulmer, 2012; Lee and Lin, 2007; Nolan, Grigorenko and Thorstensson, 2005). The authors of such studies ascribe results to improved sensory integration (Steindl et al., 2006), advanced neuromuscular development (Eguchi and Takada, 2014), application of strategies for maintaining postural control more similarly to those used in the adulthood (Smith, Ulmer and Wong, 2012), earlier maturation of responsible systems (neurological, visual, vestibular, proprioceptive systems), which is related to precocious puberty (Alves Faco et al., 2013; Malina and Bouchard, 2002; Cratty, 1970) and differences in anthropometric characteristics (Dorneles, Pranke and Mota 2013; Lee and Lin, 2007; Rivas and Andries, 2007). Certain studies obtained different results than this study (Erkut Atilgan et al., 2012; Mickle, Munro and Steele, 2011), which indicates the need for further and more detailed research. Erkut Atilgan et al. (2012) explained the results in which boys achieve better results than girls through the possibility of boys being physically more active than girls, which positively influences equilibrium due to the enhanced muscle strength. It is certainly important to mention the notion of biological maturity, which might partly explain the obtained results of the research. Although it is a fact that in average, girls reach their biological maturity earlier than boys, which is also closely related to sensitive developmental phases of motor abilities and emotional control all of which makes the obtained results logical, equilibrium can still be defined as an exceptionally complex ability. The motor ability of equilibrium integrates psychological, physiological and biomechanical components which are used in every movement, on a conscious or an unconscious level (according to Roguljić, 2015).

Conclusion

The results of this study revealed that girls achieve significantly better results than boys in both motor variables observed (medio-lateral and antero-posterior trajectory of the body) while performing a static unilateral equilibrium test with a take-off leg in the age of 7–10 years. Although there are some studies which disagree with the findings of this study, the number of studies in accordance with the obtained results is significantly larger. The indications for such results start from different viewpoints and the most common refer to the earlier maturation of systems responsible for postural control. Besides for athletes, early diagnostics of equilibrium levels is also important for people who are not engaged in some form of organised physical exercise (sports clubs, fitness, etc.). As it was already mentioned in the text, every movement cannot be functional without an optimal equilibrium level. Therefore, by developing equilibrium one can act preventively, enable the development of other motor abilities and often use it for rehabilitation purposes. Further research should be directed towards the procedures of determining equilibrium levels in a larger sample of pre-school children. Furthermore, for the purpose of more detailed analyses it is necessary to observe the differences in sexes in equilibrium tests conducted by standing on dominant and non-dominant leg.

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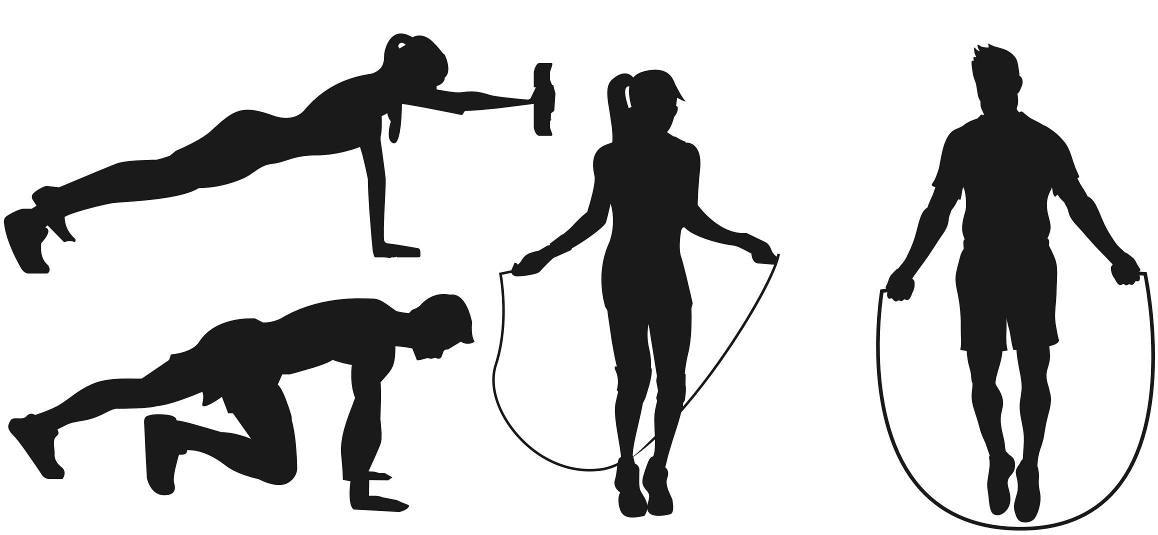
SPORT TRAINING, NUTRITION AND REGENERATION



INTENSITY OF SOCCER PLAYERS´ TRAINING LOAD IN SMALL-SIDED GAMES WITH DIFFERENT RULE MODIFICATIONS

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Nikolas Nagy, Miroslav Holienka, Matej Babic

Faculty of Physical Education and Sport, Comenius University in Bratislava, Slovak Republic

ABSTRACT

Purpose: The aim of this research was to make reference to the difference in heart rate values (HR) of soccer players in small-sided games (SSG) with different rule modifications. We assumed that the permitted number of ball touches in SSGs will significantly affect the internal load of participating soccer players' organism.
Methods: The experimental group consisted of older junior players (U19) from the FC DAC 1904 Dunajská Streda soccer club (n=6). The HR values were evaluated on the basis of collected data, which were obtained using sport testers and special software. In order to find out the statistical significance of the difference in HR the one-way ANOVA and the Bonferroni post hoc test was used. The level of statistical significance was set at 5%.
Results: We found out that by the change of the SSG rules, the internal reaction of players´ organism to training load was at different level. In the SSG1, where players were permitted only one ball contact during the SSG, the highest achieved average HR value of the monitored players' (160.08 ± 9.27 beats.min^{-1}) was recorded. This form of the SSGs was the most intense for the players' cardiovascular system. However, there were no significant differences in HR values among the different types of the SSGs.
Conclusions: Our recommendation is to employ small forms of SSGs (3 vs. 3) with different rule modifications in the systematic training process, because by the means of it we can adequately prepare the players for the real competitive match demands.

Keywords: soccer; training load; heart rate; rule modifications; small-sided games

Introduction

The constant development of contemporary soccer is also influenced by the quality of the systematic, long-term premediated and purposeful training process. Properly increasing the level of the training process brings about important questions for soccer coaches, including the appropriate optimization and suitable intensification of soccer players´ training load. In the mindfully designed training units of soccer players have an inevitable role the realization of small-sided games (SSG) with different modifications. During SSGs, it is possible to progressively raise the level of skill potential, tactical behaviour, fitness capacity and emotional intelligence of soccer players. Throughout the SSGs players need to solve a lot of variously complicated and complex game situations during time-space deficiency under active pressure of defensive player. The conditions in various forms of SSGs are really close to the competitive match conditions.

The aim of systematic training process is to help increase the adaptation capacity of player´s organism to the load, with which players are closely confronted in the game itself, or more precisely in the real match (Holienka, 2004). The training process need to focus on the creation of a specific adaptation change in the player´s organism, which is induced by purposeful repeated adaptation stimuli (Holienka, 2012). When the batching of training stimuli is proper, it contributes to the development, progressive increasing, stabilization and preservation of the training experience state, then can we note about the meaningful training load (Kačáni, 2005).

Holienka (2012) states that indicators of internal load, including the values of heart rate (HR), make it possible to determine the usefulness and effective level of training load during training units. These modern devices provide accurate feedback on actual reactions of the internal state of players´ organism to the training load. The HR values are widely accepted and frequently used physiological indicator of the players´ physical activity in the training units (Holienka, 2016). Nowadays the monitoring of HR become an inseparable part of the training load research in collective sports, such as in soccer, and many authors dealt with this issue in their research (Dellal et al., 2008; Halouani et al., 2014a; Randers et al., 2014; Köklü et al., 2015; Asci, 2016; Proietti et al., 2017; Babic & Holienka, 2018).

Sport testers give us immediate feedback on the reaction of player´s organism to the load (Benson & Connolly, 2012). Monitoring of HR values is to a large extent implemented in training units, which include different variations of SSGs. It is also widely used in youth soccer to gain and understand the physiological parameters of training units and real match load in different levels (Owen, 2016).

Holienka (1998) claims that the current required principle in systematic soccer training process – all with a ball – fulfills the game training (GT). The dominant position in it have different forms of SSGs, which include a wide range of situation that are similar to the real game situations during a competitive match. Systematic training activity of soccer players in sports games, like soccer should take into consideration the specific technical, tactical, physiological and psychological demands of individual game performance (Christopher et al., 2016; Zapletalová et al., 2017). Therefore, different variants of SSGs have become a favourite and necessary part of the training unit when we want to increase the level of game preparedness and fitness capacity of players. By applying the principle of "adequate coverage theory", we try to model in the training process through SSGs such game conditions, which are very similar to real match conditions. Ideally, the training unit has to contain such SSGs, where the physiological curve moves at the level or above of the anaerobic threshold (ANT).

Soccer coaches are able to influence the intensity of the training load in SSGs if they adequately manipulate with the variables, which affect the intensity of SSGs.

Among these variables we can mention: the number of players, the size of playing field, coaching methods, game rules, content focus of the game, goal size, number of goals, presence of goalkeepers, dosing of work : rest intervals and different rule modifications, like the number of ball touches (Aktas et al., 2014; Halouani et al. 2014b; Gonzáles-Rodenas et al., 2015; Torres-Ronda et al., 2015; Holienka, 2016; Brandes et al., 2017; Giménez et al., 2018; Mikulič et al., 2018; Nagy & Holienka, 2018; Peráček et al., 2018a, 2018b; Nagy & Babic, 2019).

Knowing that the number of ball contacts could affect the physiological responses and, therefore, the potential beneficial effect for individual and team performance improvement, it has to be noted how permitted 1 ball touch, 3 ball contacts and the free number of ball touches to affect the internal load during SSGs.

Thus, the main aim of the present study was to compare the effects of 3 variants of SSGs with different rule modifications, especially the number of ball contacts. These 3 forms of SSGs with limited and unlimited ball touches are indeed very popular and much used by soccer coaches during training sessions. The findings could potentially provide valuable, reliable and useful information to coaches for the design different forms of SSGs as part of their training process.

Methods

Experimental approach to the problem

In our research we measured internal load (cardiovascular response) during three different forms of 3 vs. 3 SSGs. SSGs were played with the same team consist of 3 players against the same opposite team for each of the 3 SSG variants, and only the number of permitted ball touches were changed among SSGs. This approach allowed us to identify the changes in the rule modifications mentioned earlier.

The dependent variable was the internal load of players´ organism, expressed by the level of HR, and the independent variable was the permitted number of ball contacts/player during the SSGs.

Participants

The research group consist of six (n=6) male youth soccer players (aged 17.8 ± 0.7 years, body mass 68.5 ± 6.1 kg, body height 176.6 ± 5.5 cm, VO_{2max} 61.06 ± 3.24 $ml.min^{-1}.kg^{-1}$, maximum heart rate (HR_{max}) 199.8 ± 7.6 $beats.min^{-1}$) from the FC DAC 1904 Dunajská Streda U19 soccer club. The monitored players were participants at the highest competition of this age category in Slovakia (1.LSD).

Methods of measurement

One of the main methods to acquire the data used during this research was HR measurement. First of all, we ascertained the values of maximum heart rate (HR_{max}). The HR_{max} was calculated using a field test by Hipp (2007). During testing the tested soccer player had to run 50 meters in a defined area, which they completed with various intensities. The test included 6 repetitions in every single set of the run. Players went through 4 sets and in each one of them the intensity was gradually increased to the maximal subjective intensity.

The test included:

- low-intensity run (warm-up): 120–130 BPM – 6 times,
- medium intensity run: 130–150 BPM – 6 times,
- submaximal intensity run: 150–170 BPM – 6 times,
- maximum (subjective) intensity run – once.

There was a 30 seconds rest interval between the repetitions and 60 seconds between the sets. According to the maximum heart rate (HR_{max}) we determined 5 load zones.

Table 1 *Intensity load zones according to the HR values (Moravec et al., 2007)*

ZONE	% HR_{max}	CHARACTER
Zone 1	50–59%	Very low intensity
Zone 2	60–69%	Low intensity
Zone 3	70–79%	Medium intensity
Zone 4	80–89%	Submaximal intensity
Zone 5	90–100%	Maximal intensity

To measure the HR the set of sports testers POLAR TEAM was used. The calculation of the percentage and time representation of HR values was done by using a special program and software.

Small-sided games (SSGs)

Game description:

Players played the SSGs in a defined area with permitted one, three and unlimited number of ball contacts. They could pass the ball between themselves any times. After scoring the goal, the game was started by the goalkeeper, whose team scored the goal.

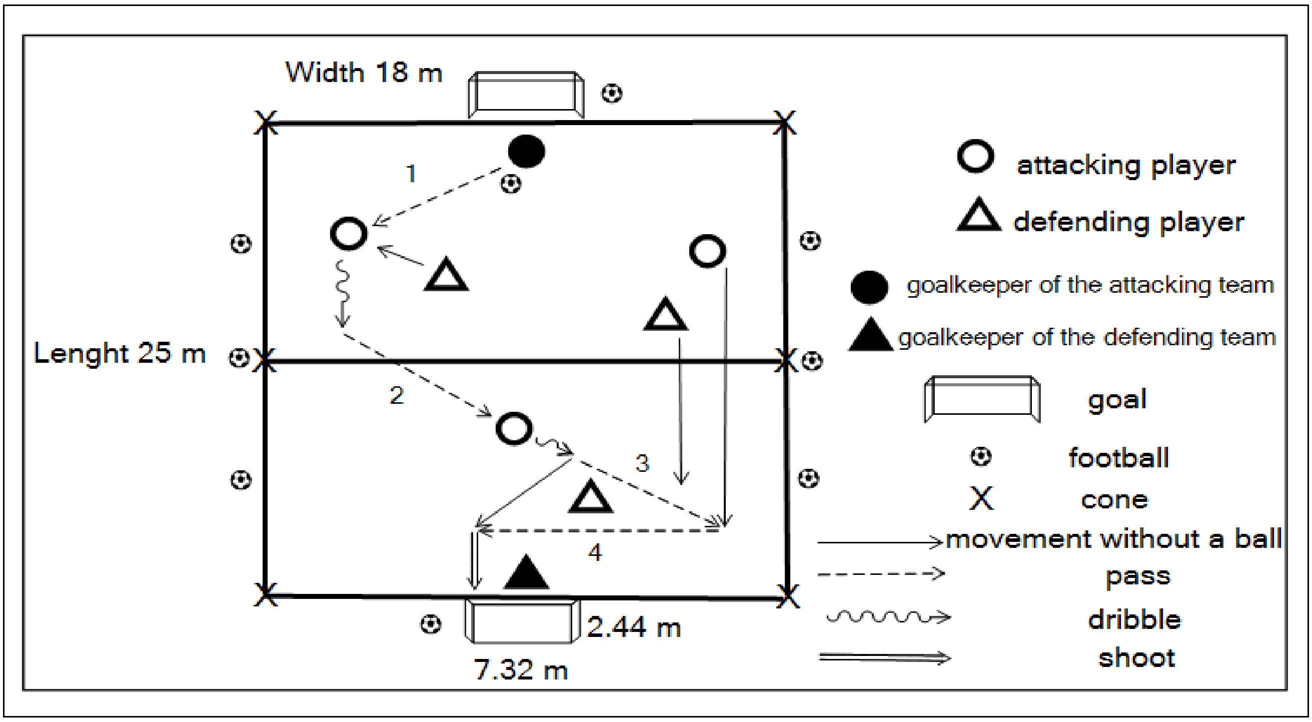

Figure 1 *SSG*

During SSG1 players must play with one permitted ball contact. In SSG2 players had 3 permitted ball touches. Throughout SSG3 players had unlimited ball contacts, they played on free manner. During the SSGs the number of repetitions was 4, the work interval (WI) lasted 2 minutes, the rest interval (RI) was in each variants 2 minutes. The work and rest ratio were 1 : 1.

Table 2 *Different forms of SSGs*

SSG	Number of ball touches	Players	GKs	Field dimensions		Field area	Area/ player	Batch load				
		(n = 6)	(n = 2)	Width [m]	Length [m]	[m²]	[m²]	WI [min.]	RI [min.]	NR	NS	L [min.]
SSG1	1	3 vs. 3	1/1	18	25	450	75	2	2	4	1	16
SSG2	3	3 vs. 3	1/1	18	25	450	75	2	2	4	1	16
SSG3	free	3 vs. 3	1/1	18	25	450	75	2	2	4	1	16

Statistical analysis

To determine the statistical significance of the HR values the One-Way ANOVA method and Bonferroni post hoc test was used. The level of statistical significance was set at 5% ($p < 0.05$). The results were interpreted, compared and we also tried to find the connections between them. On the basis of these data, we formulated conclusions and recommendations for the sport theory and to training practice.

Results

The monitored players spent during SSGs with different rule variations in selected intensity load zones different time. In table 3 the average time values and the percentage representation of players´ remaining in each intensity load zone are presented.

Table 3 *Remaining of players in each load intensity zone*

Load zones	50–59% HR_{max}		60–69% HR_{max}		70–79% HR_{max}		80–89% HR_{max}		90–100% HR_{max}	
Intensity	**Very low**		**Low**		**Medium**		**Submaximal**		**Maximal**	
SSG	**[min]**	**[%]**	**[min]**	**[%]**	**[min]**	**[%]**	**[min]**	**[%]**	**[min]**	**[%]**
SSG1	0.34	3.51	2.19	16.51	3.11	19.26	4.48	31.46	5.06	34.28
SSG2	1.02	6.28	2.51	19.36	3.43	24.87	4.13	26.12	4.51	29.75
SSG3	1.41	10.26	3.29	24.62	2.51	17.61	5.13	32.25	2.57	18.26

The highest intensity of the training load was monitored during SSG1, in which the players had to play with one ball contact, they were limited with one ball touch. Players remained in the SSG1 the longest time period in the maximal intensity load zone (90–100% HR_{max}) on average 5.06 minutes (34.28%) of SSG1 duration. In this form of SSG players spent least time in very low intensity zone (50–59% HR_{max}). In this zone the players remained even for half a minute. The lowest intensity was monitored in the SSG3, where the players had unlimited ball contacts and could play in free manner. On average players spent 2.57 minutes (18.26%) of the SSG3 duration in the load zone of maximal intensity. In SSG2, where participants had maximal 3 ball touches the players spent 4.51 minutes (29.75%) of the SSG2´s total time in the load zone of maximal intensity. The highest average value in the load zone of medium intensity represented was during SSG2, 3.43 minutes, (24.87%).In the SSG3 the players remained the most time in the load zone of submaximal intensity (80–89% HR_{max}), on average 5.13 min. (32.25%). In the load zone of low intensity players spent the most time in SSG3 too.

The internal response of organism with different rule modifications was monitored using the HR values. The recorded values are stated in Figure 5.

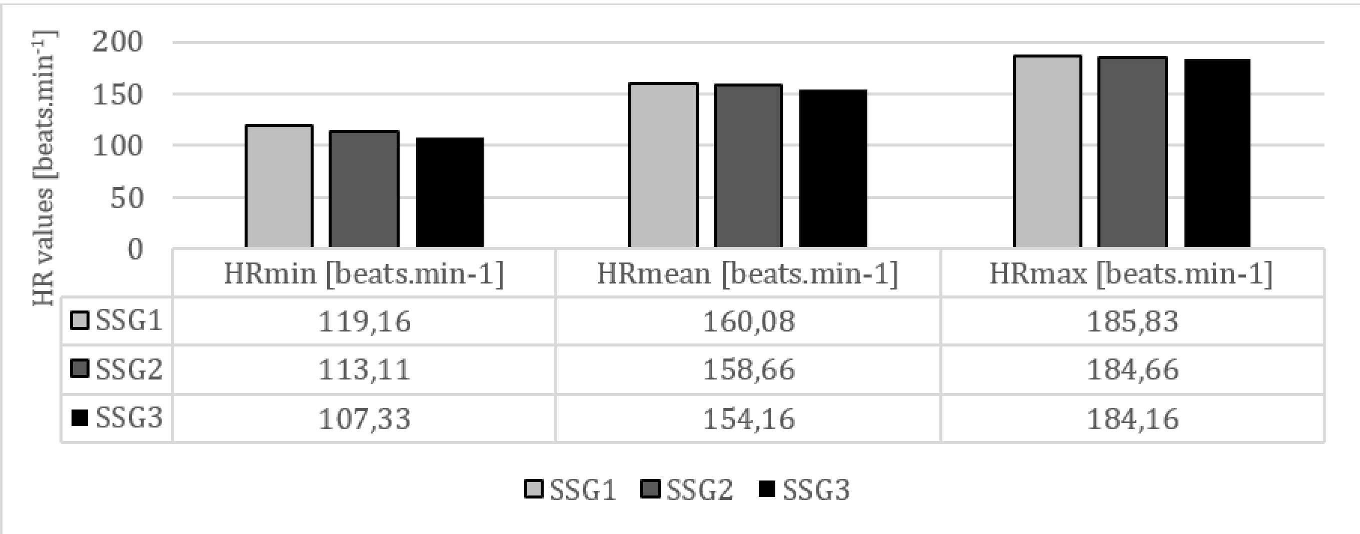

Figure 2 *The average HR values in different SSG forms*

The highest average value of minimum HR (HR_{min}) was achieved by the monitored players in the SSG1, where players had only one permitted ball contact, 119.16 ± 12.48 beats.min^{-1}. The lowest values were monitored in the SSG3, where players had unlimited ball touches, 107.33 ± 12.12 beats.min^{-1}. In the SSG2 with maximal 3 ball contacts were the HR_{min} 113.83 ± 9.31 beats.min^{-1}.

The mean HR values (HR_{mean}) of the monitored players was the lowest in the SSG3 154.16 ± 8.25 beats.min^{-1} and the highest in the SSG1 160.08 ± 9.27 beats.min^{-1}. In the SSG2 we measured 158.66 ± 8.09 beats.min^{-1}.

The recorded average value of maximal HR (HR_{max}) was the lowest in the SSG3 184.16 ± 7.02 beats.min^{-1} and the highest in SSG1 185.83 ± 9.06 beats.min^{-1}, in the SSG2 was recorded HR_{max}184.66 ± 5.75 beats.min^{-1}.

In small forms of the SSG, in which the players played 3 vs. 3, the training load was often higher than the real match load itself. The recorded ascertained values of HR_{max} show that players performed the training activity at a high level. Differences between the ascertained HR_{max} values and percentage values from HR_{max} (Tab. 4) are at a low level. We can see that the highest value was in the SSG1 (92.66%) and the lowest in the SSG3 (91.83%).

Table 4 *Values of HR_{max} and % of HR_{max} during the different SSG variations*

SSG	HR_{max}		% HR_{max}	
	[beats.min^{-1}]	SD	[%]	SD
SSG1	185.83	9.06	92.66	4.67
SSG2	184.66	5.75	92.16	3.18
SSG3	184.16	7.02	91.83	2.22

In contemporary soccer the match load is at the level of the anaerobic threshold (ANT). During the training process in different forms of SSGs the training load is at a higher level. In this case time spent above the ANT represents higher values.

Table 5 *Time spent above the ANT*

SSG	Time spent above the ANT	
	[min]	[%]
SSG1	6.23	38.11
SSG2	5.32	34.06
SSG3	4.58	32.15

Players spent the most time above the ANT in the SSG1, it was up to 6.23 minutes (38.11%) of SSG1 duration and at least in the SSG3 4.58 minutes (32.15%) of the SSG´s total time. In the SSG2 the time spent above the ANT was 5.32 min, which represents up to 34.06% of the SSG.

On the basis of the One-Way ANOVA results, we can state that there is a statistically insignificant difference in mean HR values after completing the SSGs with different rule modifications ($F = 0.7657$, $p = 0.4824$).

The statistical significance between the SSG1 and SSG2 was not proved ($t = 0.2699$, N. S.). The difference between the HR_{mean} was only 1.42 beats.min^{-1}. It was probably caused by the fact that the change of permitted number of one ball contact/player or three touches to the ball in SSGs did not significantly influence the internal response of players' organism, and therefore, the average values of HR were not different.

Between the SSG1 and SSG3 no statistically significant lower HR_{mean} values ($t = 1.1808$, N. S.) were found. In the SSG1 the HR_{mean} values were 160.08 ± 9.27 beats.min^{-1}, in the SSG3 HR_{mean} values of 5.92 beats.min^{-1} less, 154.16 ± 8.25 beats.min^{-1} were recorded.

Statistically significant differences in the HR_{mean} values between the SSG2 and SSG3 were not proved ($t = 0.9109$, N. S). The difference between the HR_{mean} values was 4.5 beats.min^{-1}. The rule modifications in SSGs did not significantly affect the internal response of the players´ organism during the game.

Discussion

The main aim of the present study was to compare the cardiovascular response in 3 different SSGs forms. Thus, 3 SSG variants, with identical number of players (3 vs. 3), pitch dimensions (18 × 5 m), same number of sets, reps, work and rest ratio (1 : 1), but different in the permitted number of ball contacts (SSG1- 1 touch, SSG2- maximal 3 ball touches, SSG3-unlimited ball contacts/player) were compared.

We purposely choose small form of SSG when the players‘ perform with a number of 3 vs. 3, in a tight area (75 m^2/player), because players need to solve various game situations under time-space deficit like in competitive match play.

HR is a generally accepted and often used physiological indicator of the players´ physical activity in the training process (Holienka & Cihová, 2016). When speaking about the results obtained from the sports devices, one has to respect the fact that the HR values showing the training load intensity of the soccer players´ organism in different forms of SSGs are only indirect indicator.

Different forms of SSGs in a systematic training process enable the players to improve and stabilize the technical and tactical side of game activities, to secure the development of creative thinking and their actions on soccer pitch. SSGs with different rule modifications ensure the realization of individual´s game activities and combinations, which have a positive effect on spatial orientation, physical activity and players´ emotions as well.

In training practice, soccer coaches quite often modify playing rules in different forms of SSGs to achieve greater exercise intensity or develop soccer specific technical and tactical skills. Rule changes increase the cognitive load required from players as a consequence of new rules (Hill-Haas et al., 2011).

Los Arcos et al. (2015) claims that the SSGs are more effective to improve and maintain the aerobic capacity of young soccer players´ than interval training. Players during the SSGs showed more joy in physical activity than during the interval training.

Through the SSGs it is possible to maintain the level of anaerobic abilities by specific means and to increase the players´ motivation. The SSGs performed on smaller playing fields, in which is involved a lower number of players, are ideal for development and improvement of special match condition and game capacity (Peráček et al., 2018a; Mikulič et al., 2018).

Small forms of SSGs (3 vs. 3 players) represent for coaches an alternative to increase the demands on the cardiovascular and metabolic system of young players (Halouani et al., 2017). The HR values in the SSG1, where players had permitted only one ball contact, were higher than in the SSG2, in which players had allowed maximal three ball touches, or in the SSG3, where players had unlimited ball contacts.

Castellano et al. (2013) claim that the intensity of the training load was highest in the SSG with a focus on ball holding, with unlimited ball contacts. In our case, in SSG1 were measured the highest HR values, when players need to solve game situations with one ball contact. This can be due to the fact that the players have to constantly work with the space, free themselves of the opponent and adequately make a free space for their teammates. Players' tried to use goalkeepers often, because they could cooperate with him, especially in SSG1.

In Table 6 is presented the internal response of the players´ organism to the match load according to Mendez-Villaneuva et al. (2013) in the U18 age category. The zones of load intensity were divided at the same level as in our research. The intensity of the training load was on the same level than the match load. In some cases, especially in SSG1 we measured a little higher intensity load than the real match conditions. We need to consider, that in our research the work interval was 2 minutes and the rest interval lasted 2 minutes too. It was ideal to prepare players to be match fit and game ready.

Table 6 *Intensity of U18 players´ match load (Mendez-Villaneuva et al., 2013)*

Zones	< 60% HR_{max}		61–70% HR_{max}		71–80% HR_{max}		81–90% HR_{max}		91–100% HR_{max}	
Match	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
[%]	2.8 ± 5.8	1.0 ± 1.6	6.6 ± 6.6	8.5 ± 5.7	17.3 ± 9.6	26.5 ± 9.9	36.7 ± 13.3	40.8 ± 8.1	36.5 ± 22.8	22.6 ± 14.4

During the soccer match the internal response of the players' organism to the load is in different levels. A systematic, purposefully thought-out training process has to stimulate those bio-energy systems, which predominate in the real match conditions. In training practice this criterion replaced with the cognition and adequate manipulation of SSG variables, including the rule modification (Peráček, 2014).

Švihorík (2005) claims that, when concerning the SSG rules, it is necessary to be mindfully prepared and preventing from the frequent interruption of SSG continuity. These rules should force the players to play and move all the time.

In the SSG1 the players had only one permitted ball contact. It was very challenging without adequate space selection, movement without the ball, physical activity, etc... The ball often got outside the playing field. Although the replacement balls were prepared around the playing field, so the players could keep the HR values and intensity of play at a high level. In SSG2 and SSG3, where players had permitted more ball contacts, the game quality was much more better.

Coelho et al. (2016) found that the players spent a statistically significant more time above the ANT level in the first half of the match than in the second half. By using small forms of the SSGs with the number of players 3 vs. 3, it is possible for us to prepare the players for the real match load intensity, like in our study with SSG1.

Table 7 *Comparison of the mean HR values during soccer matches*

AUTHOR (YEAR)	AVERAGE HR [beats/min]	TYPE OF MATCH
Florida-James & Reilly (1995)	165	competitive
Thatcher & Batterham (2004)	166	competitive
Helgerud et al. (2001)	171	competitive
Capranica (2001)	180	competitive
Krustrup (2006)	156	pre-season
Reilly (1996)	157	pre-season
Seliger (1968)	165	pre-season
Van Gool et al. (1988)	166	pre-season

The mean HR values found in different forms of SSGs are at a similar level to the values recorded in competitive or pre-season matches at different levels and with various age categories (Seliger, 1968; Van Gool et al., 1988; Florida-James & Reilly, 1995; Reilly, 1996; Capranica, 2001; Helgerud et al., 2001; Thatcher & Batterham, 2004; Krustrup, 2006).

Conclusions

The purposeful use of modern technologies in training units, such as sport testers, enable the sports experts or coaches to find out the internal response of the players´ organism to the intensity load and get objective feedback on the adequacy of the training load.

In this research our aim was to point out to the cardiovascular reaction of the players´ organism during SSGs with different number of permitted ball contacts/player. On the basis of acquired data, we can state that in the SSGs with various rule modifications the average HR values were at different level. The highest HR values were recorded during SSG1, where players had allowed only one ball contact. Players in this type of SSG remained the longest time in the load zone of maximal intensity and spent the most time above the ANT. For this reason we can claim that the SSG1 was the most intense one from these three versions.

Recommendations for didactic theory and training practice

On the basis of our findings in this research, we can state that by the change of the rules in SSGs, it is possible to increase, but also decrease the demands on individual bio-energy systems of the players´ organism.

Our recommendation is to integrate all 3 different variants of SSGs into the systematic training process, depending on players' technical capability. During SSG1 with only one permitted ball contact/player the intensity was high but there were a lot of lost balls and inaccuracy. For some players with low level of technical-tactical preparedness solving game situations adequately proved to be hard. During SSG2 with 2 permitted ball touches/player the intensity was on a lower level, but the quality of the game was much better. The difference between HR_{mean} was 2.14 beats.min^{-1}. Three allowed ball touches/player during SSG3 ensured that players have time to receive the ball, analyse the game situation and solve it correctly, but in that case the intensity level was on lower rate.

We found out that the optimization and intensification of the training load in the SSG can also be adjusted by rule modifications. During SSGs the HR values were at the same level as the match load level, so we can state that during SSG1 and SSG2 we can prepare players for real and competitive match demands.

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INFLUENCE OF THE INTERVENTION PROGRAM ACCORDING TO PULMONARY REHABILITATION PRINCIPLES ON BREATHING FUNCTIONS OF HEALTHY INDIVIDUALS

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Renáta Malátová, Petr Bahenský, Martin Mareš, David Marko

Department of Sports Studies, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic

ABSTRACT

Purpose: The aim of the study is to develop and verify an intervention program based on findings of the subject field Pulmonary Rehabilitation and the application of such programme to a daily program of healthy probands over a six-week period. The authors were concerned with determining whether an intervention program, based on a combination of aerobic load and resistance training, might affect the breathing stereotype and breathing functions in healthy individuals.

Methods: Muscle dynamometer MD03 was used to examine the extent of engagement of individual breathing regions. Breathing functions, or more specifically, the forced vital capacity (FVC) and one-second vital capacity (FEV_1), were measured by means of Spirometer Otthon, and the evaluation was conducted using program ThorSoft. The intervention included 6 probands at the age of 21.3 ± 0.8 who exercise regularly. The probands underwent initial and final tests. The data obtained were evaluated and substantial significance was determined using Cohen's d, and the Student's paired t test for dependent selection. Significance value was determined at significance value $\alpha = 0.05$. Data were processed in programs Microsoft Excel 2016 and Statistica 12.

Results: The tested set of probands showed a substantially significant change of value FVC (Cohen's d = −0.13, i.e. a small effect). This change was also statistically significant. As regards value FEV_1, a substantially significant change incurred (Cohen's d = −0.23, i.e. a small effect). Likewise, this change was statistically significant. The analysis of breathing movements of the observed group of probands revealed improvement especially in the lower thoracic region (abdominal) following the completion of the intervention program. In resting breathing, a substantially significant (Cohen's d = 2.83, a large effect) as well as statistically significant change was effectuated in this region. In the middle thoracic region, a substantially significant change (Cohen's d = 0.01, i.e. a small effect) incurred; however, there was no statistical change. No substantially or statistically significant changes were obtained for the upper thoracic (subclavian) region.

Conclusion: Our results imply that the aforementioned intervention applied in healthy individuals who exercise regularly hasn't had a positive influence on breathing functions. Though there was a small improvement in the breathing stereotype, the optimum engagement of the abdominal breathing region within the breathing wave as described in specialized literature was not accomplished.

Keywords: breathing wave; breathing regions; breathing stereotype; inspiratory pressure; intervention program; pulmonary rehabilitation

Introduction

Pulmonary rehabilitation is a multidisciplinary program of care provided to patients suffering from chronic respiratory disorder, developed individually with the aim of optimizing physical and social performance. Respiratory physiotherapy is a more specialized term related to respiratory rehabilitation techniques. (Zdařilová et al., 2005). Smolíková & Máček (2010) argue that pulmonary rehabilitation is predominantly engaged in a physical activity treatment directed at improving the adaptation to physical load and an increase in performance. Respiratory physiotherapy includes especially a set of methods and techniques of modified breathing. Accordingly, pulmonary rehabilitation should embrace both methods.

In the physical education practice, the importance of correct breathing has recently been acknowledged with an increasing intensity both in the musculoskeletal perspective, i.e. body alignment, and in the perspective of sports performance.

One of the first studies to objectivise thoracic expansion was conducted by Moll & Wright (1972). These authors draw attention to thoracic expansion as a useful indicator of a disease. Using a centimetre sliding tape, they measured thoracic expansion (perimeter) in the total of 262 subjects (standard population at the ages from 15 to 75 years) at the level of xiphosternal line. The authors concluded, *inter alia*, that after an initial increase, thoracic expansion in subjects had shown a gradual but considerable drop (by 50–60%) with increasing age. Thoracic expansion in men was higher by 13–22% than that in women.

Likewise, current research has revealed the substantial role played by breath in both health and sickness (Gosselink, 2004; Courtney, 2009; Chaitow, Bradley, & Gilbert 2014). In their study, Ragnarsdóttir &Kristinsdóttir (2006) set up an objective consisting in the determination of reference data for breathing movements and patters for healthy men and women. Movements of the upper and lower thorax were measured on both sides (right, left sides) at resting breathing and deep breathing by means of a measuring appliance for respiration movement in 100 probands at the ages from 20 to 69 years. The authors discovered that breathing movements were symmetric and changed only insignificantly with increasing age. The average breathing type in men and women was abdominal breathing at resting breathing. As regards deep breathing, abdominal movements were considerably lower in women when compared with men.

Normal breathing movements are described as a combination of abdominal and lower thoracic movements (Chaitow, Bradley, & Gilbert, 2002). Similarly, Yuan, Drost & McIvor (2013) maintain that the normal breathing pattern consists of inspiration and expiration phases, accompanied by a synchronic movement of the thorax and abdomen. Kaminoff (2006) states that normal breathing signifies a synchronized movement of the upper thoracic and lower thoracic regions and the abdomen.

Dysfunctional breathing constitutes a respiration condition characterized by irregular breathing schemes. Dyspnoea or “thirst for air” are the most frequent primary indicators. Dysfunctional breathing is also associated with non-respiration indicators, such as vertigo and palpitation (Vidotto et al., 2019). Paleček et al. (1999) reason that weakness and fatigue are the most usual functional disorders of respiration muscles. Weakness may be defined as a condition where the ability of a relaxed muscle to generate power is decreased. Contrary to fatigue, weakness is not quickly reversible. CliftonSmith (2017) claims that an incorrect breathing pattern of a sportsman at physical activity may cause early dyspnoea or fatigue of lower extremities, which fact does not reflect cardiovascular fitness or any organic pathology. A disorder of the breathing pattern at rest may interfere with a sportsman’s physical performance.

The maximum inspiration pressure is a criterion that is used most often when it comes to evaluating the power of inspiration muscles (Sclauser Pessoa et al., 2014). Paleček et al. (1999) argue that the maximum inspiration pressure is defined by the power and coordination of inspiration muscles. In its declaration as to the testing of respiration muscles, American Thoracic Society & European Respiratory Society (2002) claims that the power of inspiration muscles is reflected by the pressure developed in the thorax. In the respiration system, the power of muscles is generally estimated as pressure, and shortening of muscles as a change in the pulmonary volume or a change in structures of the thoracic or abdominal wall.

Koťová et al. (2014) monitored breath by means of pressure sensors. The research team fixed two pressure belts on a proband, the first belt at the level of navel: this belt monitored abdominal breathing; and the other belt was fixed under arms to monitor thoracic breathing. The authors proved that the above measurement method is capable of discerning isolated breathing during the breathing cycle.

As has already been mentioned, breathing mechanics and gas exchange are positively affected by the complex influence of pulmonary rehabilitation. A long-term influence invokes the development of metabolic adaptation to load, whereby motor capabilities of a weakened or sick individual improve. Attention should be drawn especially at large muscles groups of lower extremities. A minimum intensity should be set up for physical load, which should last for a certain period (Troosters et al., 2005; Smolíková & Máček, 2010). It is recommended to carry out physical activities 3 times a week for about 2 hours. A complex program should last from 6 to 12 weeks, whereas the acknowledgement has been made that a longer application will bring an effect of a more permanent nature. Most often, it is recommended that the program should last 8 weeks, after which measurable positive results are accomplished (Smolíková & Máček, 2010). Similarly, Dovalil et al. (2005) argue that in order to influence the intermuscular coordination and hence to improve the effect of the intramuscular coordination, physical exercises should be conducted for 6 to 8 weeks as a minimum. Interval training is a popular form of exercise, when an exercise unit is divided into short one- or two-minute sessions of a higher intensity load (approximately 80–90% of the maximum heart rate); these sessions take turns with recovery sessions of the same duration. Since lactate cannot be accumulated during such load sessions, the necessary ventilation drops. As a second part, the physical exercise program contains resistance exercises, which not only increase the power of flaccid muscles, but these exercises also - especially in the case of old-aged people - may help regenerate oxidative fibres. This phenomenon does not occur in young individuals. Resistance training is carried out on fitness appliances or by using the weight of own body, such that muscles are in motion at all times despite the considerable resistance load. Most exercises engage two large joints and exercises strengthening various muscle groups alternate (Smolíková & Máček, 2010).

With respect to the aforesaid, the question we have asked was whether an intervention program based on aerobic load and complete with resistance training and basic breathing exercises might have a positive influence on the breathing stereotype.

Methods

The objective of the paper was to develop and verify an intervention program based on findings of the discipline of Pulmonary rehabilitation. We formulated certain hypotheses, where we assumed that a breathing stereotype would be discovered in observed probands corresponding to the optimum breathing pattern (Véle, 2012; Šponar, 2003; Kolář et al., 2009). In addition, it was also assumed that in observed probands, certain selected spirometry data, specifically FVC, FEV_1, would improve considerably. Another presumption was that a breathing stereotype of observed probands would improve as a result of an intervention program, on the basis of an examination conducted by means of the muscle dynamometer MD03. The study included 6 healthy probands (four men and two women) at the age of 21.3 ± 0.8 who exercise regularly.

The muscle dynamometer MD03 was used to carry out a non-invasive examination of the breathing stereotype (Malátová et al., 2007, 2008; Malátová, Bahenský, & Mareš, 2017). In analysing breathing movements, we proceed from the concept of three thoracic sectors. One probe was fixed on each sector by means of belts. The spots for placing the probes were selected based on the kinematics of the three thoracic sectors according to Dylevský (2009). The first probe was placed on the lower thoracic sector on the ventral side at the level L_{4-5}. The second probe was placed on the middle thoracic sector at the level of the 8^{th} to 9^{th} ribs on the ventral side, and the third probe was fixed on the upper thoracic sector at the level of the 3^{rd} to 4^{th} ribs on the ventral side in the sternum region. The test was performed in the upright standing posture. The vertical posture is a physiological position for breathing (Smolíková & Máček, 2010). The probes enabled us to record the pressure on sensors exerted by the elevation of the individual breathing sectors for one minute at resting breathing. The same measurement procedure was applied also in the case of deep breathing. The probands were instructed to breathe during the examination as they are accustomed to. As many as 600 values were gained in this manner during an examination of one proband. In processing the data, we worked with the average of recorded maximum inspiration and expiration pressures on the individual probes at resting breathing and deep breathing for one minute.

The examination of breathing functions was carried out by means of the appliance Spirometr Otthon, and the tests were evaluated in the program ThorSoft. Both spirometry tests (FVC, FEV_1) were measured in the upright standing posture. The test methodology observed the appliance manual. Before the intervention program was applied, an initial (control) examination was carried out, and the application of the program was followed by a final examination. The intervention program was based on aerobic load, complete with resistance exercises and basic breathing exercises, the aim of which was to gain awareness of the individual breathing sectors and the subsequent interconnection of these sectors in a breathing wave. The intervention was held twice a week in the form of group exercise sessions during a six-week period under professional guidance.

To evaluate the data, we used Cohen's *d* to determine substantive significance, and Student's paired t-test to determine statistical significance for dependent selections. The level of statistical significance was ascertained at the level of significance $\alpha = 0.05$ (Blahuš, 2000). The generally used evaluation of substantial significance is for coefficient $d \geq 0.80$ – large effect, d = 0.50 to 0.80 – medium effect, d = 0.20 to 0.50 – slight effect (Cohen, 1988). Data were processed using the program Microsoft Excel 2016 and Statistica 12.

Results

During the analysis of breathing movements (the recorded maximum inspiration and expiration pressures on the individual probes) of the observed group of probands, improvement showed after completion of the intervention program, in particular as regards abdominal breathing, both at resting breathing (Cohen's *d* = 2.83, i.e. large effect), and deep breathing, where an increase was recorded (Cohen's *d* = 1.09, i.e. large effect). Changes in this breathing sectors were substantially and statistically significant. Thoracic breathing considered, values changed only minimally at resting breathing (Cohen's *d* = 0.01), this change is not substantially and statistically significant. As regards deep breathing, a change that is substantially (Cohen's *d* = −0.79, medium effect) and statistically significant occurred after the intervention program. For subclavian breathing at rest (Cohen's *d* = 0.34, slight effect) a substantially significant change occurred; however, there was no statistically significant change. In the case of deep subclavian breathing (Cohen's *d* = 0.19) a substantially significant change did not occur, but a statistically significant change did.

The following text presents our results gained by us when we worked only with the recorded maximum inspiration pressures exerted on the individual probes in the given breathing sectors.

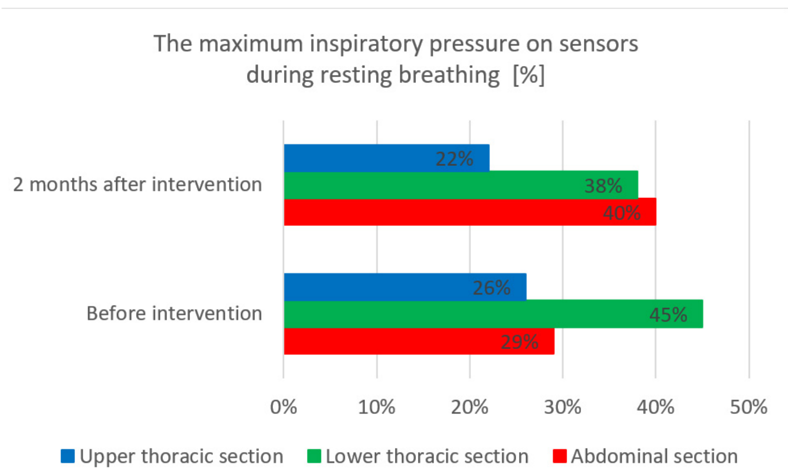

Figure 1 *Engagement of breathing sectors before and after the intervention at resting breathing*

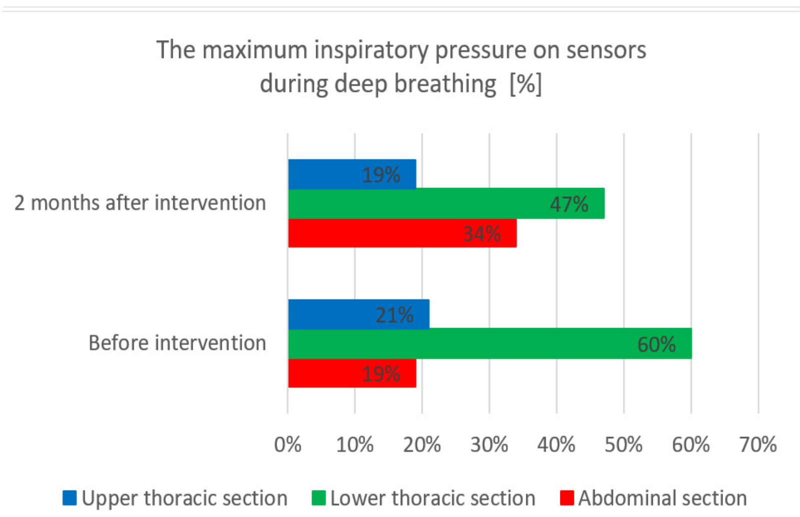

Figure 2 *Engagement of breathing sectors before and after the intervention at deep breathing*

Figures 1 and 2 show that the intervention yielded an improvement in the engagement of the abdominal sector in the framework of the breathing wave both at resting breathing and deep breathing. It may be stated that the intervention led to a better coordination of inspiration muscles.

Next, we present results of the measurement of forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1). The values measured before the intervention were as follows: FVC 5.45 ± 0.9 and FEV_1 4.563 ± 0.691. After the intervention, the values were lower: FVC stood at 5.338 ± 0,843 and FEV_1 was 4.408 ± 0.64. Both values slightly decline, by 2% for FVC and by 3.4% for FEV_1. In the tested set of probands, the change of FVC was not substantially significant (Cohen's *d* = −0.13); nonetheless, the change is statistically significant. As regards the value of FEV_1, the change of FEV_1 was substantially significant (Cohen's *d* = −0.23, slight effect); this change is also statistically significant.

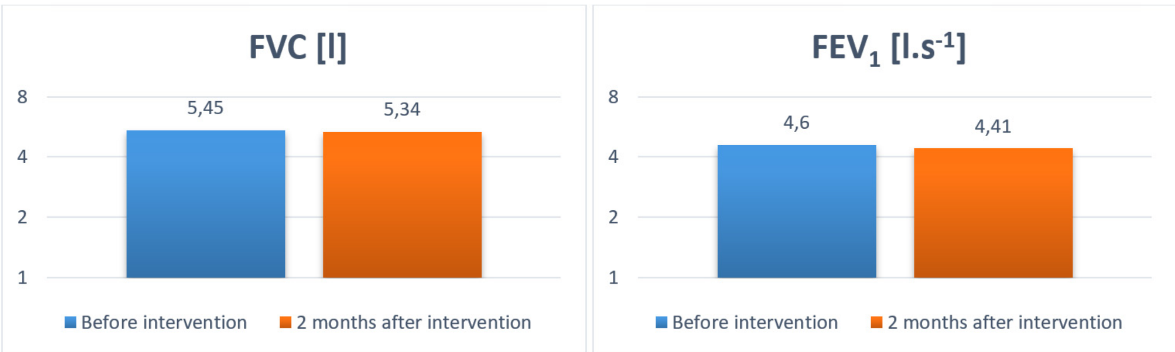

Figure 3 *a) Graphic representation of forced vital capacity (FVC) before and after the intervention, b) Graphic representation of forced expiratory volume in one second before and after the intervention (FEV_1).*

Discussion

All breathing sectors should be engaged during the correct breathing pattern (Véle, 2012; Kolář et al., 2009). As Figures 1 and 2 reveal, the probands activated the given breathing sectors both before and after the intervention. Another issue is the proportion in which these sectors should be engaged. It is claimed in specialized literature (Kolář et al., 2009; Dylevský, 2009; Kocjan et al., 2017; Bordoni & Zanier, 3013; Chaitow, Bradley, & Gilbert, 2014) that the diaphragm alone is responsible for 60% to 70% of the overall efficacy of breathing. Kolář et al. (2009) states that the activity of diaphragm as such is adequate to ventilate two thirds of the lung vital capacity. As is common knowledge, the diaphragm decreases actively in inspiration, whereby the abdomen arches slightly and the lower ribs begin to open at the moment when the downward movement of diaphragm stops by abdominal organs through the increasing intraabdominal pressure and the concurrent activity of *m. transversus abdominis* and other abdominal muscles, which slightly curb the passive arching of the abdominal wall. Afterwards, the abdomen arches only slightly, pressure in the lungs decreases to enable the air to flow into the lungs, the intraabdominal pressure continues to increase and is maintained by the isometric activity of muscles of the abdominal wall and the pelvic diaphragm. In this phase, intercostal muscles activate, the diaphragm alone helps raise the lower ribs, hereby extending the thorax.

In the last phase of inspiration, abdominal muscles together with the diaphragm and muscles of the pelvic diaphragm and pelvic girdle stabilize the spine. At the same time, the upper ribs activate and respiration continues upwards as a breathing wave (Véle, 2012). Similarly, Kolář et al. (2009) argue that the content of the abdominal cavity is primarily incompressible, hence in inspiration, organs of the abdominal cavity move caudally and the abdominal wall moves in the external direction. Lower ribs and sternum move cranially. The cranial movement is carried through the sternum to upper ribs, which are also elevated by the activity of auxiliary respiration muscles, whereby the upper part of rib cage is expanded mainly in the anteroposterior direction. Based on the aforesaid, it may be stated that the abdominal sector is the location of where the largest activation takes place. This assertion corresponds to the ratio presented by Šponar (2003), i.e. as regards a breathing wave, the abdominal breathing, costal breathing and subclavian breathing form 60%, 30% and 10%, respectively, of the total efficacy of breathing. In their study, Koťová et al. (2014) concluded that the ratio between the thoracic and abdominal breathing is 49% : 51% in favour of the abdominal breathing. The above ratios were approached by our group neither before nor after the intervention. Individuals who regularly practise sports activities should activate correctly all of the three breathing sectors during a breathing wave. However, this presupposition proved incorrect for the group of probands observed by us. Accordingly, hypothesis 1 was not confirmed. The point to be acknowledged is that a disorder of the breathing stereotype will generally influence the whole body (Chaitow, Bradley, & Gilbert, 2014). The above implies that correct breathing should be given more emphasis in education, especially as regards physical activities of children (Sedlářová et al., 2008). The current unnatural way of life that puts restrictions on natural physical activities, occupational sedentary behaviour and passive ways of spending leisure time all contribute to the fact that contemporary society is unable to breathe correctly (Haichová & Yesudian, 2014). McKeown (2013) is another researcher to claim that the more the society grows richer, the more our lifestyle changes, affecting the way we breathe. Last but not least, Barknowitzová (2004) emphasizes the considerable influence of the today's lifestyle that influences the body alignment and is reflected in the quality of breathing.

The intervention program was based on aerobic training, complete with resistance and basic breathing exercises. The intervention was introduced on account of the fact that this type of training is used not only for the ill but also in sportsmen's training (Smolíková & Máček, 2010). After the intervention, the engagement of the abdominal sector improved in the framework of a breathing wave, for resting breathing and deep breathing to 40% and 34%, respectively, which confirms hypothesis 3. We also observed the manner in which the intervention would affect pulmonary functions, specifically values of FVC and FEV_1. Gosselink et al. (2000) claims that FVC is connected with the power of expiration muscles. In their study, Han & Kim (2018) examined effects of a breathing technique in combination with dynamic exercises of upper extremities on pulmonary functions in healthy men at the age of 20.

The experiment was conducted three times a week for a four-week period. The above authors concluded that the intervention did improve pulmonary functions. However, after the six-week intervention held twice a week, no improvement was seen in our study, which observed healthy individuals who exercise regularly. Contrariwise, the values of FVC and FEV_1 slightly worsened, a fact which might have been caused by the then health condition or inaccurate measurement.

Conclusion

For the observed individuals, our study proved a larger engagement of the middle and upper breathing sectors in comparison with the lower (abdominal) breathing sector both at rest breathing and deep breathing before the intervention and after the application of the intervention. The six-week intervention resulted in improvement of the engagement of the lower (abdominal) breathing sector, at resting breathing from 29% to 40%, and at deep breathing from 19% to 34%. The intervention had a positive influence on the breathing stereotype in the observed group of probands.

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RELIABILITY AND VALIDITY OF THE NEWLY DEVELOPED TESTS OF FOOTBALL SPECIFIC CHANGE OF DIRECTION SPEED AND REACTIVE AGILITY IN YOUTH PLAYERS

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Nikola Foretic[1], Barbara Gilic[1, 2], Damir Sekulic[1]

[1]*University of Split, Faculty of Kinesiology, Split, Croatia*
[2]*University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia*

ABSTRACT

Purpose: Agility is an important determinant of success in football (soccer), but there is a lack of reliable and valid tests applicable in the evaluation of different agility components in youth football players. In this study we evaluated the reliability and factorial validity of the two newly developed tests of agility in male youth football players.
Methods: The sample comprised 44 youth football players (all males, 14–15 years of age) who were tested on anthropometrics (body height and mass), newly developed tests of football specific reactive agility (FS-RAG) and change of direction speed (FS-CODS), one standard test of CODS (20-yards), and sprinting over 20-m distance (S20M). The relative reliability is evaluated by calculation of Intra-Class-Correlation coefficients (ICC), while the absolute reliability was evaluated by calculation of the coefficient of variation (CV). Further, systematic bias was checked by analysis of variance for repeated measurements (ANOVA). The associations between studied variables were evidenced by Pearson's correlation. Finally, factor analysis was calculated to define the factorial validity of agility tests (FS-RAG, FS-CODS, 20-yards).
Results: The newly developed football-specific tests were found to be reliable, with better reliability of FS-CODS (ICC: 0.81, CV: 6%), than of FS-RAG (ICC: 0.76, CV: 9%). The ANOVA evidenced significant ($p < 0.05$) learning effects for FS-RAG, but post-hoc analysis indicated stabilization of the results until the third testing trial. Factor analysis extracted one significant factor under the Guttmann-Kaiser criterion (Explained Variance: 1.67), showing the appropriate factorial validity of newly developed tests in comparison to standard agility indicator 20-yards. Meanwhile, the significant correlations between all agility performances with S20M (Pearson's R: 0.52–0.63; all $p < 0.01$) revealed that sprinting capacity significantly influence agility performances and that conditioning capacities of youth football players are not yet discriminated.
Conclusion: Results showed appropriate reliability and validity of the newly developed tests of football specific change of direction speed and reactive agility. Therefore, here proposed FS-CODS and FS-RAG can be used as reliable and valid measures of agility components in youth football players. Further studies should evaluate the discriminative validity of the here proposed tests (i.e. identification of position-specific or performance-related differences), as well as reliability in younger players than those studied herein.

Keywords: soccer; agility; sport-specific tests; reliability; validity

Introduction

Agility is a motor ability that directly influences successful performance in majority of team sports (Freitas et al., 2019). It is defined as a performance quality of an athlete to rapidly change direction and speed of movement (Gabbett, 2006). Agility has two main components: *change of direction speed component* and *perceptual and decision making component* (Sheppard & Young, 2006).

Football is a team sport characterized by short sprints, rapid acceleration or deceleration, turning, jumping, kicking, and tackling (Wisloeff, Helgerud, & Hoff, 1998). Following this, it is clear that most important abilities for successful football performance are those connected with speed and force production such as; power, speed and agility. Agility in football is often described as a player quality to fast change direction or speed of movement, to start and stop quickly, with or without the ball (Sporis, Jukic, Milanovic, & Vucetic, 2010). Time-motion analysis show that football player changes direction every 2–4 seconds and makes 1,200–1,400 changes of direction during a game (Bangsbo, 1992).

In football, agility appears in two forms dependable on game situations; *non-reactive* (CODS) – pre-planned players change of direction that is not conditioned by any external factor and *reactive* (RAG) – non-planned change of direction that is influenced by opponent action. Both forms appear with or without the ball. CODS depends on: technique of movement, straight sprinting speed, anthropometry, reactive strength, concentric strength and power & left-right leg muscles imbalances. On the other side RAG depends on completely different qualities: visual scanning, knowledge of given situations, pattern recognition and anticipation (Sheppard & Young, 2006). Although the nature of the football game produces many unexpected situations and puts reactive agility on very important place in player's ability setup, both CODS and RAG should be trained and developed from the youth categories.

As a fundamental physical trait, agility should be regularly monitored and assessed, if possible, in sport-specific conditions. Sport-specific tests are developed to simulate basic movement patterns in real-sport situations. It is overall opinion that these tests better asses players capacities for successful performance in given sport than general fitness tests (Uljevic, Spasic & Sekulic, 2013). Football coaches, trainers, and players continually search for simple and effective tests that may help to revel deficiency in agility. Along with simplicity and efficiency those tests must have acceptable metric characteristics. Most of all tests must have satisfying reliability and validity.

Since there is a lack of reliable and valid tests applicable in the evaluation of different agility components, especially in youth football players, we have developed new tests of football specific change of direction speed and reactive agility. In regard to this, main goal of the study was evaluation of the reliability and factorial validity of these two newly developed tests.

Methods

Subjects

Subjects in this study were 44 youth male football players, 14–15 years old. Only participants who had no injuries and/or illnesses for 30 days before the experiment were included in this investigation. The ethics board of the author's institution provided approval of the research experiment. Participants voluntarily took part in the testing after they provided written consent. All players had been playing football for at least 4–6 years. The average training frequency of all players ranged from 10 to 14 hours per week, with an average of 5–6 sessions weekly.

Procedures

Players were tested on 2 basic anthropometric variables; body height (BH) and body mass (BM). Body height was measured with GPM anthropometer (*Siber Hegner*, Zurich, Switzerland) while body mass was assessed using the *Tanita BC-418* device (Amsterdam, Netherlands).

The agility variables included 2 newly developed tests of football specific reactive agility (FS-RAG) and change of direction speed (FS-CODS), one standard test of CODS (20-yards), and sprinting over 20-m distance (S20M).

For the S20M test, the participants were placed 1 meter behind the start line with their body leaned forward. The first timing gate (*Powertimer, Newtest*, Finland) was on the start line (0 m), and the second at the finish line (20 m), reflectors were at 1 m height. The participants were told not to include backward movements at the start and to sprint at maximal speed the whole distance with avoiding a "dive finish." The athletes had three trials with a rest period of 2 minutes between each sprint. The best score was used for the analyses.

For the 20-yards (CODS) three marker cones are placed along a line five yards apart. The player stands 50 cm from the middle line and starts moving with 90° full body rotation by going to the left direction. When passing the middle line he activates timing gate (*Powertimer, Newtest*, Finland). After coming to the first cone on 5 yard, player turns and runs 10 yards to the right side. He turns again and finishes by running back through the start/finish timing gate.

The specific football agility performances were tested with one protocol that evaluated the FS_CODS and three protocols for the FS_RAG, and the testing was performed on plastic turf grass. All performances were tested with the same equipment and test set-up, with the difference that the participants in the FS_CODS protocol were aware of the movement pattern in advance. In contrast, the participants had no advanced knowledge of the testing scenario when they performed the FS_RAG testing protocols. Each protocol consisted of 5 trials.

Measurements were performed using a hardware device system based on an ATMEL micro-controller (model AT89C51RE2; ATMEL Corp, San Jose, CA, United States) as the core of the system. A photoelectric infrared (IR) sensor (E18-D80NK) was used as an external time triggering input, and LEDs were used as controlled outputs. The photoelectric IR sensor has been shown to be as reliable as high-speed sensors, with a response time of less than 2 ms (500 Hz) and a digital output signal. The sensor's detection distance ranged from 3 to 80 cm and was capable of detecting transparent or opaque objects. Because it has a digital output (high-low state) with an NPN transistor open collector, the sensor is connected through a microcontroller IO port. For the purposes of our study, this device was connected to a laptop PC operated on Windows 7. This equipment has previously been used and proven to be both valid and reliable for reactive agility and CODS assessments (Sekulic et al., 2017; Sisic, Jelicic, Pehar, Spasic, & Sekulic, 2016).

The FS_CODS and FS_RAG were performed in the testing area shown in Figure 1. The participants commenced from the start line, and the timing was initiated when they crossed the IR signal. At this particular moment, a hardware module (microcontroller – MC) lit one of the two LEDs placed inside the 30-cm-high cones (labelled A and B). When tested on the FS_RAG, the participant had to assess which cone was lit, run to the particular cone, kick (rebound) the ball in front of the cone placed at the specially constructed stand positioned 3 cm above the ground, and return to the start line as quickly as possible. When a participant crossed the IR signal on their way back, the timing stopped. Testing of the FS_RAG was performed over three protocols and the participants had no advanced knowledge of the testing scenario. The participants performed the protocols in a random order. Following the reliability analysis (refer to the results on reliability), the best achievement for each of the three protocols was employed as the final result for each participant. The rest period between attempts was 10–15 s with 3 min of recovery between the protocols. The testing of the FS_CODS was similar to the testing of the FS_RAG performances; however, a participant had advanced knowledge of which cone would light up and only one protocol that consisted of five attempts was performed (scenario: A-B-A-B-A). Following the reliability analysis, the best achievement was retained as the final result for each participant.

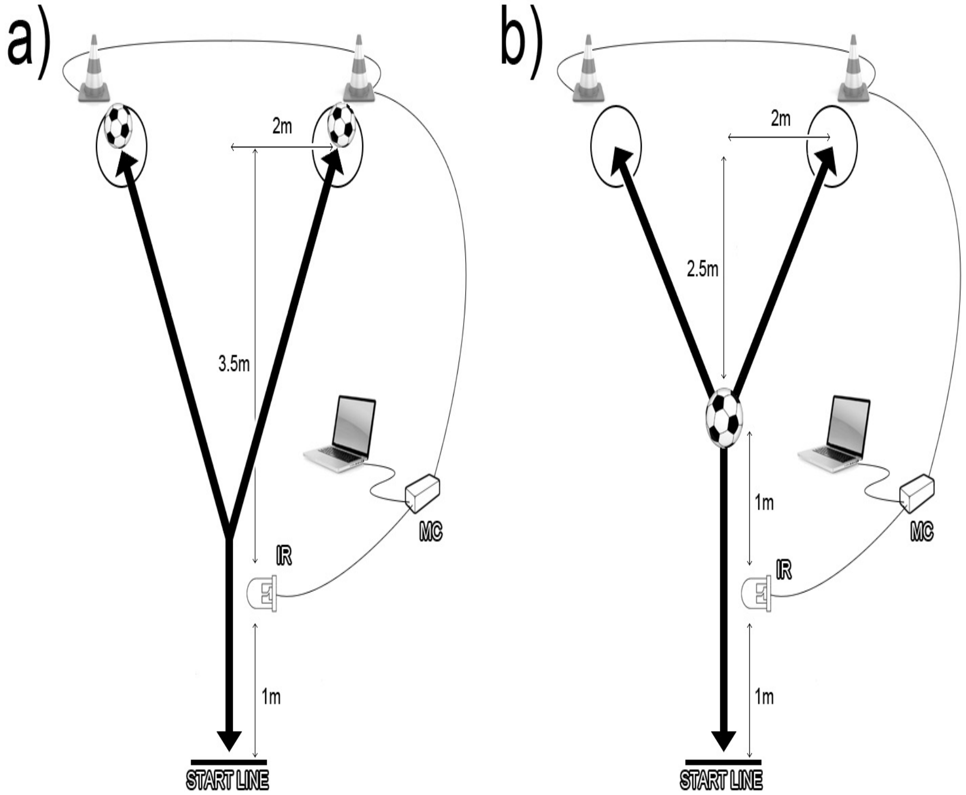

Figure 1 *Tests of specific football agility (FS_CODS and FS_RAG)*

Statistical analysis

The relative reliability is evaluated by calculation of Intra-Class-Correlation coefficients (ICC), while the absolute reliability was evaluated by calculation of the coefficient of variation (CV). Further, systematic bias was checked by analysis of variance for repeated measurements (ANOVA). The associations between studied variables were evidenced by Pearson's correlation. Finally, factor analysis was calculated to define the factorial validity of agility tests (FS-RAG, FS-CODS, and 20-yards).

Results

The reliability of the FS_RAG and FS_CODS is presented in Table 1. The newly developed football-specific tests were found to be reliable, with better reliability of FS-CODS (ICC: 0.81, CV: 6%), than of FS-RAG (ICC: 0.76, CV: 9%). ANOVA indicated significant differences between testing trials for RAG, but post-hoc analysis revealed significant differences between first trial and remaining two trials, indicating stabilization of the results until the third testing trial.

Table 1 *Reliability and descriptive parameters for the football-specific agility tests*

	Mean	Std Dev	ICC	CV	ANOVA F test (p)
FS-CODS					
Trial 1	2.59	0.15			
Trial 2	2.55	0.19			
Trial 3	2.54	0.27			
FS-CODS_final	2.45	0.18	0.81	0.06	3.12 (0.14)
FS-RAG					
Trial 1	3.62	0.40			
Trial 2	3.32	0.38			
Trial 3	3.21	0.39			
FS-RAG_final	3.19	0.40	0.76	0.09	7.11 (0.04)

Factor analysis extracted one significant factor under the Guttmann-Kaiser criterion (Explained Variance: 1.67), showing the appropriate factorial validity of newly developed tests in comparison to standard agility indicator 20-yards (Table 2)

Table 2 *Factor analysis results (F1 – correlations with main component, Expl Var – factor variance, Prp Totl – proportion of total variance explained)*

	F1
FS-CODS	-0.51
FS-RAG	-0.85
20 YARDS	-0.82
Expl Var	1.67
Prp Totl	0.56

Table 3 *Correlation coefficients among studied variables (* indicates statistical significance of p < 0.05)*

	FS-CODS	FS-RAG	20 yards
FS-RAG	0.58*		
20 yards	0.61*	0.60*	
Sprint 20 m	0.58*	0.52*	0.63*

Correlation coefficients among studied variables were statistically significant with percentage of explained variance ranging from 27–38% (Table 3).

Discussion

Good reliability of newly developed football-specific tests is outcome of variability of the sample. It is well known that greater diversity between the subjects contribute to the higher numerical values of the correlation coefficients which produces better reliability of the given test. Since sample of this study is consisted of preadolescent boys that have different maturation status and different quality level strong correlation between particles and good reliability of the tests are not surprising.

When comparing reliability results with current research in the area of agility performance testing resemblance can be noticed. Pojskic et al. (2018) defined the reliability and validity of newly developed tests of the reactive and non-reactive agility to discriminate between the performance levels of junior soccer players. They reported ICC for CODS 0.92 and for RAG 0.70–0.88 (Pojskic et al., 2018). In another study of Spasic et al. (2014) examined sport-specific tests of reactive-agility and change-of-direction-speed to replicate real-sport environment in handball. Results showed satisfactory reliability for reactive-agility-test (ICC 0.91–0.93) and CODS-test (ICC of 0.85–0.90). Study of Sekulic et al. (2017) determined the reliability and discriminative validity of 1 standard agility test and 4 newly developed basketball-specific agility tests, in defining playing positions and performance levels in basketball. Determined reliability was very high with ICC ranging from 0.91 to 0.95 for CODS and 0.85–0.86 for RAG (Sekulic et al., 2017). Although test validated in mentioned studies are not completely similar to our test and some of them were constructed for other sports than football we can say that our results of reliability are in agreement with recent studies in the area.

Better reliability of FS-CODS than of FS-RAG is result of error of measurement. Reactive agility (RAG) is more complex motor task than non-reactive (Sheppard & Young, 2006). As so participants have much more unstandardized movements that increase possibility of testing error. Similar explanation was offered by Sekulic et al. (2017) when authors compared CODS and RAG tests for basketball players on dominant and non-dominant side of performance (Sekulic et al., 2017).

Differences between testing trials for FS-RAG revealed learning effects. However post-hoc analysis indicated stabilization of the results until the third testing trial. Therefore, it is evident that reactive agility testing demands from participant perceptual and decision making qualities. As testing continues (second and third trial) participants are becoming more focused on visual scanning and pattern recognition. This help them in learning movement pattern and perform test better (Benvenuti, Minganti, Condello, Capranica, & Tessitore, 2010).

Factor validity of newly developed football agility tests is proven by its comparison to basic agility test 20-yards. It can be stated that both FS-CODS and FS-RAG belong to the same motor ability (agility) area in this age of football player’s development. Meanwhile, the significant correlations between all agility performances with S20M (Pearson’s R: 0.52–0.64; all $p < 0.01$) revealed that sprinting capacity significantly influence agility performances and that conditioning capacities of youth football players are not yet discriminated.

Conclusion

Results showed appropriate reliability and validity of the newly developed tests of football specific change of direction speed and reactive agility. Therefore, here proposed FS-CODS and FS-RAG can be used as reliable and valid measures of agility components in youth football players. Further studies should evaluate the discriminative validity of the here proposed tests (i.e. identification of position-specific or performance-related differences), as well as reliability in younger players than those studied herein.

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VITAMIN D STATUS AMONG YOUTH SOCCER PLAYERS; ASSOCIATION WITH CHRONOLOGICAL AGE, MATURITY STATUS, JUMPING AND SPRINTING PERFORMANCE

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Ivan Peric[1], Barbara Gilic[2, 3], Mateo Blazevic[2]

[1]*University of Osijek, School of Medicine, Croatia*
[2]*University of Split, Faculty of Kinesiology, Croatia*
[3]*University of Zagreb, Faculty of Kinesiology, Croatia*

ABSTRACT

Purpose: Vitamin D is known to have a significant role in numerous body-system processes. Specifically, it has an impact on muscle functioning and, therefore sports performance. Children and adolescents have increased need for vitamin D because of its importance in growth and development, and it is evident that they are more susceptible to have vitamin D deficiency. Consequently, vitamin D status is particularly important issue in youth competitive sport. The aim of this study was to determine the prevalence of vitamin D deficiency/insufficiency (measured as 25(OH)D concentration), and the possible associations between vitamin D, with age, maturity status, sprinting- and jumping-performance among youth soccer players.
Methods: The sample of participants in this research comprised 62 youth soccer players (age: 15.7 ± 2.2 years). They were divided into two categories according to 25(OH)D levels measured at the end of the winter season: group with inadequate levels of 25(OH)D (vitamin D deficiency/insufficiency [< 75 nmol/L]), and group with adequate levels of 25(OH)D (vitamin D sufficiency [> 75 nmol/L]). Biological maturity status (maturity offset) was calculated from participants age and height by the following equation:
Maturity offset = −7.999994 + (0.0036124 × (age(yrs.) × height(cm)). Performance variables were 10 meters sprint test (S10m) and countermovement jump test (CMJ).
Results: Results showed relatively good 25(OH)D concentrations (78.32 ± 23.39 nmol/L), with prevalence of deficiency (< 50 nmol/L) in 8.06%, and insufficiency (50–75 nmol/L) in 46.77% athletes. Significant correlations were evidenced between the CMJ and 25(OH)D level ($R = 0.27$, $p < 0.05$), but chronological age was also correlated with CMJ ($R = 0.64$, $p < 0.05$). Further, higher chronological age was found in participants with sufficient vitamin D levels (15.1 ± 2.4 vs. 16.4 ± 1.6 years; t-test = 2.43, $p < 0.05$). However, no significant association was evidenced between vitamin D and maturity status.
Conclusion: Vitamin D groups significantly differed by chronological age but not by maturity status, which collectively with correlation between CMJ and vitamin D status indicates that both vitamin D status and performance in youth soccer players is actually influenced by chronological age. Meanwhile, biological age doesn't have a significant physiological influence on vitamin D concentration, while some external factors (i.e. time spent outdoors, parental control, sunscreen usage), should be considered important.

Keywords: Vitamin D; age; maturity; jumping; sprinting; soccer

Introduction

Vitamin D is a pro-hormone soluble in fat; it can be synthesized upon skin exposure to ultraviolet B radiation or trough intake of food rich with vitamin D (i.e., fatty fish, eggs, cheese, mushrooms, etc.)

(Holick, 2007). Previously, vitamin D has been recognized mostly only for its beneficial effect on bone development and health as it regulates calcium and phosphate homeostasis, but more recently, vitamin D receptors have been found in many tissues, indicating its importance in regulating numerous body-system functions (Bischoff-Ferrari et al., 2004). Specifically, it might be necessary for optimal muscle function and performance, immune function, and inflammatory modulation. The discovery of vitamin D receptor (VDR) in skeletal muscle tissue provides evidence for the importance of this hormone in muscle metabolism (Hassan-Smith et al., 2017). Changes in protein synthesis, muscle regeneration, myogenesis, mitochondrial activity, and glucose metabolism have been proposed as molecular mechanisms affected by vitamin D, which are considered to make an impact on muscle function, strength and performance (Montenegro, Cruzat, Carlessi, & Newsholme, 2019). Nevertheless, low vitamin D levels in athletes are associated with low bone health, muscle function impairment, and decreased immune function, leading to the reduced regenerative capacity after the exercise session (Dahlquist, Dieter, & Koehle, 2015).

Athletes are more predisposed to have vitamin D deficiency most likely because of the increased active use in many metabolic pathways, therefore they require larger amounts of vitamin D compared to general population (Ogan & Pritchett, 2013). For this reason, it has been hypothesized that vitamin D could impact physical performance in athletes, but there is a limited number of studies which attained supportive results for this theory (Kopeć, Solarz, Majda, Słowińska-Lisowska, & Mędraś, 2013; Koundourakis, Androulakis, Malliaraki, & Margioris, 2014). However, the fact that vitamin D decreases bone fractures and muscle-tissue damage should be considered important for athletes health and, consequently, performance (Ceglia, 2008; DeLuca, 2004). Soccer is a sport which requires large amounts of sprints, jumps, fast changes of direction, and increased aerobic and anaerobic capacities in general. The study conducted on adult professional soccer players suggested that vitamin D is affecting neuromuscular and aerobic performance (Koundourakis et al., 2014). Therefore, it is possible that vitamin D levels could be related to physical performance in soccer players, and this is particularly possible in youth players because of their greater metabolic needs for this pro-hormone (Constantini, Arieli, Chodick, & Dubnov-Raz, 2010). Therefore, the aim of this study was to evaluate the association of vitamin D status with jumping- and sprinting-performances among youth soccer players.

Methods

The sample of participants in this research comprised 62 youth soccer players (age: 15.7 ± 2.2 years). All players were members of the same soccer club in Split, Croatia, and were engaged in systematic soccer training for at least 6 years. All the players have been informed of the purpose, risks, and procedures of the investigation, and were at good health and had no current injuries. Parental consent was obtained as athletes were under 18 years old. The testing was performed during February 2019.

The variables included players maturity status, vitamin D status as measured by 25(OH)D concentration (Bischoff-Ferrari, Giovannucci, Willett, Dietrich, & Dawson-Hughes, 2006), 10 meters sprint test, and countermovement jump test. The biological maturity offset (MO) predicts years from achieving the peak height velocity (PHV) and was calculated by the following equation: MO $= -7.999994 + (0.0036124 \times (\text{age(yrs.)} \times \text{height(cm)}))$; ($R^2 = 0.896$; SEE = 0.542)). A MO of −1.0 suggests that the athlete was measured 1 year before his PHV; a MO of 0 suggests that the player was tested at the point of the PHV; and a MO of + 1.0 indicates that the player was measured 1 year after the PHV (Moore et al., 2015). For the 25(OH)D measurement, the blood samples taken from the athletes were analysed at the accredited laboratory of the University Hospital of Split, Croatia. According to the 25(OH)D levels, players were divided into two categories: group with inadequate levels of 25(OH)D (vitamin D deficiency/insufficiency [< 75 nmol/L]), and group with adequate levels of 25(OH)D (vitamin D sufficiency [> 75 nmol/L]) (Karin et al., 2018). The 25(OH)D levels were measured using an Elecsys Vitamin D total assay with Cobas e601 analyser (Roche Diagnostics International Ltd., Rotkreuz, Switzerland). The 10 meters sprint test (S10m) was used for assessing the running speed. One photoelectronic timing gate (*Powertimer, Newtest*, Finland) was placed

10 meters from a marked starting line, and one gate was placed at the start line. The athlete had preferred foot placed on the marked line 1 meter before the start line, from the standing start, and had to run at maximum speed along the 10-meter field. 3 testing trials have been performed, with 2–3 minutes of rest between the trials (Sekulic, Spasic, Mirkov, Cavar, & Sattler, 2013). For the countermovement jump test (CMJ), players were starting from and upright position with hands placed on the hips. They performed fast downward movement to 90° of knee flexion followed by a maximum-force upward vertical movement. The Optojump system (Microgate, Bolzano, Italy), a dual-beam photoelectric device that measures flight time and ground contact time during a jump or during repeated jumps, has been used for measuring the CMJ (Sattler, Sekulic, Hadzic, Uljevic, & Dervisevic, 2012).

Statistics included frequencies and percentages (for Vitamin D status observed on categorical scales) and means and standard deviations (for continuous variables). The associations between variables was evidenced by calculation of Pearson's correlation coefficients. Additionally, t-test for independent samples between groups based on vitamin D status (vitamin D insufficiency/deficiency vs. vitamin D sufficiency) was calculated for age, maturity offset, CMJ and S10m.

Results

Results showed relatively good 25(OH)D concentrations (78.32 ± 23.39 nmol/L), with prevalence of deficiency (< 50 nmol/L) in 8.06%, and insufficiency (50–75 nmol/L) in 46.77% athletes (Figure 1).

Significant correlations were evidenced between the CMJ and 25(OH)D level ($R = 0.27$, $p < 0.05$), but chronological age was also correlated with CMJ ($R = 0.64$, $p < 0.05$) (Table 1).

The higher chronological age was found in participants with sufficient vitamin D levels (15.1 ± 2.4 vs. 16.4 ± 1.6 years; t-test = 2.43, $p < 0.05$). However, no significant association was evidenced between vitamin D and maturity status (Table 2).

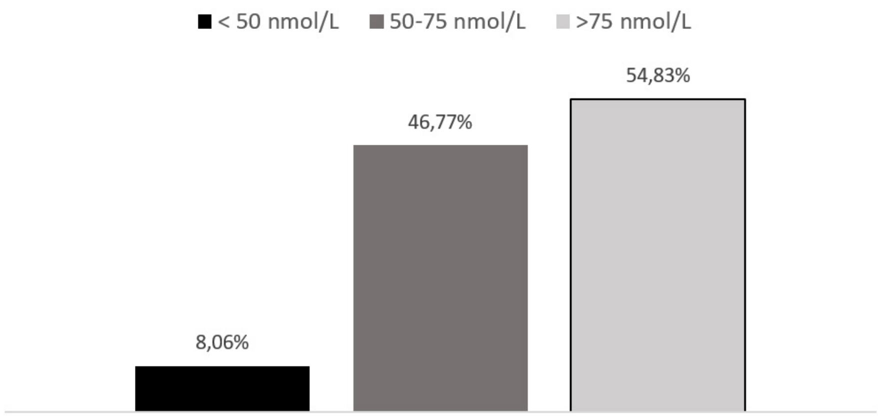

Figure 1 *Vitamin D status in youth soccer players (as measured by 25(OH)D)*

Table 1 *Correlation coefficients between studied variables*

	Age	MO	S10m	CMJ
Age				
MO	0.86*			
S10m	-0.60*	-0.36		
CMJ	0.64*	0.32	-0.68*	
VITAMIN D	0.28*	-0.10	-0.26	0.27*

*Legend: MO – maturity offset, S10m – sprint 10 meters, CMJ – countermovement jump, * denotes statistical significance of p < 0.05*

Table 2 *Descriptive statistics and t-test differences between groups based on vitamin D status*

	Vitamin D insufficiency/deficiency			Vitamin D sufficiency			T test	
	Mean	Std.Dev.		Mean	Std.Dev.		t-value	p
Age (years)	15.11	2.40		16.41	1.63		-2.43	0.02
MO (years)	3.58	0.63		3.35	0.91		0.76	0.45
S10m (s)	1.80	0.11		1.74	0.11		1.95	0.06
CMJ (cm)	31.09	5.71		33.70	6.02		-1.64	0.11

Legend: MO – maturity offset, S10m – sprint 10 meters, CMJ – countermovement jump

Discussion

We have found good results for vitamin D with only 8.06% / 46.77% soccer players with vitamin D deficiency/insufficiency. Meanwhile, recent study of Karin et al., done in the same region as our study, reported 58% / 29% of studied children being vitamin D deficient/insufficient (Karin et al., 2018). Danish study found 45% vitamin D deficiency among youth swimmers (Geiker et al., 2017). However, such differences in results could be explained by differences in the samples of participants. Briefly, Karin et al. investigated pre-schoolers, and it is known that children at this age have different biological and metabolic processes as they are in the phase of intensive growth and development (Rogol, Clark, & Roemmich, 2000). Meanwhile, Danish participants were swimmers and therefore spent most of their training in the indoor facilities, contrary to soccer players who practice outside.

Of all studied performance variables, only CMJ was significantly correlated with 25(OH)D, theoretically supporting the thesis that vitamin D has an impact on muscle functioning as suggested previously (Cannell, Hollis, Sorenson, Taft, & Anderson, 2009). Indeed, the results of the study evaluating vitamin D and exercise performance in professional soccer players suggested that vitamin D level is associated with muscle strength, also expressed by horizontal jumps (CMJ and Squat jump) (Koundourakis et al., 2014). However, our results showed that players with greater CMJ and higher vitamin D levels are also chronologically older, indicating that chronological age is actually a confounding factor of relationship defined between CMJ and vitamin D status (i.e. older children jump higher, and at the same time have higher vitamin D levels).

The finding that chronological age, but not maturity status, is correlated with higher vitamin D levels could lead to the assumption that biological age does not have a significant influence on physiological processes at the studied athletes. Supportively, study done with young hockey players which were divided into vitamin D sufficient-insufficient groups, that also had a low prevalence of vitamin D insufficiency (13.3%), showed that athletes with better vitamin D levels were older (Mehran, Schulz, Neri, Robertson, & Limpisvasti, 2016). Collectively, it is reasonable to conclude that other, external factors are more important concerning vitamin D status. These factors are most likely the amount of time spent outside exposed to sunlight, clothing, sunscreen usage, nutritional habits etc. (Hagenau et al., 2009). Specifically, for children and adolescents who live with their parents, all previously mentioned factors could be highly influenced by parenting style, simply because of the parental influence on their children lifestyle. For example, in the studied region, there is a growing concern about possible negative influence of sunlight radiation on skin health. Therefore, in the recent years parents sometimes (over)protect children from sunlight exposure by reduction of the time the children are exposed to sunlight, extensive usage of the sunscreens with high protective factors, and clothes. Altogether it could result in a lower vitamin D levels in younger children, who are naturally under the stronger parental influence then older ones.

Conclusion

Vitamin D groups significantly differed by chronological age, but not by maturity status. Together, with the correlation between CMJ and vitamin D status indicates that both vitamin D status and performance in youth soccer players are influenced by chronological age. Meanwhile, our results indicated that biological age does not have a significant physiological influence on vitamin D concentration, while some external factors like time spent outdoors, parental control, and sunscreen usage, should be considered important determinants of vitamin D status in studied players.

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THE IMPACT OF CORE EXERCISE AND MYOFASCIAL RELEASE IN THE INITIAL PART OF TRAINING ON THE PERFORMANCE AND PREVENTION OF INJURIES IN FOOTBAL PLAYERS

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Patrik Beňuš[1,2], David Líška[1], Daniel Gurín[1], Martin Pupiš[3], Zuzana Pupišová[3]

[1]*Slovak Medical University in Bratislava, Faculty of Health in Banská Bystrica, Slovakia*
[2]*Football club Jupie* FŠMH*, Slovakia*
[3]*Faculty of Arts, University of Matej Bel in Banská Bystrica, Slovakia*

ABSTRACT

Introduction: One of the basic processes to improve stability and prevent injuries in sport is warming up. The aim of our work is to verify the impact of the first part of the training unit (warm-up) on the stability and performance of the footballer.
Probands: The research work was carried out on 37 football players in the category U-19 and U-17 in the football club – JUPIE football school of Marek Hamšík. Probands were divided into two groups. The test group consisted of 19 U-19 football players (age average 17.2 ± 0.87), the control group consisted of 18 U-17 football players (age average 15 ± 0.5).
Methods: Both groups underwent input measurement consisting of Y balance test and performance tests – slalom with ball, run 5 × 10m. Subsequently, the test group footballers underwent our intervention, myofascial release + core training, which was added to the opening part of the training unit. The study lasted 4 weeks.
Results: Probands of both groups achieved a statistically significant improvement in the y balance test. When comparing the performance tests, they achieved significant improvement in the test group – run 5 × 10m ($p = 0.0024$) and slalom with the ball ($p = 0.0159$) and in the control group – run 5 × 10m ($p = 0.0182$). The improvement in slalom with the ball test in the control group was not statistically significant ($p = 0.1798$).
Conclusion: We have shown a significant effect of core exercises and myofascial release at the beginning of the training unit. However, the benefit was also achieved in the control group, except for the test - slalom with the ball.

Keywords: postural stability; Y balance test; core training; myofascial release; football

Introduction

Movement or sports can be performed on different levels, from recreational form to amateur to the level of professional sports. Improving one´s skills is most often the main purpose of sports. Athletes try to achieve ever better performance through different procedures. Whether it is forms of regeneration, special training, or precisely defined concepts for the sport. Injuries are another very important topic in athletes. They want to avoid it as much as possible, because it make them to lose their player’s form, to take short or long breaks from their active work and to change their financial ratings on a professional level.

A lot of injuries are behind the decline in performance, depending on the development of a sports career and ultimately can also end the sport activity. Football, despite being a contact sport, brings several injuries that are not caused by contact with other player on the pitch. On the other hand, players get injured without contact with other players. It is mainly an ankle or knee injury. Nowadays, when football pitches already have a fairly good surface quality, it is not possible to refer to the "crooked terrain" as was often mentioned in the past. In our work, we focus on role of postural stability of players and the possibility of influencing stability by changing first part of the training process – warming up.

The Aim

The aim of work was to determine the level of postural stability using the Y balance test kit in football players and subsequently to determine the effect of myofascial release and core exercises on postural stability and performance in general and special tests of football.

A partial goal of our work was also to trace the prevalence and incidence of individual injuries in football players tested by us during their playing career. Data were collected through a questionnaire.

Participants

The sample included 37 participants that were football players in the U-19 and U-17 category in the football club - JUPIE Marek Hamšík football school. Probands were divided into two groups. The test group consisted of 19 football players in category U-19 (age average 17.2 ± 0.87), the control group consisted of 18 football players in category U-17 (age average 15 ± 0.5).

Methods

The participants, who were divided into two groups (test, control), were tested in two stages – diagnostic measurement and output measurement. The test group was tested before and after intervention. The control group was run concurrently with the test group before our intervention, and then the output measurement after our program (4 weeks), which we performed with the test group. We compared the results within and between groups. Diagnostic measurements in both groups were performed as follows. We introduced the players to the whole testing process. Subsequently, we obtained personal data (gender, age, weight, height, playing post, dominant leg) from respondents of both groups using a questionnaire. The questionnaire also included questions on the prevalence and incidence of injuries during the previous football career and also this season, as testing was making in the winter period of football season (mid-season 2018/2019). Questions were also focused on the mechanism of injury (contact, non-contact) and how often individual types occurred. Wound localization and injured structures (muscle, joint, bone) were also followed. After obtaining the data, there was a standard club warm-up, which consisted of warming up the organism (2 min. Free running + motion game – in our case chase for 5 minutes), followed by running alphabet and dynamic stretching. After the collective warm-up, we started to measure postural stability by means of the Y balance test, in our case the Y balance test professional kit. First, we measured the length of the lower limb that was needed in the evaluation. The limb length was measured in the supine, from SIAS - anterior superior spina to malleolus medialis.

The test was performed in the following order, in the anterior direction, followed by posteromedial and then posterolateral. In each direction, the respondent had to record three successful attempts. After testing the stability, we switched to performance testing by testing the general part - boat running 5 × 10m and testing individual gaming activity – slalom with the ball.

After the diagnostic measurement, we entered the training process of the test group. The control group continued its training process without our intervention. So, according to the instructions of the coach, he was instructed not to change the opening / preparation part of the training unit – from the standard club warm-up in the category. So it was similar to what we described before the diagnostic measurement. Regarding the introductory part of the training group of the test group, we intervened as follows: the training started with 3 minutes running on pitch (with / without ball), then each player took a soccer ball to serve as a foam roller for myofascial release – these muscle areas have gradually relaxed – calf, hind thigh, outer thigh, anterior thigh, inner thigh, back – each region for 10 seconds. Subsequently, players of test group practiced core training, which consisted of the following exercises: plank on palm, plank on forearm, plank side on the forearm (both side), endurance in the squat, glute bridge on one leg (right/left), superman (5 reps with 5s endurance), eccentric decline squat (5 reps on each leg). The exercises were performed for 25 s, with 10 s pauses between exercises. Core exercises were performed in two series. Between the series, the players practiced an exercise with a passing ball. The second series of core exercises followed by activation / mobilization, it means exercises with dynamic stretching elements, in a collective form. This training program lasted for 4 weeks (from 21 January to 15 February 2019). After the 4-week program, the final measurement was performed, where all tests were again tested as in the diagnostic measurement (Y balance test, 5 × 10m boating, slalom with ball) with the same process.

Questionnaire

The non-standardized questionnaire we created contained 20 questions, which consisted of two parts:

- *Part 1* consisted of questions for obtaining personal data: age, height, weight, playing post, dominant lower limb; the age category;
- *Part 2* consisted of injuries related to sports activity, in particular from football.

The questionnaire consisted of open questions where the respondent himself answered the question, closed questions where the respondent had to choose the answer from the given options. Among the elimination criteria we included incomplete listing of the questionnaire and the reluctance of football players to issue a questionnaire.

Y balance test

We tested players for Y balance test (YBT) using the Y balance test kit, we made sure that there was one, at most two testers in the test room to eliminate disturbing factors, such as to compete and compare with other players. Subsequently, the proband was asked to remove the shoes and in the case of inappropriate clothing for testing he was asked to remove his underwear so that the clothing did not prevent him from performing the maximum reach. Then there was a verbal explanation of testing for the Y balance test kit and a demonstration of the therapist. After that, the respondent made measurements. Testing proceeded as follows:

1. right leg in anterior direction (3 successful attempts) and then left leg in anterior direction (3 successful attempts)
2. right foot in posteromedial direction (3 successful attempts) and then left foot in posteromedial direction (3 successful attempts)
3. right leg in posterolateral direction (3 successful attempts) and then left leg in posterolateral direction (3 successful attempts)

Failure was evaluated according to YBT standards. The duration of the test depended on the ability to perform a successful YBT experiment. Some probands did 3 successful attempts for the first time, some needed more attempts.

In our work, we have identified a risk factor for injury, a data based on YBT testing. The composite reach distance below 94% as well as the second risk factor was the absolute reach asymmetry (in the anterior and posteromedial directions) with a difference ≥ 4 cm. (Plisky, 2006; Smith, 2015; Gonell, 2015)

Run 5 × 10m – acceleration factor

At a distance of 10 m from each other we mark two parallel lines on the track. Behind the first of them from the half-start, starts the tested to the second line. After stepping one foot behind the other line, it returns as quickly as possible beyond the starting line, which must again cross one leg. In the same way he will pass all 5 sections without interruption. There was only one run, who had two attempts with a minimum break of 5 minutes between each start. We recorded only the best respondent time in the statistics. Time was measured with a GARMIN Forerunner 235 Optic sports watch.

Slalom with ball – the level of technical mastery of ball at speed

The player must run obstacle course as fast as possible with the ball. There were eight cones at an unequal distance, the track twists twice at right angles. We recorded only the best respondent time in the statistics. Time was measured with a GARMIN Forerunner 235 Optic sports watch. Test sketch:

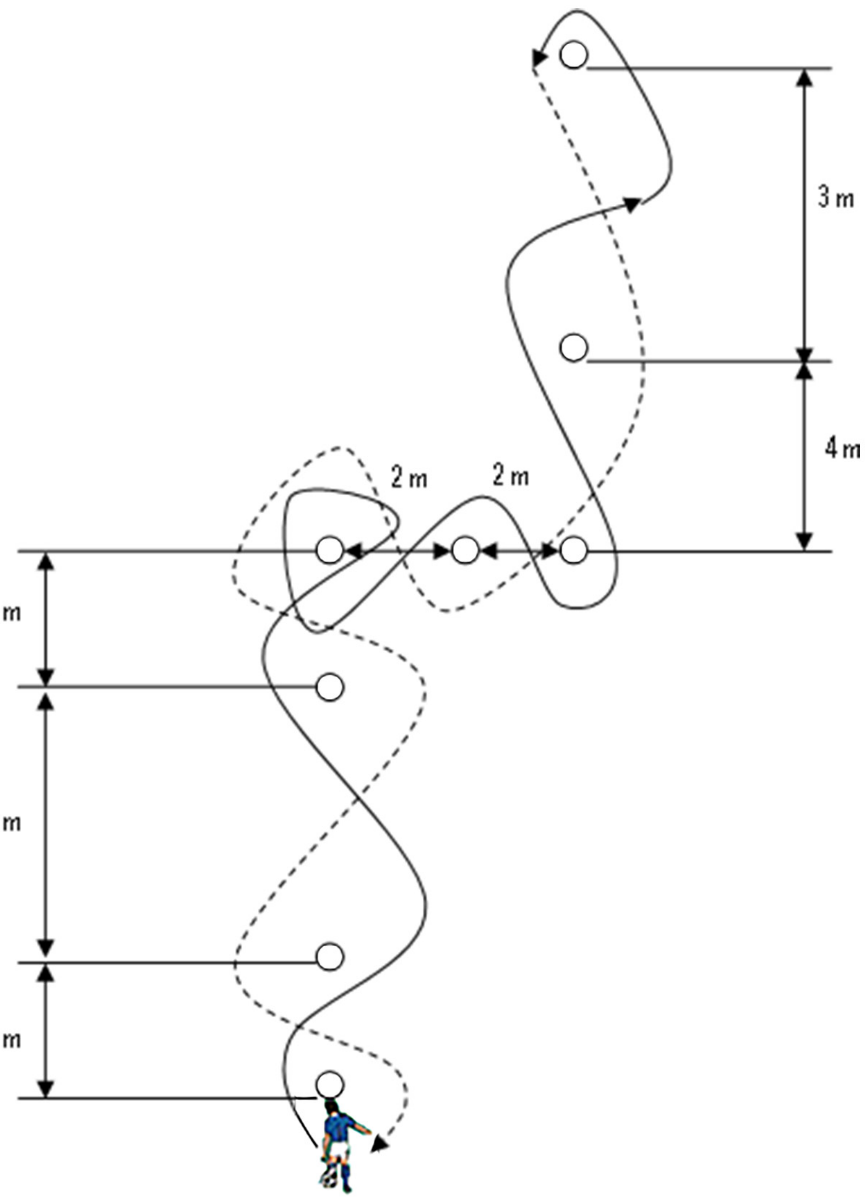

Figure 1 *Slalom with ball*

Statistical methods

For processing of data we used descriptive statistics with meaning arithmetic average and standard deviation. Based on normal data distribution we used paired T-test for comparison in groups. In comparing between groups we used the T-test with unequal variance. The interdependencies were determined based on Pearson's correlation coefficient. A significance level of 95% (α = 0.05) was determined for all established comparisons.

Results

The test group consisted of 19 football players who completed 20 training units from 21. January 2019 to 15. February 2019. The control group consisted of 18 football players who completed 20 training units from 8. January 2019 to 3. February 2019. Group characteristics and data of injury is shown in Table 1.

Table 1 *Basic characteristics of groups*

	The test group	**The control group**
Age	17,2 ± 0,87	15 ± 05
BMI	21,88 ± 1,67	20,1 ± 1,75
Without injury	2	1
1 injury	0	4
2–3 injuries	8	6
4–6 injuries	5	7
6 or more injuries	4	0
Average career injuries	3,71	2,69
Contactless injury	4	4
Contact injury	5	5
Both forms of injury	8	8
Without injury	2	1
Contactless injury dominance	10	7
Contact injury dominance	7	10
***The number specifies the number of players**		

Evaluation of results at YBT:

**PDK= right lower limb*
***ĽDK= left lower limb*

The respondents of the test group achieved a statistically significant improvement when comparing the composite range of reach in the input measurement for PDK was 93.51 ± 8.76% compared to the 95.63 ± 8.95% measured in the output measurement (p = 0.010). There was also a statistically significant improvement for ĽDK at 94.78 ± 7.96% in the input measurement versus 96.36 ± 8.70% in the output measurement (p = 0.038).

The control group respondents achieved a statistically significant improvement when comparing the composite range of reach in the input measurement for PDK was 89.31 ± 5.24% compared to 91.55 ± 5.62% measured in the output measurement (p = 0.025). There was also a statistically significant improvement for ĽDK at 89.51 ± 6.19% in the input measurement versus 91.66 ± 5.45% in the output measurement (p = 0.0279).

Comparisons of diagnostic and outcome evaluation of YBT data and performance tests in the test and control group: Respondents of both groups achieved a statistically significant improvement in run 5 × 10m; in the test group, input measurement 13.13 ± 0.82 (s) versus output measurement 11.83 ± 0.62 (s) (p = 0.0024); in the control group, an input measurement of 12.36 ± 0.77 (s) versus an output measurement of 12.27 ± 0.69 (s) (p = 0.0182). When comparing the slalom performance test with the ball, a statistically significant improvement was achieved by the test group, the input measurement of 19.73 ± 1.25 (s) over the output measurement of 19.53 ± 1.08 (s) ($p = 0.0159$); in the control group, the change was not statistically significant, the input measurement 20.13 ± 1.22 (s) versus the output measurement 20.03 ± 0.90 (s) ($p = 0.1798$). Comparison of absolute impact asymmetry (in anterior and posteromedial direction) to YBT within the group was not statistically significant. For the test group in the anterior direction ($p = 0.255$) in the posteromedial direction ($p = 0.095$). For the control group in the anterior direction ($p = 0.406$) in the posteromedial direction ($p = 0.055$).

Discussion

Low levels of postural stability, changed motor control, or insufficient neuromuscular control were all described as predictors of lower limb injury in athletes. The implementation of an injury prevention program, which includes exercise for balancing and neuromuscular control of footballers, has been shown to reduce injuries and also reduce healthcare costs (McGuine, 2000). The aim of our work was to determine the level of stability of YBT players and also to verify the impact of basic exercises and myofascial release on the stability and performance of players.

There was no statistically significant change in either the test or control group when comparing the input and output testing results for absolute reach asymmetry in the anterior and posteromedial direction. However, we have noticed a change in the correlation of asymmetry of reach and number of injuries. In the test group, there was a correlation between asymmetry reach of anterior direction and the number of injuries at the input measurement ($r = 0.51$), at output, the correlation decreased ($r = 0.37$). In the control group, the correlation was at input ($r = 0.03$) and output ($r = 0.41$). In the posteromedial direction, the correlation between asymmetry of reach and injuries was very low. Based on the results, there is therefore a correlation between the asymmetry of reach in the anterior direction and the number of injuries. Our results agree with the study presented by Plisky, 2006 and Smith, 2015.

In our work, we included an intervention in the test group in the form of a change in warming up compared to the control group. The intervention consisted in a change or addition of core exercise elements that have positive effects as prevention of injuries and support performance improvement – Soligard, 2008; Leetun 2004; Peate, 2007. Based on our results, the full effect of our intervention in improving YBT results in the test group ($p = 0.010$ for PDK, $p = 0.038$ for LDC) cannot be attributed, since the control group also achieved statistical improvement ($p = 0.025$ for PDK, $p = 0.0279$ for LDK). When comparing the results between the groups, there were differences in both the input and output testing. However, a comparison of the average of the differences did not show statistical significance. However, despite these results, we did not rule out the effect of core training and myofascial release to improve stability on YBT. Intervention could also contribute to improving stability and performance at YBT. It is important to recall that the intervention took place for 4 weeks in the winter period of season, where the emphasis is placed on the physical aspect of the athlete – strength, speed, etc. And just the strength increase could have contributed to improving the results of the YBT control group. It would certainly be interesting to continue our program or add the intervention we have created to the training process during the competition period.

Some authors describe that core exercise and also myofascial release has an impact on improving sports performance – Afyon, 2017; Nesser, 2008; Healey 2014; MacDonald 2013. Based on our results when comparing the effect of the intervention on the sports performance of a football player, we achieved a statistical improvement in both tests in the test group ($p = 0.0024$ run 5 × 10m; $p = 0.0182$ slalom with ball). In the control group, we observed only a significant change in the run 5 × 10m ($p = 0.0182$); Just as the YBT performance could be affected by the winter period of season and its training process could also be affected by performance testing. However, the effect of core training and myofascial release seems to have a significant effect on the need to improve the individual's gaming activity over the control group.

The nervous system is 90% developed within 8 years of age. Coordination skills in boys develop between 7 and 12 years (Laczo, 2014). Thus, there is no assumption that age differences in groups could affect results due to ontogenesis.

Conclusion

Observation of the results, we demonstrated a significant effect of core exercise and myofascial relaxations at the beginning of the training unit. However, the benefit was also achieved in the control group. Our intervention contributed to improving stability on the Y balance test kit, and also showed a significant improvement in the performance tests – run 5 × 10m, but especially in the individual gaming activity of the individual – slalom with the ball, where there was no significant improvement in the control group. Further work could complement the relationship of core training and myofascial release to performance on the Y balance test kit, because we have not confirmed or refuted this relationship in our work.

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BREATHING PATTERN DURING LOAD AND ITS CHANGE DUE TO THE INTERVENTIONAL PROGRAM OF BREATHING EXERCISE

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Petr Bahenský, Tomáš Hermann, Renata Malátová

Department of Sports Studies, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic

ABSTRACT

Purpose: Correct breathing pattern in resting breathing is connected to the overall physical health, whereas the breathing pattern affects the performance in endurance sports. The principle of breathing economy consists primarily of the involvement of diaphragm as the main breathing muscle. The paper is engaged in the breathing stereotype in resting breathing and breathing under load. The objective of our paper is to verify whether it is possible to influence breathing stereotype by applying a two-month intervention breathing program.
Methods: The paper examines changes in the resting breathing stereotype and the breathing stereotype during load in adolescent, healthy runners. Twenty participants took part in the intervention. They underwent initial and final tests of the breathing stereotype at rest and in submaximal load. Eleven of them were members of an experimental group and the remaining nine constituted a control group. The experimental group included seven boys at the age of 16.1 ± 1.3, with height 173.2 ± 6.5 cm and weight 56.8 ± 4.6 kg, and four girls at the age of 16.5 ± 0.5, with height 161.7 ± 3.1 cm and weight 54.3 ± 2.3 kg. The breathing stereotype was measured using muscle dynamometer MD03 before and during a indirect calorimetry test conducted on a bicycle ergometer. The data obtained were evaluated in terms of substantive (Cohen's d) and statistical significance (α = 0.05).
Results: The breathing intervention resulted in positive changes in the breathing stereotype at rest and under load. At rest, the engagement of the abdominal segment increased by 16.2%, that of the thoracic segment and subclavian segment decreased by 3.6% and 12.6%, respectively, when compared to the initial test. In the submaximal load, the engagement of the abdominal segment increased by 4%, and there was a decrease by 2% for both the thoracic and subclavian segments in comparison to the initial test. The control group showed no significant changes in the engagement of the individual segments of breathing muscles.
Conclusion: Our results has proved that a two-month interventional program of breathing exercises, aimed at activation of the diaphragm and other breathing regions, has a substantial influence on the breathing stereotype both at rest and in the submaximal load.

Keywords: breathing; breathing pattern; breathing exercise; load; diaphragm

Introduction

Breathing is connected not only with gas exchange, but also with the postural function (Hodges & Gandevia, 2000). Breathing movements are divided into three sectors: abdominal, lower thoracic and upper thoracic (Kolář et al., 2009; Véle, 2012). At resting breathing, the lower (abdominal) sector is the first to be activated, followed by the middle sector and then by the upper breathing sector. This gradual activation gives rise to a breathing wave (Dylevský, 2009). In abdominal breathing, the diaphragm is the organ to be most engaged. Thoracic breathing is characterized by predominant engagement of inter-rib muscles. In case of intensive breathing, inter-rib muscles work on expiration as well; in resting breathing, expiration is passive and is taken care of by the elasticity of thorax (Šponar, 2003). In this type of breathing, the body takes in less oxygen in comparison with abdominal breathing (Lysebeth, 1984). In subclavius breathing, inter-rib muscles are engaged, as in thoracic breathing, and in addition, cervical oblique muscles are also active. In clavicular breathing, the less movable shortest ribs are engaged as well: subclavius breathing therefore requires more effort than in case of rib breathing (Šponar, 2003).

The diaphragm is the major breathing muscle on whose activities depends approximately two thirds of gas exchange in lungs (Fleischmann & Linc, 1987). Ganong (1995) and Kolář et al. (2009) argues that in resting breathing, the diaphragm is responsible for up to 75% changes of the thorax volume. Dylevský (2009) maintains that the abdominal sector, which is associated with the activity of the diaphragm, is responsible for 60% of the total efficacy of breathing. In resting breathing, abdominal breathing, thoracic or rib breathing and subclavian breathing would have 60%, 30% and 10%, respectively, within a single breathing wave (Šponar, 2003).

The energy demands of breathing at rest make up approximately 2–5% of the total energy consumption of the body. During intensive muscle work, energy consumption may increase severalfold, especially in persons with limited pliability of lungs or increased resistance of breathing pathways (Slavíková & Švíglerová, 2012). The mechanics of breathing changes during physical activities. Up to a certain intensity (ca. 40 breaths per minute), expiration muscles need not be used, inspiration is active and expiration is passive. Upon reaching a certain level of load intensity, expiration muscles (internal inter-rib muscles and abdominal muscles) must be engaged: this engagement invokes a large consumption of energy. Deep breathing with a lower breathing frequency is more advantageous in economic terms (Havlíčková et al., 2006). Regular endurance physical activities improve the breathing mechanics. The share of diaphragm breathing increases in case of physical load. Trainers and singing teachers lay great emphasis on diaphragm breathing (Bartůňková et al., 2013). Clifton-Smith (2017) states that the athletes who were identified to have a defect of the breathing paters often show an increased rest tone of oblique muscles. If active at rest, these muscles can have an effect of an abdominal corset, which prevents the diaphragm from descending, and creates a dominant pattern of the upper part of thorax.

The examination of maximum inspiration and expiration presses serves for evaluating the strength and functional condition of breathing muscles (De Turk & Cahalin, 2004). To evaluate the breathing stereotype, the following methods may be applied: palpation examination of breathing, whole-body plethysmography, skiagram of thorax, spirometry, or various tools recording changes of the elevation of individual segments of the torso (Cahalin, 2004; Kandus & Satinská, 2001). The engagement of individual segments of muscles can be recorded e.g. by means of a 3-dimensional system (Kaneko & Horie, 2012) or by circumferential parameters of thorax (Bockenhauer et al., 2007; Cahalin, 2004). Another option is to determine the activity of breathing muscles by polyelectromyographic examination (Kandus & Satinská, 2001). The strength of breathing muscles may be examined also by non-invasive examination methods of maximum inspiration and expiration oral pressures (Rochester, 2003) or by means of a muscle dynamometer (Malátová, Bahenský, Kanásová, & Štumbauer 2019; Malátová, Bahenský, & Mareš 2016).

The objective of breathing exercises is to achieve an optimum breathing economy. It is possible to change the breathing stereotype by practising deep breathing, a fact confirmed in their work also by Thomas & McIntosh (1994). When practising, the breathing pattern of participants must be monitored and participants must be notified of inadequacies, if any (Smolíková & Máček, 2010). To achieve a required effect, at least ten breathing exercises must be done, whence the important regular rhythm is created by the body. Static, dynamic and mobilization breathing gymnastics are the most common form used in practice (Kolář et al., 2009). Breathing techniques include isolated breathing, where three different manners of breathing are practised: diaphragm breathing, thoracic breathing and subclavian breathing. The objective of practising diaphragm breathing is in particular to become aware of the diaphragm activity and to learn to control this activity. In turn, the objective of practising thoracic breathing is to increase the elasticity of the rib cage. The objective of practising subclavian breathing is to relax the region of nape and to become aware of the accessibility of upper lung apexes (Lysebeth, 1984). To influence the intermuscular coordination and improve the effect of intermuscular coordination, physical exercises must be done for six to eight weeks as a minimum. Adaptation changes in the form of hypertrophy will show after a longer period, in the range of months and years (Dovalil et al., 2005). The aim of our paper is to verify whether the breathing stereotype during load may be affected by applying a two-month intervention breathing programme.

Methods

This study was implemented at the DPSS of FE of SBU in the Laboratory of Load this Diagnostics. The ethics committee PF JU approved (this) study on October 19, 2018 (002/2018). All subjects have given their informed consent to participate in the research study. The study was attended by 20 middle and long distance runners who have been engaged in endurance training for at least six times a week for one year as a minimum. Eleven of these runners formed an experimental group and the remaining nine became members of a control group. The experimental group consisted of seven boys at the age of 16.1 ± 1.3, with height 173.2 ± 6.5 cm and weight 56.8 ± 4.6 kg, and four girls at the age of 16.5 ± 0.5, with height 161.7 ± 3.1 cm and weight 54.3 ± 2.3 kg. Members of the control group were five boys at the age of 16.3 ± 1.3, with height 172.7 ± 5.5 cm and weight 57.4 ± 4.7 kg, and girls at the age of 16.6 ± 0.5, with height 161.0 ± 4.7 cm and weight 52.9 ± 2.5 kg. The selection was intentional, whereas endurance athletes were chosen because their breathing functions are above-average, a fact implied in the character or specialization of their training. According to the selection criteria, the decisive factors included the adolescent age and at least one-year endurance training.

The paper examined a change of the resting breathing stereotype and the breathing stereotype under load in adolescent, healthy runners. The runners underwent an initial (pre-intervention) and final (after the intervention of breathing exercises) examinations of the breathing stereotype at rest and in the submaximal load (at 4 W . kg^{-1}) during a indirect calorimetry test on a bicycle ergometer. Within the indirect calorimetry test, the initial two-minute warm-up phase at the load of 1 W . kg^{-1} was followed by an escalating test, when the load increases by 0.5 W . kg^{-1} every minute until the test is interrupted by the participant himself/herself. Every participant underwent the same test, with the initial load standing at 1.5 W . kg^{-1}.

The set of breathing exercises was based on yoga and the aim was to activate the diaphragm and to become aware of individual breathing sectors. The intervention programme was held for two months, when the tested group of participants conducted exercises focused on isolated breathing in various positions, practising the breathing wave, full breath and rhythmic breathing. Exercises were carried out in various positions: in a lying position, in a sitting position on heels, in sitting, kneeling and standing positions. Breathing exercises in these positions encourage and invoke changes in the breathing stereotype. Moreover, full breath was practised in accordance with movement in short dynamic sets (Bursová, 2005). The acquisition of breathing exercises was effectuated during the first week of breathing intervention, in the framework of three joint sessions. Breathing during the breathing exercises was done through the nose. At the beginning of the intervention, participants breathed spontaneously, and later proceeded to the extension of the inspiration and expiration phases. Participants carried out exercises at least five times a week for ten minutes as a minimum. Every week, one joint session was held, where the performance of breathing exercises was monitored and corrected. Information on the length of the exercises conducted was recorded by participants; this information was processed on a continuous basis.

Control diagnostics came up after 8 weeks of the application of intervention. The control group was tested at the same time as participants of breathing exercises intervention. Members of the control group performed no breathing exercises. Throughout the intervention period, both groups underwent the identical running training. The breathing stereotype was measured using muscle dynamometer MD 03 before and during the indirect calorimetry test on a bicycle ergometer, for one minute at every stage of the test . The data obtained were assessed in terms of substantive significance by Cohen's d and statistical significance (α = 0.05). The data were processed using the following: Cohen's d to determine substantive significance, Student's paired t-test for depended selections to determine statistical significance. The level of significance was determined at the level of significance $\alpha = 0.05$. Data were processed in programmes Microsoft Excel 2016 and Statistica 12.

Results

Participants carried out breathing exercises for the average of 13.5 ± 3.6 minutes per day during a two-month period. As regards the experimental group, in resting breathing, engagement in the abdominal sector deepened on a substantive significant level, with a large effect (d = 1.20). Initial values 0.55 ± 0.23 N.100 ms^{-1} increased to 0.98 ± 0.44 N.100 ms^{-1}. Engagement in the thoracic sector decreased in substantive significant terms, with a small effect (d = 0.34) from initial values 0.90 ± 0.60 N.100 ms^{-1} to 0.74 ± 0.32 N.100 ms^{-1}, in subclavian sector, the decrease in engagement was insignificant, from initial values 0.52 ± 0.34 N.100 ms^{-1} to 0.49 ± 0.28 N.100 ms^{-1}.

A statistically significant change was recorded for the abdominal sector only. A percentage change is illustrated in figures 1 and 2, where there was a significant increase in the proportion of engagement of the abdominal sector – by 12%. The percentage engagement decreased in the thoracic sector and subclavian sector by 8% and 4%, respectively. Considering the control group, no significant change in the strength of load of probes occurred, the same applies to the engagement of individual sectors. Initial values on the abdominal sector reached 0.61 ± 0.26 N.100 ms^{-1}, and final values were 0.61 ± 0.26 N.100 ms^{-1}. In the thoracic sector, initial values stood at 0.97 ± 0.52 N.100 ms^{-1}, and final values were 0.96 ± 0.52 N.100 ms^{-1}, in the subclavian sector, the initial values were 0.51 ± 0.31 N.100 ms^{-1}, and final values reached 0.52 ± 0.31 N.100 ms^{-1}. No percentage change occured, the engagement of the abdominal sector, thoracic sector and subclavian sector was 32%, 44% and 24%, respectively.

In breathing at the submaximal load, the engagement of all sectors observed increased significantly. Breath deepened considerably and breathing frequency decreased significantly. The change for the abdominal sector has a large effect (d = 1.02), from initial values 1.41 ± 0.63 N.100 ms^{-1} to 2.11 ± 0.74 N.100 ms^{-1}, also the percentage engagement of this sector increased by 2% (see figures 3 and 4). The thoracic sector is characterized by a substantially significant increase in the engagement, with a medium effect (d = 0.72), from initial values 2.83 ± 1.10 N.100 ms^{-1} to 3.59 ± 1.03 N.100 ms^{-1}, the percentage engagement decreased by 2%. The engagement of the subclavian sector increased significantly, with a small effect (d = 0.31), from initial values 1.57 ± 1.05 N.100 ms^{-1} to 1.90 ± 1.12 N.100 ms^{-1}; the percentage share in breathing remained unchanged. A statistically significant change was identified only for the abdominal sector. In the control group, there were no significant changes of the parameters observed. The initial values for the abdominal sectors reached 1.23 ± 0.49 N.100 ms^{-1}, and final values were 1.23 ± 0.48 N.100 ms^{-1}. The initial values for the thoracic sector stood at 2.75 ± 1.17 N.100 ms^{-1}, and final values were 2.76 ± 1.18 N.100 ms^{-1}. For the subclavian sectors, the initial values were 1.43 ± 1.08 N.100 ms^{-1} and final values stood at 1.44 ± 1.08 N.100 ms^{-1}. The percentage share in breathing for all sectors remained unchanged. The engagement of the abdominal sector, thoracic sector and subclavian sector was 25%, 50% and 25%, respectively.

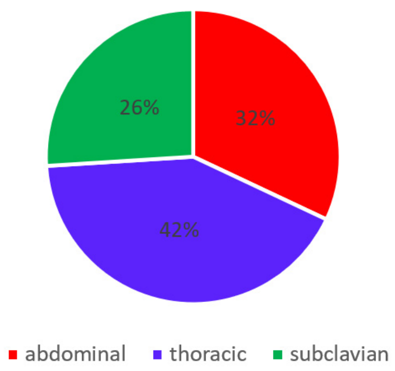

Figure 1 *Engagement of breathing sectors at rest before intervention*

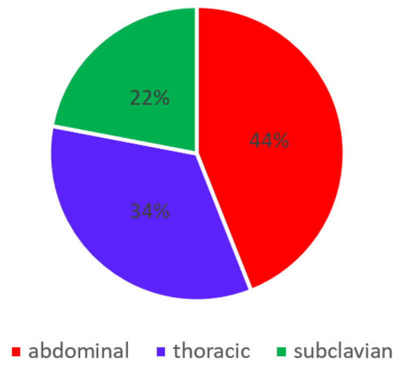

Figure 2 *Engagement of breathing sectors at rest after intervention*

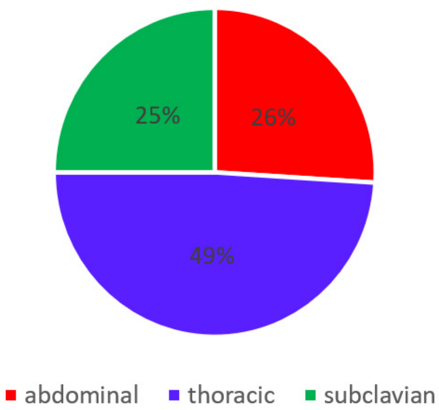

Figure 3 *Engagement of breathing sectors before intervention*

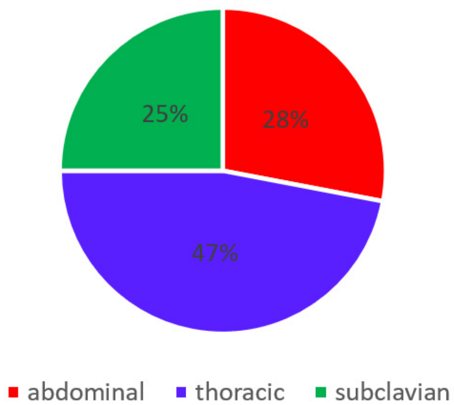

Figure 4 *Engagement of breathing sectors under load under load after intervention*

Discussion

Most studies concerned with the breathing stereotype focus on ill individuals or individuals who have been injured. Certain studies analyse healthy individuals, when it was confirmed that not only static ventilation parameters (Bahenský, Malátová, & Mareš, 2016; Malátová, Bahenský, Kanásová & Štumbauer 2019) but also dynamic ventilation parameters (Bahenský, Malátová, & Bunc, 2019) can be affected in healthy individuals.

Initial tests revealed disorders of the breathing stereotype in all members of the experimental and control groups, whereas the percentage engagement of the abdominal sector reached only 32% at rest in both groups. In the experimental group, the proportion of engagement of the abdominal, thoracic and subclavian sectors changed from 32:42:26% to 44:34:22 % thanks to the intervention; nevertheless, the proportion 60:30:10 % (Šponar, 2003) was not achieved even after the intervention. Physical activities considered, an athlete's ineffective breathing pattern may cause premature dyspnoea, or exhaustion of lower extremities, which does not reflect cardiovascular fitness or any organic pathology. Alternatively, a disorder of the breathing pattern at rest may disrupt an athlete's performance (Clifton-Smith, 2017).

Our intervention programme was developed to cover a period of eight weeks, with emphasis on influencing the breathing pattern. It was confirmed that an eight-week period is a sufficient time for adaptation changes and for improving the breathing economy (McArdle, Katch, & Katch, 1996). The results we have achieved imply that a positive change of the breathing stereotype at rest occured. The percentage engagement of the abdominal breathing segment increased significantly, and the percentage engagement of the thoracic and subclavian percentage sectors decreased in resting breathing. However, despite the improvement in abdominal breathing, the percentage engagement of the abdomen is not utilize sufficiently to achieve the correct breathing stereotype, as described in literature (Kolář et al., 2009; Dylevský, 2000). Instead of the optimum breathing stereotype with a share of abdominal breathing of 60–70%, the participants observed by us reached only the average of 44% engagement in resting breathing.

Under load, the breathing stereotype remained virtually unchanged when compared with results of resting breathing; this result is attributed to latency and the transfer from resting breathing to breathing under load as well as the fact that participants trained the breathing stereotype in resting positions. Even though changes in the engagement of the breathing stereotype are not as significant as those in resting breathing, participants approached the correct percentage threshold of the engagement of individual breathing segment, as determined in literature (Kolář et al., 2009; Bartůňková et al., 2013; Slavíková & Švíglerová, 2012). The change of breathing stereotype under load is significant. To achieve a better breathing stereotype under load, it might be beneficial to undergo an intervention programme with a higher proportion of dynamic exercises, which develop the harmony between breath and movement. The completion of such programme might lead to a faster automation of the corrected breathing stereotype under load.

The study is also limited by the number of the participants involved; it would be advisable to confirm its findings using a larger group of persons. Furthermore, the level of permanency of the effects after the end of intervention of breathing exercises should be determined. The major factors influencing the success rate of the therapy include: regularity and quality of performance of breathing exercises. We consider it suitable to focus on breathing exercises at least for ten minutes five times a week as a minimum. Purposeful breathing exercises may be helpful in improving the breathing pattern and thereby decrease the energy demands of breathing and affect positively the prerequisites for endurance physical activities.

Conclusion

A two-month intervention, with frequency of exercises five times a week, when the length of one unit is 10 min as a minimum, may influence the breathing pattern to a considerable extent and engage the abdominal sector in breathing significantly.

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COMPARISON OF RESULTS OF SPIROERGOMETRY ON RUNNING AND BICYCLE ERGOMETER OF ATHLETES WITH RUNNING AND CYCLING SPECIALIZATION

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David Marko

Department of Sports Studies, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic

ABSTRACT

Purpose: A choice between a running or bicycle ergometer is not possible in every laboratory. Significant differences may appear in measuring results of ergometers with different load specificity. The objective of our paper is to determine a difference in values measured during a spiroergometry test on a bicycle ergometer and a running ergometer in adolescent endurance sportsmen, with different specializations, for mountain cyclists and middle- and long-distance runners.
Methods: The experiment involved 10 cyclists and 10 runners at the national top level. The cyclists and runners were divided in two groups: one half of the tested group completed the first test on a running ergometer and the other on a bicycle ergometer. The test on the other ergometer was taken after three days' time. The progressed load test up to "vita maxima" was used for both ergometers. The examined parameters included values of VO_{2max}, V_T, VE, BF, HR_{max} and WR_{max}. Results were evaluated in terms of both statistical and substantial significance. Statistical significance was ascertained by means of t-test at the level $\alpha = 0.05$. Cohen's d was used to evaluate substantial significance.
Results: The results showed substantially significant differences for runners in all examined parameters. A substantially significant difference in measurement results of cyclists was discovered for parameters VO_{2max}, V_T, VE and WR_{max}. In runners, the mean of values for the most important parameter VO_{2max} reached 60.6 ± 4.24 $ml.min^{-1}.kg^{-1}$ when running, and 56.0 ± 5.34 $ml.min^{-1}.kg^{-1}$ when cycling; values reached by cyclists were 56.6 ± 5.16 $ml.min^{-1}.kg^{-1}$ when running, and 61.30 ± 4.47 $ml.min^{-1}.kg^{-1}$ when cycling. The only parameter not to correspond with the sportsmen's specializations was V_T, as it revealed larger values on a bicycle also for runners.
Conclusion: Results confirmed the correspondence between the load specificity according to the ergometer selected and the specificity of sports pursued. It was proven that it is necessary to select a suitable type of appliance for determining VO_{2max} according to the sports pursued.

Keywords: VO_{2max}; runners; cyclists; adolescents; ergometer

Introduction

Functional load diagnostics, as an objective tool, makes it possible to assess motor fitness and sports performance. Generally, the purpose of functional load diagnostics is to examine the physiological response and adaption of the body to load (Bartůňková et al., 2013). There exist an array of procedures and methods enabling the assessment of fitness and performance. Laboratory tests, whether directly or indirectly determining the maximum oxygen uptake, rank among those most frequently applied. The maximum oxygen uptake constitutes the basic parameter of human fitness and performance, since this parameter represents the upper limit of aerobic load tolerance. The maximum oxygen uptake signifies not only the lung capacity, ability of the heart and blood to transport oxygen to muscles at work, but also the utilization of oxygen in muscles under load (Heller, 2018).

According to Heller (2018) the value of the maximum oxygen uptake (VO_{2max}) stands at approximately 73 ml.kg^{-1}.min^{-1} in mountain cyclists and about 71 ml.kg^{-1}.min^{-1} in middle and long distance runners. In adolescence, the development of VO_{2max} continues, in both training and non-training population (Neumann, Pfützner, & Berbalk, 2000). The development of VO_{2max} in adolescent runners is examined e.g. by Daniels, Oldridge, Nagle, & White (1978) and Bahenský, & Bunc (2018).

The test of maximum oxygen uptake, VO_{2max} test, is most commonly carried out by means of running or bicycle ergometers (Noakes, 2002). Load-testing laboratories are most often equipped with bicycle ergometers as these are considerably cheaper than their running counterparts. These ergometers are characterized by considerable differences worth mentioning. The main difference lies in measurement results on account of different movement stereotypes (Bunc, 2012). A running treadmill and a bicycle ergometer have unique mechanical features and different physiological effects (Smodlaka, 1982).

Values measured by a running ergometer are generally higher than those gained by a bicycle ergometer (Bunc, 2009; Bartůňková et al., 2013). Hermansen, & Saltin (1969) studied the values measured by running and bicycle ergometers for 55 male probands at the ages between 19 and 68, where the values measured in running were higher by 7% than those measured on a bicycle. In testing male students, statistically higher values of the maximum oxygen consumption were measured in favour of a running ergometer (Miyamura, & Honda, 1972; McArdle, Katch, & Pechar, 1973). The problems of different results for spiroergometry of runners and cyclists were dealt addressed e.g. by Římák, Fiala, Kunzová, & Kaňovský (2012), who discovered higher values of the maximum oxygen consumption during a test on a bicycle ergometer, specifically by 12% in cyclists, and a statistically insignificant value 4.6% in runners. On the contrary, the research of Pannier, Vrijens, & Van Cauter (1980) and Verstappen, Huppertz, & Snoeckx (1982) yielded statistically higher values of runners during a test on a running ergometer. The maximum oxygen uptake of top sportsmen is usually measured at their specific load (Máček & Radvanský, 2011; Verstappen, Huppertz, & Snoeckx, 1982).

The objective of our study is to determine the dependence of results of spiroergometry tests by means of running and bicycle ergometers in adolescent categories of runners and cyclists.

Methods

The study involved 20 adolescent boys, out of which 10 were middle and long distance runners, and 10 were cyclists in MTB category. The average age of cyclists was 16.90 ± 1.75 years, weight 72.90 ± 5.61 kg and height 181.30 ± 2.86 cm. All cyclists are members of Česká spořitelna Specialized Junior MTB team. At the average, probands spend 13 hours per week cycling and complete at the average 7,170 ± 1,438 km on an annual basis. As regards runners, the average age was 15.80 ± 1.24 years, average weight 65.40 ± 9.73 kg and height 179.90 ± 7.80 cm. All members of the research group of runners undergo 6 and more training units per week. The performance level of the tested runners reaches that of the Czech youth top runners, four probands are members of the youth national team and won medals in youth categories of the Championship of the Czech Republic. The number of kilometres completed by running by the tested group of runners reached 2092 ± 492 km per year. The tested probands had experience in taking load tests, of the same type as in case of our experiment. The author of the present paper has no conflict of interest in connection with this study. The research was performed with consent of the Ethics Committee, Faculty of Education, University of South Bohemia, Ref. No.: 001/2018. All procedures conducted within the study comply with ethical standards of the Institutional Research Committee and the Helsinki Declaration.

Protocol

In the course of the study, probands of the both sports disciplines were tested using two different ergometers, i.e. running and bicycle ergometers. All probands underwent a test on both ergometers, with a three-day interval between the tests. The three-day interval enabled the probands to recover after the first test to an adequate extent, while eliminating different results due to a worse or better performance after the second test. Importantly, the probands undertook the test on the same level of physical and mental tiredness: for this reason, the same training plan was set up before both tests. The possibility of influencing the results due to different levels of tiredness was also eliminated by a "plan with cross-classification and repetition of measurement" (Hendl, 2004). The plan with cross-classification consisted in random division of the runners' and cyclists' group into two halves, whereas the first half undertook the first test on a running ergometer and the other half was tested on a bicycle ergometer. The parameters examined included values VO_{2max}, V_T, VE, HR_{max}, BF and WR_{max}. Resultant values were compared between the ergometers and both groups.

The maximum functional parameters were determined by means of a progressed-load test up to "vita maxima". The running ergometer test was preceded by a four-minute running warm-up at the speed of 6 $km.h^{-1}$ and a subsequent two-minute break. The initial speed of the treadmill was set up individually according to the test results conducted three months before, and increased by 1 $km.h^{-1}$ every minute until the test was stopped by the proband himself. Throughout the test, the constant inclination was set up at 5%. The test was followed by a three-minute walking phase at the pace of 4 $km.h^{-1}$; this phase does not affect test results.

A two-minute cycling warm-up with resistance of 25 W and the cadence of 80–100 $n.min^{-1}$ preceded the test on a bicycle. All 10 cyclist as well as runners were tested 3 months before our study so the initial resistance of the test itself was set up in line with the individual fitness level of the given proband (approximately 2.5 $W.kg^{-1}$) and increased by 20 W every minute until the test was terminated by the proband himself. The same protocol is applied e.g. by Bahenský, & Malátová (2018). The cadence during the test stood at 98–102 $n.min^{-1}$. The "cool-down" phase with resistance of 25 W and cadence of 60 $n.min^{-1}$ followed the termination of the test; this phase does not affect test results.

Statistical analysis

Material significance of differences in values gained on both ergometers was determined by Cohen's *d*, which can be applied to evaluate the effect between two independent variables (Blahuš, 2000). The size of coefficient *d* was established according to Hendl (2004), specifically as follows:

- d ≥ 0.80 – large effect,
- d = 0.50 to 0.80 – medium effect,
- d = 0.20 to 0.50 – slight effect.

The values were compared also in terms of statistical significance, using t-test at the level $\alpha = 0.05$.

Results

Table 1 presents resultant parameters of runners on both ergometers. Runners achieved larger values of VO_{2max} in running; this difference is materially significant, with a large effect (d = 0.903). The statistical importance of the difference in parameter VO_2max was also proven ($p < 0.01$). Parameter V_T was found to reveal a materially significant difference (d = 0.325) in favour of the bicycle test. The difference of V_T values was statistically insignificant. Runners reached higher VE values in running. The difference of VE values is materially significant, with a medium effect (d = 0.614). Statistical significance was not proven. Breathing frequency in runners was greater in case of the test on a running treadmill, with a materially significant difference (d = 0.541), yielding a medium effect. Statistical significance was not proven. The difference of values of HR_{max} in runners was materially (d = 0.656) and statistically ($p < 0.05$) significant, in favour of the running treadmill. As to parameter WR_{max}, runners achieved larger values when running on the running treadmill. The difference was both materially (d = 1.115) and statistically ($p < 0.01$) significant.

Table 1 *Resultant values of runners on the running treadmill and bicycle*

	VO_{2max}	V_T	VE	BF	HR_{max}	WR_{max}
	[ml.min^{-1}.kg^{-1}]	[l]	[l.min^{-1}]	[n.min^{-1}]	[n.min^{-1}]	[W]
Running ergometer	60,6 ± 4,2	2,34 ± 0,5	143,45 ± 11,1	63,8 ± 11,4	196 ± 8,1	402 ± 68,9
Bicycle ergometer	56,0 ± 5,3	2,52 ± 0,5	135,68 ± 12,7	56,60 ± 13,6	189 ± 10,2	334,5 ± 37,3

VO_{2max}: Maximum oxygen uptake; V_T: Tidal volume; VE: Pulmonary ventilation during exercise; BF: Breathing frequency; HR_{max}: Maximum heart rate; WR_{max}: Maximum work rate

Table 2 shows resultant values of cyclists on both ergometers. Cyclists reached greater values of VO_{2max} in the bicycle ergometer test; the difference of the values is both materially ($d = 0.923$), and statistically ($p < 0.01$) significant. In the case of parameter V_T, a materially ($d = 0.871$) and statistically ($p < 0.01$) significant difference between both ergometers was determined. The difference of the values as to parameter VE was materially significant ($d = 0.795$), with medium effect. Statistical significance was not proven for this parameter. Parameter BF was not found to have a materially or statistically significant difference between both ergometers in the cyclists. The difference of values of parameter HR_{max} was not statistically or materially significant in cyclists. Cyclists achieved higher WR_{max} values in riding a bicycle ergometer. The difference of values between the ergometers was materially ($d = 1.543$) and statistically ($p < 0.01$) significant.

Table 2 *Resultant values of cyclists on the running treadmill and bicycle*

	VO_{2max}	VT	VE	BF	HR_{max}	WR_{max}
	[ml.min^{-1}.kg^{-1}]	[l]	[l.min^{-1}]	[n.min^{-1}]	[n.min^{-1}]	[W]
Running ergometer	56,6 ± 5,1	2,51 ± 0,4	156,80 ± 13,2	63,3 ± 9,6	195,2 ± 8,9	411,1 ± 36,4
Bicycle ergometer	61,3 ± 4,4	2,90 ± 0,4	172,13 ± 22,2	61,5 ± 11,5	195,5 ± 8,9	473,2 ± 39,7

VO_{2max}: Maximum oxygen uptake; V_T: Tidal volume; VE: Pulmonary ventilation during exercise; BF: Breathing frequency; HR_{max}: Maximum heart rate; WR_{max}: Maximum work rate

Discussion

Both ergometers reveal differences in measurement results (Bunc, 2012); our results confirm this assertion. The research of Pannier, Vrijens, & Van Cauter (1980) and Verstappen, Huppertz, & Snoeckx (1982) revealed statistically higher values of runners in case of the test on a running ergometer.. Also in the research of Basset & Boulay (2000), groups of triathlets, runners and cyclist had significantly ($P < 0.05$) higher values of VO_{2max} on the treadmill compared with the cycle ergometer; our data comply with this assertion for runners group. All of the ten participants of the study in the runners' group reached higher values of VO_{2max} on the running ergometer, specifically by a significant value of 8.21%. Contrariwise, cyclists were found by Římák, Fiala, Kunzová, & Kaňovský (2012) to reach higher values of the maximum oxygen consumption in the test on a bicycle ergometer, specifically by 12%. All of the ten participants of the study in the cyclists' group accomplished higher values of VO_{2max} when riding the bicycle ergometer. The value of VO_{2max} was higher by 8.30% at the average on a bicycle ergometer in case of cyclists.

We anticipated that, due to the specificity of the load, cyclists would reach higher values of VO_{2max} when riding the bicycle, when compared with the runners on a treadmill; however, a greater difference was expected for runners, not cyclists. We proceeded from the theory that running – which is included in most sports preparations – would not present as a big problem for cyclists as a bicycle riding technique for runners. The reason for the greater difference between values of VO_{2max} could consist in the fact that cyclists might not have coped with higher speed of the running treadmill, that reason not being the exhaustion of the respiratory, circulatory and metabolic systems. This issue is addressed e. g. by Bartůňková et al. (2013).

Our resultant values of VO_{2max} comply with the studies of Máček, & Radvanský (2011) and Verstappen, Huppertz, & Snoeckx (1982). Top sportsmen achieved higher values of VO_{2max} under their specific load.

Runners accomplished higher V_T values when riding a bicycle, i.e. by 7.96%. The lower V_T may have been caused by a poorer coordination of the upper torso when running at higher speed, with the result of worse breathing stereotype and breathing economy. An explanation may also be found in the engagement of abdominal muscles in running: these muscles are engaged to a great extent in inspiration. These muscles may tire during running, whereby decrease the value V_T and the overall breathing economy.

The difference between V_T values was even more distinct in cyclists than in runners. Cyclists achieved higher values by 15.88% in riding on a bicycle. These results may contribute to the theory mentioned above in the case of runners. When running at higher speed, the problems with body coordination may be even more noticeable in cyclists; as a result, this may evidently disrupt their breathing stereotype. The breathing stereotype may, however, be influenced by targeted training (Bahenský, Malátová, & Bunc 2019).

In the study of Tanner, Duke, & Stager (2014), 22 trained males underwent a progressed-load test up to maximum on two ergometers, running and bicycle. V_E did not differ between the individual ergometers. Our results do not tally with the above study. The resultant V_E values in runners, despite the lower V_T, were higher on a running ergometer, specifically by a materially significant value 5.73%. The lower V_T was compensated in runners by the higher BF, which was larger on a running ergometer by 12.72%. Cyclists achieved higher values V_E in the test on a running ergometer, specifically by 9.78%. The difference between BF was not significant in the case of cyclists.

Runners reached higher values of HR_{max} on a running ergometer. This result may be explained by the engagement of larger muscle groups in running and most probably also by a higher work intensity, in a sports activity structurally the same or similar to the sport practised by the given individual. The difference between values of HR_{max} was not significant in the case of cyclists. This might be explained by the above theory proclaiming a higher number of engaged muscle groups, and also a great probability of reaching HR_{max} in a sports activity that is the same in terms of structure as that in the sport pursued by the given individual.

Runners were found to achieve higher values of WR_{max} on a running ergometer, contrariwise, these values were higher in cyclists on a bicycle ergometer. The difference for runners and cyclists was 20.18% and 15.11%, respectively.

Conclusion

Our study proved that the appliance used does influence the value of VO_{2max} in the case of using a running ergometer and a bicycle ergometer for runners and cyclists. All of the ten participating runners were found to achieve a higher value of VO_{2max} in the test on a running ergometer. All of the ten participating cyclists were found to a higher value of VO_{2max} in the test on bicycle ergometer. As a consequence of a poor coordination at higher speed of running and a more considerable engagement of abdominal muscles, the breathing stereotype may be disrupted and V_T value may decrease. Runners and cyclists alike achieved higher V_T values in running on a bicycle ergometer. Higher values of VE and WR_{max} were reached by both runners and cyclists in the test when it came to their specific activities. The difference in parameters BF and HR_{max} was significant only in runners, who achieved higher values when running. It is suitable to test highly trained sportsmen on an appliance on which the nature of the physical activity performed comes as closest as possible to that in the sportsmen's specific load.

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PREDICTING FUTSAL SPECIFIC CHANGE OF DIRECTION SPEED AND REACTIVE AGILITY; ANALYSIS OF SPECIFIC CORRELATES IN TOP-LEVEL PLAYERS

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Ivan Zeljko[1], Miodrag Spasic[2], Damir Sekulic[2]

[1]*University of Mostar, Faculty of Science and Education, Mostar, Bosnia and Herzegovina*
[2]*University of Split, Faculty of Kinesiology, Split, Croatia*

ABSTRACT

Purpose: Change of direction speed (CODS) and reactive agility (RAG) are important qualities in futsal, but studies rarely examined the predictors of these conditioning capacities in players of advanced level. This study aimed to evaluate predictive validity of certain anthropometric and conditioning capacities in evaluation of futsal specific CODS and RAG in top-level players.
Methods: The sample comprised 54 male players from Croatia and Bosnia and Herzegovina, members of teams competing at the highest national rank, including national champions for the 2017–2018 competitive season in both countries. The variables comprised set of predictors (body mass, body height, triceps skinfold, reactive strength index [RSI], sprint 10 m [S10M], and broad jump [BJ]; and four criteria: futsal specific CODS and RAG, performed with and without dribbling (CODS_D, CODS_WD, RAG_D, RAG_WD). To identify the association between variables Pearson's correlation and multiple regressions were calculated.
Results: Observed predictors explained statistically significant ($p < 0.05$) percentage of variance for all four criteria (Rsq: 0.28, 0.30, 0.23 and 0.25, for CODS_WD, CODS_D, RAG_WD, RAG_D, respectively). Body mass was significant predictor for all criteria (Beta: 0.35–0.51), with poorer performances in heavier players. In both performances which involved dribbling, significant predictors was RSI (Beta: −0.27 and −0.31 for CODS_D and RAG_D, respectively), with superior performances in players with better RSI. The S10M and BJ were not identified as being significantly correlated to studied RAG and CODS performances.
Conclusion: Study confirmed specific influence of studied predictors of futsal specific CODS and RAG with consistent negative influence of body mass on studied performances. Almost certainly this can be explained by specifics of RAG and CODS execution. Specifically, tests are performed over relatively small distances, with several changes of direction, which clearly mimic the futsal specific performances. Although sprint performance is often observed as important determinant of CODS and RAG, herein we did not confirm its predictive validity in explanation of futsal specific CODS and RAG. Future studies should evaluate other potentially important predictors of these capacities in futsal.

Keywords: prediction; multiple regression; conditioning capacities; pre-planned agility; non-planned agility

Introduction

Agility can be defined as the ability to rapidly change direction and speed of movement. It is a highly complex quality, and differentiation between non-reactive agility (i.e. change of direction speed – CODS), and reactive agility (RAG) deserves special attention. In brief, while CODS involves an active change of direction speed, RAG is performed throughout a non-planned scenario to which the athlete must respond to a specific visual or audio stimulus by performing a precise change of direction as quickly as possible (Pojskic et al., 2018). Research has shown that CODS and RAG are independent qualities. Specifically, the percentage of common variance of these two qualities rarely exceeded 30% which indicate that RAG and CODS should be tested and trained separately (Serpell et al., 2010).

Due to the diversity of agility maneuvers within a sport and between sports, agility components are hard to develop in general (i.e. each type of agility requires specific exercises). Therefore, knowing which factors directly influence agility could lead to specific training and the development of these factors to improve different types of agility performances. However, most of the studies done so far examined the factors associated with CODS, while there is a limited number of studies where authors reported factors associated with RAG (Pehar et al., 2018; Sekulic et al., 2013). What is also important, recent analyses confirmed the necessity of investigation of sport-specific testing protocols in order to precisely accentuate the type of CODS and RAG which appears in sport of interest (Pehar et al., 2018, Spasic et al., 2015).

Futsal is a sport that involves intermittent periods of high-intensity physical effort over two, 20-minute periods per game, and research shows that agility appears to be a vital component to successful play since sport requires sudden changes in movement patters, fast sprints, and rapid decision-making to obtain or maintain ball possession (Teixeira et al., 2019). However, studies which specifically examined agility in futsal are limited, while to the best of our knowledge no study so far directly reported factors associated to CODS and RAG in this sport. Therefore, the aim of this study was to evaluate predictive validity of certain anthropometric and conditioning capacities in evaluation of futsal specific CODS and RAG in top-level futsal players.

Methods

The sample participants in this study comprised 54 male futsal players from Croatia and Bosnia and Herzegovina (age: 25 ± 4.1 years, body height: 182 ± 5–8 cm, mass: 81 ± 12.3 kg), members of teams competing at the highest national rank, including national champions for the 2017–2018 competitive season in both countries. The participants were selected based on the following criteria: older than 18 years of age; free from injury or illness; and have regularly performed standard training for at least three weeks prior the study. Goalkeepers were not included in this investigation.

The variables comprised set of predictors (body mass, body height, triceps skinfold, reactive strength index [RSI], sprint 10 m [S10M], and broad jump [BJ]); and four criteria: futsal specific CODS and RAG, performed with and without dribbling (CODS_D, CODS_WD, RAG_D, RAG_WD). Body mass, body height, and triceps skinfold were measured by standard techniques and calibrated equipment. The BJ (in cm) was measured using the standardized measuring mat (Elan, Begunje, Slovenia) throughout three attempts and the best performance was used as the final result for each player. The S10M (in 0.01 s) was evaluated by Muscle Lab timing gate (Muscle Lab, Norway), participants performed three sprints with 2–3 minutes rest, and the best achievement was used as final result for each player. The RSI (index) was derived from the height jumped in a 30-cm depth jump, and the time spent on the ground developing the forces required for that jump, which was measured by Optojump system (Microgate, Bolzano, Italy). The RAG and CODS performances were measured by futsal specific protocols involving test executions with dribbling (CODS_D, and RAG_D), and without dribbling the ball (CODS_WD, and RAG_WD) (Figure 1). In general, RAG tests were commenced throughout five-, and CODS tests throughout three-testing-trials, and the best result of each participant for each test was used for statistical analyses (in 0.01 s).

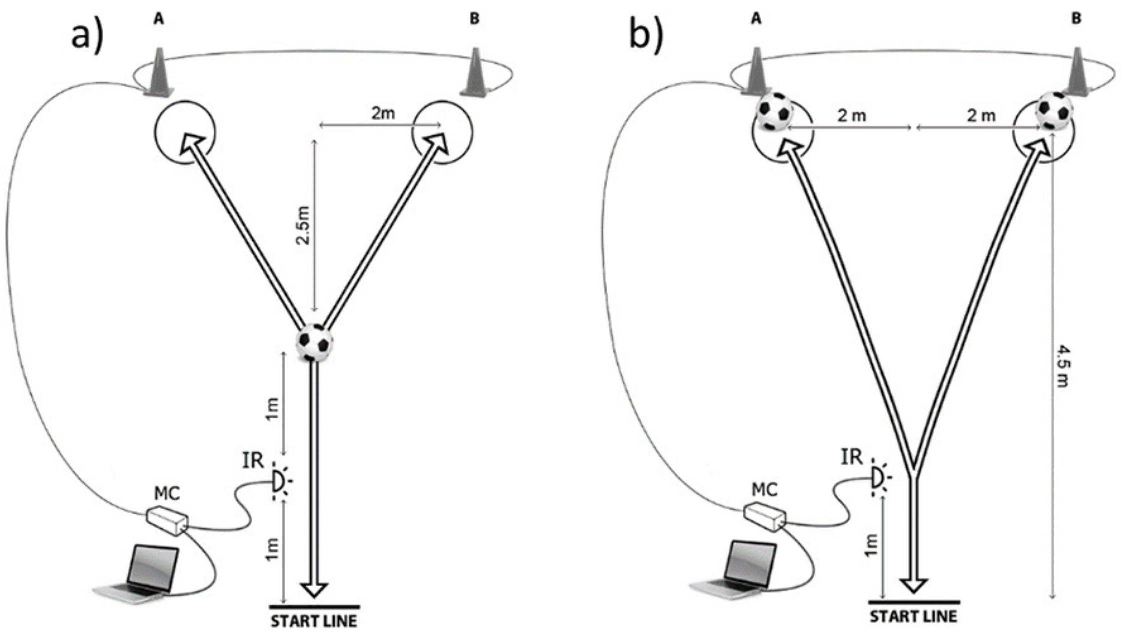

Figure 1 *Testing of the futsal specific change of direction speed and reactive agility (a) with dribbling, and (b) without dribbling*

Statistics included means and standard deviations, while the associations between predictors and agility performances were evaluated by Pearson's correlation coefficients, and multiple regression calculations. The alpha level of < 0.05 was applied.

Results

Descriptive statistics for obtained variables are presented in Table 1. The CODS performances are approximately 15% faster than corresponding RAG performances. Also, the performances with ball are 13–15% slower than corresponding performances that didn't include dribbling.

Table 1 *Descriptive statistics for obtained variables*

	Mean	Minimum	Maximum	Std.Dev.
BH (cm)	182.66	168.00	197.50	5.86
BM (kg)	80.92	56.50	139.90	12.27
TrSF (mm)	10.71	3.90	25.20	4.60
BJ (cm)	238.45	195.00	279.00	19.74
RSI (index)	148.48	62.24	222.30	36.67
CODS_WD (s)	2.16	1.83	2.75	0.20
CODS_D (s)	2.54	2.04	3.24	0.26
RAG_WD (s)	2.47	2.12	3.18	0.26
RAG_D (s)	2.68	2.20	3.51	0.26

LEGEND: BH – body height, BM – body mass, TrSF – triceps skinfold, BJ – broad jump. RSI – reactive strength index. CODS_WD – change of direction speed performed without dribbling the ball, CODS_D – change of direction speed performed with dribbling the ball, RAG_WD – reactive agility performed without dribbling, RAG_D – reactive agility performed with dribbling

Pearson's correlation coefficients indicate significant correlation between body mass and RSI with all observed agility performances. Similarly, triceps skinfold and BJ were significantly correlated with three of four agility performances (Table 2).

Table 2 *Pearson's correlation coefficients between observed variables (* denotes statistical significance of p < 0.05)*

	CODS_WD (s)	CODS_D (s)	RAG_D (s)	RAG_WD (s)
BH (cm)	0.17	0.18	0.05	0.04
BM (kg)	0.41*	0.46*	0.34*	0.32*
TrSF (mm)	0.36*	0.33*	0.28*	0.22
BJ (cm)	-0.29*	-0.30*	-0.30*	-0.19
RSI (index)	-0.40*	-0.34*	-0.33*	-0.35*

LEGEND: BH – body height, BM – body mass, TrSF – triceps skinfold, BJ – broad jump. RSI – reactive strength index. CODS_WD – change of direction speed performed without dribbling the ball, CODS_D – change of direction speed performed with dribbling the ball, RAG_WD – reactive agility performed without dribbling, RAG_D – reactive agility performed with dribbling

Table 3 *Multiple regression results between predictors and agility-performances criteria (* denotes statistical significance of p < 0.05)*

	Criteria			
	CODS_WD (s)	**CODS_D (s)**	**RAG_D (s)**	**RAG_WD (s)**
Predictors	Beta	Beta	Beta	Beta
BH (cm)	0.10	0.09	0.11	0.04
BM (kg)	0.49*	0.51*	0.35*	0.37*
TrSF (mm)	0.20	0.18	0.14	0.10
BJ (cm)	-0.11	-0.09	-0.12	-0.04
RSI (index)	-0.12	-0.27*	-0.11	-0.31*
R	0.52*	0.55*	0.48*	0.51*
Rsq	0.28*	0.30*	0.23*	0.25*

LEGEND: BH – body height, BM – body mass, TrSF – triceps skinfold, BJ – broad jump. RSI – reactive strength index. CODS_WD – change of direction speed performed without dribbling the ball, CODS_D – change of direction speed performed with dribbling the ball, RAG_WD – reactive agility performed without dribbling, RAG_D – reactive agility performed with dribbling; Beta – standardized regression coefficient, R – multiple correlation coefficient, Rsq – coefficient of determination

Observed predictors explained statistically significant ($p < 0.05$) percentage of variance for all four criteria (Rsq: 0.28, 0.30, 0.23 and 0.25, for CODS_WD, CODS_D, RAG_WD, RAG_D, respectively). Body mass was significant predictor for all criteria (Beta: 0.35–0.51), with poorer performances in heavier players. In both performances which involved dribbling, significant predictors was RSI (Beta: −0.27 and −0.31 for CODS_D and RAG_D, respectively), with superior performances in players with better RSI.

Discussion

Body mass was found significantly partially related to all CODS and RAG performances, with poorer performance in heavier players. The mechanism of (negative) influence of body mass on agility performances is relatively understandable, knowing the characteristic of the test performance. In brief, the RAG and CODS tests used in this study involve several changes of direction, including pre-planned and non-planned scenarios (for CODS and RAG, respectively). While all changes of direction are performed after achieving highest possible velocities over distance of approximately 3 meters (see Figure 1 for details) it is understandable that higher body mass will negatively influence the capability to effectively perform necessary change of direction, irrespective of its non-planned, or pre-planned nature. Supportively, previous studies where authors investigated the predictors of various agility performances noted similar associations between body mass and agility in basketball players (Pehar et al., 2018).

A certain novelty of our study is the fact that this is probably the first study which confirmed negative influence of higher body mass on agility performances which include dribbling with the ball. However, it is clear that association between body mass and performances which include dribbling (CODS_D, RAG_D) are less pronounced than associations between body mass and less complex agility performance (e.g. those which doesn't involve dribbling the ball; CODS_WD, and RAG_WD). This finding is almost certainly related to the overall influence of skill-level on studied agility performances. In brief, the level of characteristic futsal skill greatly influences the level of performances which involve dribbling, irrespective of other characteristics (i.e. anthropometrics) and capacities (i.e. power, sprinting). Consequently, somewhat lower correlation between body mass with performances which involve dribbling (RAG_D and CODS_D) is understandable.

Previous studies which investigated the predictors of different agility performances already highlighted the theoretical importance of different forms of RSI in explaining the variance of CODS and RAG. Specifically, Pehar et al. in recent study noted the importance of this quality in explaining basketball specific CODS and RAG, while Young et al. noted superior agility in Australian-rules football players who had better RSI (Pehar et al., 2018; Young et al., 2015). This association is explainable knowing the physiological basis of RSI, and similarity of this muscular capacity with agility performances. In short, RSI is the ability to efficiently switch between eccentric and concentric muscular contractions, or in other words – the ability to efficiently perform plyometric activities). Physiologically, the stretch shortening cycle results in more powerful contractions than purely concentric action (Flanagan & Comyns, 2008) The stretch shortening cycle that occurs in the eccentric part of plyometric performance increases the excitability of proprioceptors (mostly the Golgi tendon organ and muscle spindle) and results in an optimal reaction of the neuromuscular system, which naturally contributes to better agility performance as well (Sattler et al., 2015).

Although previous studies regularly noted the importance of sprinting and horizontal jumping on CODS and RAG performance (Sekulic et al., 2013), in our study neither S10M, nor BJ were found as significantly related to futsal specific CODS and RAG. Two explanations are plausible in defining the differences in findings between our results and those obtained previously. First, RAG and CODS tests in this study involved performances over relatively short distance, and several changes of directions (see Figure 1 for test dimensions). Therefore, although horizontal displacement capacity (i.e. sprint, horizontal jump) may theoretically be beneficial in RAG and CODS, the test dimensions actually decreased the influence of both S10M and BJ on studied agility-performances. Second, all variations of the RAG and CODS tests observed here were relatively complex. Consequently, the influence of "energetic capacities" (i.e. power, sprint) is logically lower than influence of some qualitative physical capacities (i.e. coordination).

Conclusion

The study highlighted importance of players' body mass and RSI on RAG and CODS performances. In general, the most superior RAG and CODS performances are expected of those players who have relatively low body mass and good RSI. However, while body mass was found as significant predictor of all studied performances, the RSI significantly influenced RAG and CODS which involved dribbling with the ball. These information should be disseminated to strength and conditioning coaches working with futsal players. This is particularly important knowing that sprinting and horizontal jumping (i.e. power-related capacities) were not evidenced as significant predictors of studied futsal specific RAG and CODS, while most of the strength and conditioning programs actually aim toward development of these capacities as a way of improvement of various agility performances.

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MATCH RUNNING PERFORMANCE IN RELATION TO A PLAYING POSITION IN CROATIAN FOOTBALL LEAGUE

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Toni Modrić[1], Šime Veršić[1,2], Nikola Foretić[2]

[1]*HNK Hajduk, Split, Croatia*
[2]*Faculty of Kinesiology, University of Split, Croatia*

ABSTRACT

Global popularity of football (soccer) has led to implementation of scientific and technological knowledge in its everyday use. One of such things that has been expanding in recent years is the application of various technologies for monitoring running performance during trainings and matches. The aim of this study was to evaluate match running performance of professional football/soccer players during official matches by using global positioning system (GPS) technology, and to compare it among playing positions.

One hundred and one match performance of "Hajduk" team in 14 matches of Croatian Football League season 2018/2019 were used for this study. The activities of the players were monitored using GPS technology (Catapult S5 and X4 devices, Melbourne, Australia) with a sampling frequency of 10 Hz. Total distance covered, distance in different speed categories, total and high intensity accelerations and decelerations were analyzed for players in five different playing positions: central defenders (n=26), full-backs (n=24), midfielders (n=33), wingers (n=10), and forwards (n=8). Additionally, running performances were correlated with InStat index, regular performance indicator which is calculated on the basis of unique set of key parameters for each position (12 to 14 factors).

Average total distance covered during match was 10.3 km, with midfielders covering largest (11.1 km) and central backs covering smallest average distance (9.3 km). Playing positions differed significantly in high intensity running (F-test = 21.97 and 18.84, $p < 0.01$ for 20–25 km/h and > 25 km/h, respectively). The side positions (wingers and full-backs) covered highest-, while central defenders covered lowest-average distance (914, 775, and 376 m, respectively). The wingers had highest number of high intensity accelerations and decelerations (> 3 m/s^2; F-test = 16.56 and 17.98, $p < 0.01$, respectively). Central defenders had largest number of average accelerations and decelerations (> 0.5 m/s^2; F-test = 6.57, and 15.26, $p < 0.01$, respectively). InStat index was not correlated with data obtained by GPS measurement.

Results from this study indicate that running demands differ depending on playing positions so these findings should be applied in creating training plan and program. Future studies should evaluate data from multiple teams for getting more applicable findings.

Keywords: running performance; soccer; accelerations; decelerations

Introduction

Football (soccer) is a highly complex team sport of changing dynamics and multistructural movements played by two teams, each consisting of 10 outfield players on various positions and a goalkeeper

(Kubayi & Toriola, 2018). While the final team achievement directly depends on performance of all 11 players there is a clear necessity for reliable and accurate evaluation of players' performance achievement. Not surprisingly, the performance analysis takes crucial place in overall evaluation of players' performance (Christopher Carling, Williams, & Reilly, 2007). Global popularity of football has led to implementation of scientific and technological knowledge in its everyday use, and this is particularly evident within the field of performance analysis.

The global positioning software systems (GPS) is one of the measurement tools which has been found as highly applicable in football and consequently used by many teams around the globe (Ehrmann, Duncan, Sindhusake, Franzsen, & Greene, 2016). In brief, GPS allows collecting data about players' running performance such as total distance covered, distance covered at different intensities, number of accelerations and decelerations etc. Studies done so far provided evidences about significant differences among playing positions in running at different intensities with midfielders covering the largest distance of all playing positions and wingers performing most high-intensive sprints (Mallo, Mena, Nevado, & Paredes, 2015). Further, match running performance in Brazilian professional football players determined that winning teams, home playing teams and teams that plays against "weaker" opponents had higher total distance covered (Aquino et al., 2020).

The game performance indicators are another important set of variables which allow evaluation of overall performance in football. Game performance indicators are defined as the selection and combination of variables that define some aspect of performance and which help achieve athletic success (Lago-Peñas & Lago-Ballesteros, 2011). Nowadays, numerous video based platforms which track the performance indicators of football players are available (i.e. InStat, Optasport, Wyscout). Generally, the platforms quickly and accurately provide a large range of data about game performance indicators, allowing the simultaneous analysis of physical efforts, movement patterns, and technical actions of players, with and without the ball (Chris Carling, Bloomfield, NELSON, & Reilly, 2012; Dellal et al., 2011).

The aim of this study was to: (i) evaluate running performances, and game performance indicators, and (ii) to evidence possible associations which may exist between these two sets variables in professional football players. Additionally, we compared running performances and standard football performance variables.

Methods

Twenty professional adult soccer players volunteered to participate in this study. Ninety-six match performance were used, all data were collected during 14 matches of Croatian Football League season 2018/2019. Players (mean ± SD, age: 23.85 ± 2.88 years; body height: 183.05 ± 8.88 cm; body mass: 78.69 ± 7.17 kg) were classified in five different playing positions regarding their role in the playing formation of the team: central defenders (n=25), full-backs (n=23), midfielders (n=32), wingers (n=9), and forwards (n=7).

Variables in this study were two sets of football performance variables (running performance, and game performance indicators), and final game outcome (lost, draw, win). Running performances of the players were collected by GPS technology (Catapult S5 and X4 devices, Melbourne, Australia) with a sampling frequency of 10 Hz. Variables included: total distance covered (m), distance in different speed categories – (I) walking (< 7.1 km/h), (II) jogging (7.2–14.3 km/h), (III) running (14.4–19,7 km/h), (IV) high speed running (19.8–25.1 km/h) and (V) maximum sprint (> 25.2 km/h), total accelerations (>0,5 m/s^2), high intensity accelerations (> 3 m/s^2), total deceleration (< [-] 0,5 m/s^2) and high intensity decelerations (< [-] 3 m/s^2).

Game performance indicators of each player were collected by InStat index (Instat, Moscow, Russia). The InStat index is generally calculated on the basis of unique set of key parameters for each position (12 to 14 performance parameters, depending on the position in game), with the higher numerical value indicating better performance.

The normality of the distributions was checked by Kolmogorov-Smirnov test, and data are presented as the means ± standard deviations. Differences between playing positions in running performances and InStat index were tested with one-way analysis of variance (ANOVA). When a significant difference occurred, Scheffe post-hoc tests were used. The associations between running performances and InStat index were evaluated by Pearson's correlation.

For all analyses, Statistica 13.0 (TIBCO Software Inc, USA) was used, and a p-level of 95% was applied.

Results

Total distance covered during a match averaged 10307.6 ± 935.4 m with CD having shortest (significant post-hoc differences when compared to FB, CM, WM) and CM having greatest covered distance (significantly different from CD, FB, WM, FW) (Table 1). Distance covered at different speed differed significantly in relation to playing positions, except the distance covered with the lowest intensity (< 7.1 km/h). CM covered greatest distance while jogging (7.2–14.3 km/h; significantly different from CD, FB, WM, FW). CD had shortest distance covered in running (14.4–19.7 km/h; significantly different from FB, CM, WM), submaximal sprint (19.8–25.1 km/h; significantly different from FB, CM, WM, FW) and sprint (> 25.1 km/h; significantly different from FB, WM). CM and WM covered greatest distance by running (significantly different from CD, FB, and FW; and CD and FW respectively). Players on side positions, WM and FB, had greatest distance in two fastest zones – high speed running (significantly different from CD, CM, FW and CD respectively) and sprint (significantly different from CD, CM, FW). (Table 1)

The players had on average 717.2 ± 74.2 accelerations and 675.1 ± 70.3 deccelerations. FW carried out least number of accelerations (significantly different from CD, FB, CM) and decelerations (significantly different from CD, FB, CM, WM) while CD carried out the most accelerations and decelerations (significantly different from FW). The average number of high intensity accelerations and decelerations by player during the game was 3.2 ± 2.7 and 11.4 ± 6.3 respectively. WM carried out most hight intensity accelerations (significantly different from CD, FB, CM) and decelerations (significantly different from CD, FB, CM, FW) per game (Table 2).

Table 1 *Distance covered (m) at different speeds, with differences among playing positions (data are presented as Means ± Std.Dev if not indicated otherwise)*

Position	W	J	R	HSR	S	TD
CD	4056.4 ± 371.5	3856 ± 387.7	1000.3 ± 201.6	288.8 ± 65.1	88.1 ± 61.2	9292.2 ± 601.6
FB	4312.3 ± 338.6	4004.2 ± 352.7	1335.2 ± 230.3	538.6 ± 135.1	237 ± 99.3	10431.2 ± 541.8
CM	4262.6 ± 345.4	4598.7 ± 478.9	1673.3 ± 229.5	488.1 ± 139.5	122.5 ± 70.3	11150.9 ± 644.9
WM	4087.9 ± 201.4	3571 ± 342.1	1529.8 ± 124.1	644 ± 111.3	270.4 ± 65.1	10283 ± 285.5
FW	4538.6 ± 445.4	3445.6 ± 745	1136.7 ± 170.9	440.4 ± 85.7	139.4 ± 50.2	9705.6 ± 707.2
Average	4224.5 ± 935.4	4099.3 ± 545.6	1354.4 ± 341.4	459.4 ± 160.8	156.1 ± 98.9	10307.6 ± 935.4
ANOVA	F = 3,68*	F = 17.65*	F = 39.06*	F = 21.97*	F = 18.84*	F = 36.9*

LEGEND: W – walking, J – jogging, R – running, HSR – high speed running, S – sprint, TD – total distance

Table 2 *Accelerations and decelerations with differences among playing positions (data are presented as Means ± Std.Dev if not indicated otherwise)*

Position	ACC	DEC	HIA	HID
CD	742.9 ± 57.3	715 ± 52.4	2.4 ± 1.9	6.2 ± 2.9
FB	711 ± 67.5	671.4 ± 57.1	3.3 ± 1.6	13.3 ± 4.9
CM	733.6 ± 73.6	681.8 ± 56.7	1.9 ± 2.3	11.6 ± 5.9
WM	687.9 ± 36.3	662.2 ± 38.9	7.4 ± 2.4	21.4 ± 5.4
FW	607.9 ± 90.2	531 ± 72.5	6.1 ± 3.1	10.7 ± 3.2
Average	717.2 ± 74.2	675.1 ± 70.3	3.2 ± 2.7	11.4 ± 6.3
ANOVA	F = 6.57*	F = 15.26*	F = 16.56*	F = 17.98*

LEGEND: ACC – accelerations, DEC – decelerations, HIA – High intensity accelerations, HID – high intensity decelerations

Data obtained by InStat index were not correlated with running performances (Pearson's correlation: Total distance 0.06; Walking −0.03; Jogging 0.02; Running 0.16; High speed running 0.03; Sprinting 0.01; Accelerations −0.03; Decelerations −0.1; High intensity accelerations 0.18; High intensity decelerations 0.04; all $p > 0.05$).

Discussion

We have found significant differences in running performance among playing positions, and our results are generally in agreement with previous studies which investigated these issues in English Premier League, Spanish first division, Italian Seria A, French League 1, Brazilian first division (Barros et al., 2007; Bradley et al., 2009; Dellal et al., 2011; Di Salvo et al., 2007; Vigne, Gaudino, Rogowski, Alloatti, & Hautier, 2010). Considering the different tactical roles for different playing positions in football game, recent researches confirm that distance covered during the match appears to be related to playing position (Aquino et al., 2020; Dellal et al., 2011; Di Salvo et al., 2007; Vigne et al., 2010). Specifically, our results support previous findings obtained in Brazilian first division, where authors noted that total distance covered by FB, CM and WM were greater than those of CD and FW (Barros et al., 2007). Supportively, the lowest total distance in our study is evident for CD (9292m in average). At the same time, CM covered significantly more distance than players in all other positions (11150 m, in average), which is known to be related to specific playing duties (i.e. CM is responsible for connection between defense and attack and such tactical roles enable them to make greater distance) (Di Salvo et al., 2007; Vigne et al., 2010).

In general, total distance covered is not the factor which distinguishes Croatian players from those playing in elite European divisions. In short, previous studies done in Spanish and English top divisions indicated 10.7 km as an average value of total distance covered, while our results indicated less than 4% lower total distance covered in Croatian highest division (Bradley et al., 2009; Mallo et al., 2015). On the other hand, there is an evident difference in intensities of running. More precisely, while studies noted that elite football players cover 10% of total distance in high intensity (Andrzejewski, Chmura, Pluta, & Konarski, 2015), our results indicated that Croatian players perform 6.4% in high intensity running.

High intensity activities are usually known as all activities with running speed of 19.8km/h and above. The distance covered at high intensities has been traditionally identified as a key performance indicator of physical match performance (Mohr, Krustrup, & Bangsbo, 2003) and one of the crucial elements of success in football (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009). Our results showed that highest amount of high intensity running (high speed running + sprint running) is covered by WM, while the CD have lowest values for these indicators. This is consistent to previous investigations where authors evidenced such results for English Premier League and Spanish first division (Bradley et al., 2009; Dellal et al., 2011; Di Salvo et al., 2007; Mallo et al., 2015).

It is known that external players (e.g. WM and FB) perform significantly more sprints then central playing positions (Di Salvo et al., 2007). Supportively, our results showed that greatest sprint distance was covered by WM and FB. However, despite similar differences among playing positions between our and previous studies, values on high intensity running in Croatian players are evidently lower than those from best European national competitions (Bradley et al., 2009; Mallo et al., 2015). More specifically, mean high intensity distance covered among all playing positions in English Premier League is 936m, in Spanish first division authors reported average of 821m and, while in here studied Croatian first division average value of high intensity running was 615m. Collectively, this is another indicator that Croatian first division players actually perform at lower game pace than their colleagues from best European divisions.

Highest number of accelerations and decelerations in our study was evidenced for CD, and lowest for FW, which is consistent with some similar researches on friendly matches in Spanish first division (Mallo et al., 2015). Specifically, one of most the important tactical roles of FW is to keep the ball possession in central position, so it is typical that FWs don't cover the large distance. On the other hand, CD must be constantly prepared for defensive reaction and while trying to find appropriate positioning, they frequently change running directions, but also even the types of running (i.e. frontal running in order to make defensive line to catch opposing players offside, lateral shuffles to take better position versus FW). This certainly result even in high number of accelerations and decelerations for these players. However, considering to the kind of units accelerometer and the way that data are mathematically treated, it could have a significant effect on the calculation of accelerations and decelerations, which actually limits the comparability between different studies (Mallo et al., 2015). Specifically, while the capacity to accelerate and decelerate plays a critical role in elite football as it represents high energy demanding activities, the determination of accelerations might still have unresolved methodological issues (Mallo et al., 2015).

Correlation between running parameters and InStat Index was not found. As InStat index is affected by game performance indicators that are specific (i.e. different) for each playing position, these findings are not surprising. In further researches these implications should be analyzed specifically for each playing position.

Conclusion

The results of this study confirmed previous finding on this theme and showed that physical demands of football game vary between playing positions and should be taken into consideration by coaches and practitioners in creating specific training plans. We previously stated that high intensity activities are crucial elements of success in football, but regarding to these findings, it seems that efforts in running zone are crucial among CD position. Furthermore, number of accelerations and decelerations have proven to be very important for CD, while high intensity accelerations and decelerations are performed most by WM. As mentioned before, correlations between game performance indicators and running parameters should be studied for each position separately.

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EFFECTS OF IMMEDIATE MECHANOTHERAPY AND INTERMITTENT CONTRAST WATER IMMERSION ON SUBSEQUENT CYCLING PERFORMANCE

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Ivan Struhár, Michal Kumstát, Kateřina Kapounková, Klára Šoltés Mertová, Iva Hrnčiříková

Department of Health Promotion, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

ABSTRACT

Purpose: Finding the balance between the training, the competition, and recovery is a crucial component for maximal sports performance. A huge range of sport recovery methods is presented as an important part of training programs. In recent years, there has been an increasing interest in using the contrast water immersion and massage and its effect on subsequent muscle function. Recent studies have shown that the contrast water immersion affects the maximal force, which can be useful for subsequent repeated performance. This study aims to investigate the differences between using immediate mechanotherapy and contrast water immersion on cycling performance.
Methods: Eight physically active male participants (age 27.1 ± 2.32 years; body mass 77.38 ± 5.43 kg; body height 1.78 ± 0.05 m; body fat 10.12 ± 2.23 %; maximum heart rate 182 ± 4 beats·min^{-1}; VO_{2max} 47.92 ± 7.16 mL.kg^{-1}.min^{-1}) volunteered and gave written informed consent to participate in this study. Participants completed three trials, each separated by one week. Each trial consisted of two “all-out” exercise bouts (30-20-10 s) against the load resistance of 0.07 kg/body weight. Three minutes recovery phase was between the “all-out” exercise bouts (1 W/kg; a pedal rate of 70–75 rpm). Following this, the selected recovery strategy was applied for 24 minutes (PAS-passive recovery, MT-massage therapy, CWI-contrast water immersion). The effect of recovery was assessed through changes in performance parameters, blood lactate concentration, and blood gases analyses.
Results: The results obtained from the analysis showed positive statistical significance difference between using PAS vs. MT ($p = 0.0313$) and PAS vs. CWI ($p = 0.0441$) for peak power. Interestingly, there were similar differences in fatigue index when we had compared PAS vs. MT and PAS vs. CWI. A decrease in lactate levels overtime was the highest for CWI.
Conclusion: The results of this study indicated that CWI and MT could be considered as a useful method in sports recovery. The results of this research support the idea that passive recovery is not the right way of recovery, especially when the athletes expect subsequent performance. Future trials should assess the impact of water temperature and different massage techniques on performance and also for subjective feelings of athletes.

Keywords: anaerobic performance; blood lactate; sports recovery; massage therapy

Introduction

In the last few years, there has been a growing interest in sports recovery not only for performance enhancement but also for injury prevention. A large and growing body of literature has investigated numerous passive and active recovery methods, such as massage therapy, cold water immersion, cryotherapy, contrast water immersion, compression therapy, deep water running, stretching, electromyostimulation, hyperbaric oxygen therapy or carbohydrate replenishment (Barnett, 2006; Leeder, Gissane, van Someren, Gregson, & Howatson, 2012; Nelson, 2013; Struhar & Kumstat, 2017; Struhár, Kumstát, & Králová, 2018; Versey, Halson, & Dawson, 2013; Kumstát, Rybářová, Thomas, & Novotný, 2016). However, a significant problem with the recovery type is using in a real sports practice because of the economic burden or availability recovery techniques. Sports training and competition may usually decrease the next performance. This physiological consequence of intensive physical activity can last hours even days which create a situation when the athlete is not able to train at the required intensity. The imbalance between the proper recovery and training stress can lead to functional or non-functional overreaching or overtraining syndrome. Not only anecdotal evidence also proved to decrease physical performance, but also dysfunction of pathways and response in inflammatory and metabolic systems (Meeusen et al., 2013).

Some methods, like cryotherapy or electro-myostimulation are challenging to perform in the immediate phase of recovery. For this reason, it is essential to find alternatives which are not so expensive and time- consuming and also not required the unique proprieties. In recent years, there has been an increasing interest in contrast water immersion (CWI) which means alternating immersion in hot and cold water. The protocols of CWI usually consists of 0.5–3 min in one temperature followed by the same time in contrast temperature (Coffey, Leveritt, & Gill, 2004; D. Higgins & Kaminski, 1998; Vaile, Halson, Gill, & Dawson, 2008). The temperatures vary from 10 to 16°C for cold water and 40 to 46°C for hot water. The exact mechanism of CWI remains uncertain. Firstly, alternating warm and cold water is one of the key factors. Immersion of body part into the hot water evokes superficial vasodilation while cold water immersion is often associated with vasoconstriction. CWI reduces the inflammatory process and also alleviates acute pain after intense physical activity.

Another standard recovery method is massage because of its simplicity of use. However, the main effects are still unclear and often under investigation of sports scientists (Best & Crawford, 2017; Joseph, Hancharoenkul, Sitilertpisan, Pirunsan, & Paungmali, 2018; Resnick, 2016). Massage is often used to decrease pain and to alleviate delayed of muscle soreness. It is essential to mention that classical or sports massage do not statistically increase the blood flow, which is often described as the main effect of massage therapy (Hinds et al., 2004). However, the findings from the study of Crane (Crane et al., 2012) proved that massage attenuated the production of the inflammatory cytokines and interleukin-6 (IL-6). Subsequently, that is the real evidence that the massage can be considered beneficial by reducing inflammation for athletes.

The main aim of this investigation is to assess the effect of immediate mechanotherapy and CWI on cycling performance.

Methods

Participants

Healthy physically active male participants (age 27.1 ± 2.32 years; body mass 77.38 ± 5.43 kg; body height 1.78 ± 0.05 m; body fat 10.12 ± 2.23 %; maximum heart rate 182 ± 4 beats·min^{-1}; VO_{2max} 47.92 ± 7.16 mL·kg^{-1}·min^{-1}) volunteered and gave written informed consent to participate in this study. Participants had the right to withdraw from the study at any time. Prior to undertaking the investigation, ethical clearance was obtained from the Research Ethics Committee of Masaryk University. Exclusion criteria included athletes with (a) potential medical health problems (b) orthopedic history of back, knee and ankle in the six months preceding the study (c) taking drugs related to performance enhancement

Participants were asked to refrain from alcohol and caffeine products and strenuous exercise for the 24 h prior testing day. However, we advised continuing their normal levels of physical activity. Participants were all recreationally active (running, cycling, and tennis) and were familiar with the experimental testing methods used in the study.

Study design and ethical aspects

The study evaluated the effectiveness of three frequently used selected recovery strategies on subsequent cycling performance. Participants performed the three experimental trials carried out at the same time of day separated by seven days. One week before the study, age, body height, and weight were recorded, and participants performed a familiarization trial on a cycle ergometer (Lode Excalibur Sport). They also performed a shortened example of recovery strategies (passive recovery, massage therapy, and contrast water immersion). All experimental measurements were conducted in the Human Performance Laboratory of Faculty of Sports Studies.

On the day of testing, the participant randomly chose one type of recovery strategy without knowing the type. The testing protocol (Test I., Test II.) started with lactate (LA) and blood gases (BG) measurements. After initial testing biochemical parameters, the ergometer seat height was adjusted, so the participant´s legs had approximately 2–5° bend in the knee at leg extension. The test started with the warm-up phase (1 W/kg; a pedal rate of 70–80 rpm). Following this, the participant was instructed to pedal three times "all-out" exercise bouts (30-20-10 s) against the load resistance of 0.07 kg/body weight. Three minutes recovery phase was between the "all-out" exercise bouts (1 W/kg; a pedal rate of 70–75 rpm). Finally, LA activity and BG analyses were measured after the last "all-out" exercise bout. In the follow-up phase of the study, the selected recovery strategy was applied for 24 minutes. After the recovery strategy, the same testing protocol was repeated (without the recovery strategy). Participants were advised to take a carbohydrate-rich meal 2 hours before testing. During the testing, only drinking water was allowed ad libitum.

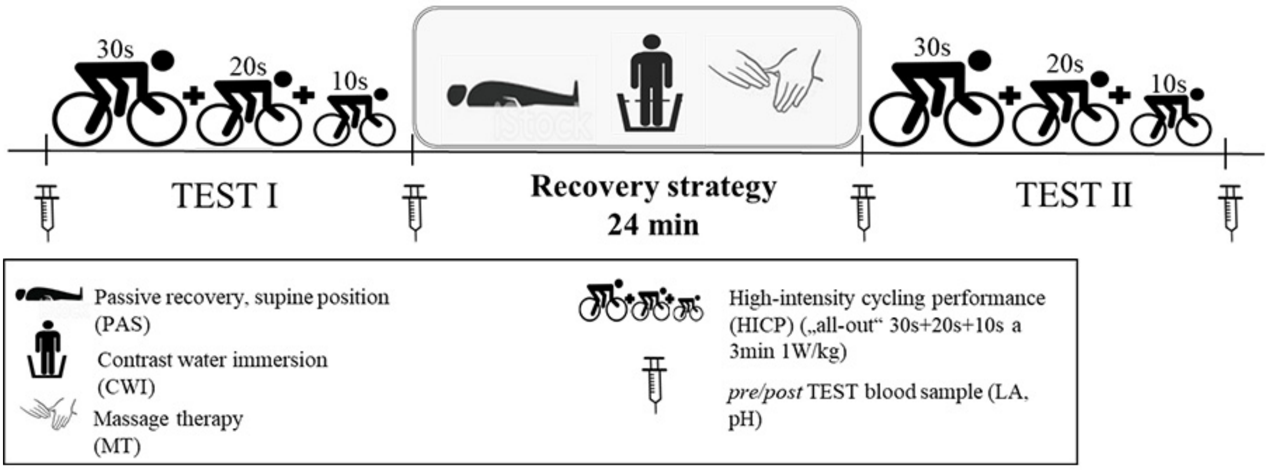

Figure 1 *Experimental design*

Characteristics of the treatments protocols

All selected strategies were used after Test I.

- *Passive recovery (PAS)*

The passive strategy was done in a precisely controlled supine position on a massage table. Head, knees, and feet were approximately at the same level. This strategy was completed in an air-conditioned laboratory at a temperature of 22°C. Participants stayed in this position for 24 min.

- *Massage therapy (MT)*

A licensed massage therapist with eight years of experience completed a 24 min leg massage (12 min for each side). The therapy was done in the supine position by using a conventional massage emulsion (EMSPOMA white). For this study, Western massages strokes were used (effleurage, petrissage, friction, tapotement, and the final effleurage).

The massage therapy protocol started with 1 min of superficial effleurage and 1 min of deep effleurage. Subsequently, the therapist performed compressive effleurage (1 min), friction with both palms (1.5 min) and petrissage (1.5 min) on calf muscles (performed with the bent knee). Then, compressive effleurage with four fingers and friction with both palms were administrated on iliotibial band (2 min). Afterward, the therapist performed petrissage on the thigh (2 min). Finally, the tissues of the thigh were agitated with tapotement (2 min; tapping, pinching, and hacking).

- *Contrast water immersion (CWI)*

The CWI protocol consisted of alternating 6 min immersions in tanks of cold (10–11 °C) and warm water (40–41 °C), repeated two times (10 s transfer time). CWI was done in standing position at height of fossa poplitea. The temperature of the water was constantly monitored. In case of higher or lower temperature, the researches adjusted the temperature according to the actual state.

Measures

Preliminary VO_{2max} test

All participants completed a maximal effort incremental cycling performance test on an electromagnetically braked cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands). The incremental step test was completed two weeks before the study.

Verbal encouragement was provided at the end of the test to ensure that a maximal effort was reached. Especially, participant kept the cadence between 70–75 rpm during the whole test.

The test started with a warm-up phase without pedal load (2 min, 0 W) and then 4 min the self-selected pace for 4 min. The self-selected phase was completely according to the subjective decision of each participant (70–130 W). After the warm-up phase, power output was increased by 25 $W.min^{-1}$ until the participant was unable to maintain the expected work output (the pedal rate fell by > 10 rpm). The maintenance of expected pedal frequency was the first criterion of test validity. In addition of this, at least two criterions had to be filled for acceptance of the VO_{2max} measurement (1) The presence of a “plateau” in VO_2 ($\Delta VO_2 \leq 150$ mL/min) (2) respiratory exchange ratio (RER) > 1.15 at the end of the test (3) heart rate (HR) is within 10 $b.min^{-1}$ of the age-predicted maximum

Analysis of Blood Lactate (LA)

LA concentration was measured through a portable lactate analyzer Lactate Plus device (manufactured by Nova Biomedical) which analyzed a capillary blood sample obtained from finger-prick with a lancet. Blood lactate was measured four times before and after the test (Test I., II.).

Capillary blood gas analysis

Blood gas analysis was conducted by an electrochemical apparatus Gastat Navi (Techno MedicaCo., Ltd.). Whole blood samples were collected by finger prick using a sterile single-use lancing device. Blood sample of ~60 μl was collected into plain heparinized capillary tubes analyzed for pH.

Cycling performance

Each participant was instructed to finish bouts of maximum cycling performance on a cycle ergometer (Lode Excalibur Sport). The maximum cycling performance (CP) test consisted of three bouts of maximal effort (“all-out”) exercise (1) 30 s (2) 20 s (3) 10 s. The load resistance of the flywheel was set up on 0.075 kg of a subject's body weight. For this verbal study, encouragement was given during the bouts of exercise to ensure that the participant performed their maximal cycling capacity. The inconsistency of verbal encouragement can influence the cycling performance of the participant. Because of this, the Rocky movie motivational music for training and working played during each bout of the maximum cycling performance.

For the study, peak power, relative peak power, fatigue index, and maximum cadence were recorded during the three bouts maximum cycling performance test.

Statistical analysis

Data analyses were performed using Statistica 12.0 program. Descriptive statistics (mean ± SD) for the different variables were calculated. Normality assumptions for all data (pre and post) were checked respectively with Shapiro-Wilk test. The level of significance was set at $p < 0.05$.

Results

The overall performance measurement results are summarized in Table 1. The results obtained from the analysis showed positive statistical significance difference between using PAS vs. MT ($p = 0.0313$) and PAS vs. CWI ($p = 0.0441$) for peak power (20 s performance). Further statistical tests also revealed statistical significance between TEST I vs. TEST II (CWI, 10 s, $p = 0.0455$; MT, 20 s, $p = 0.0395$).

Table 1 *Descriptive data from repeated high-intensity cycling performance (HICP)*

PAS	30 s		*p*	20 s		*p*	10 s		*p*
	TEST I	**TEST II**		**TEST I**	**TEST II**		**TEST I**	**TEST II**	
Peak Power (W)	751.21 ± 23.40	782.75 ± 69.18	*NS*	798.23 ± 11.50	802.32 ± 59.80	*NS*	801.04 ± 27.21	814.33 ± 36.00	*NS*
Fatigue Index (%)	61.05 ± 13.43	60.52 ± 12.86	*NS*	51.50 ± 9.40	53.71 ± 11.87	*NS*	29.47 ± 5.66	31.45 ± 7.51	*NS*
CWI	**30 s**		*p*	**20 s**		*p*	**10 s**		*p*
	TEST I	**TEST II**		**TEST I**	**TEST II**		**TEST I**	**TEST II**	
Peak Power (W)	759.61 ± 29.02	769.14 ± 29.18	*NS*	801.05 ± 94.14	805.93 ± 156.01	*NS*	789.14 ± 63.22	824.34 ± 54.12	*0.0455**
Fatigue Index (%)	52.65 ± 5.71	53.95 ± 7.08	*NS*	59.04 ± 7.12	60.08 ± 5.09	*NS*	31.98 ± 5.70	32.27 ± 6.08	*NS*
MT	**30 s**		*p*	**20 s**		*P*	**10 s**		*p*
	TEST I	**TEST II**		**TEST I**	**TEST II**		**TEST I**	**TEST II**	
Peak Power (W)	778.21 ± 94.30	786.14 ± 89.24	*NS*	756.72 ± 54.60	798.89 ± 45.94	*0.0395**	802.33 ± 78.12	815.45 ± 64.19	*NS*
Fatigue Index (%)	49.58 ± 7.20	48.18 ± 6.15	*NS*	45.60 ± 7.38	49.18 ± 5.61	*NS*	39.53 ± 10.30	41.14 ± 9.54	*NS*

*$p < 0.05$; NS: not statistically significant

PAS – Passive recovery; **MT** – Massage therapy; **CWI** – contrast water immersion

In our paper, the focus of attention was also for assessing the lactate clearance. One of the more significant findings to emerge from this study is that the rate of decrease LA concentration was higher (TEST II_{pre}-TEST I_{post}) for CWI 1.53 ± 0.35 mmol/L, compared with PAS 0.5 ± 0.24 mmol/L ($p = 0.0348$).

It is equally important to mention that the similar results were found for MT 1.37 ± 0.19 mmol/L, compared with PAS 0.5 ± 0.24 mmol/L ($p = 0.0414$).

Discussion

This study assessed the effects of contrasts water immersion, massage therapy and passive recovery on performance and biochemical indicators of exercise-induced muscle fatigue. Firstly, we decided to use CWI. The protocol consisted of alternating 6 min immersions in tanks of cold (10–11 °C) and warm water (40–41 °C), repeated two times (10 s transfer time). The decrease in temperature tissue can stimulate cutaneous receptors. This can affect decreasing the swelling and also inflammation process in the human body (Enwemeka et al., 2002). Cold also decreases nerve conduction velocity in tissues affected by cold temperature which affect muscle pain. Subsequently, we can expect better performance, especially if the athletes have to produce maximal power several times during the match or competition. After the application of cold therapy, superficial heating by warm water was used. It is believed that it causes decreasing sympathetic nerve drive (Cochrane, 2004). This process increases circulation by vasodilation of blood vessels. It has been found higher 10 s peak performance (Pre-test: 789.14 ± 63.22 vs. Post-test: 824.34 ± 54.12; $p = 0.0455$) after the application of CWI. Similar results were found in the rate of decrease LA concentration (TEST II_{pre}-TEST I_{post}) for CWI 1.53 ± 0.35 mol/L, compared with PAS 0.5 ± 0.24 mmol/L ($p = 0.0348$). These results are consistent in good agreement with other studies which have shown that CWI (T. R. Higgins, Greene, & Baker, 2017; Hing, White, Bouaaphone, & Lee, 2008; Versey et al., 2013).

The present study was also designed to determine the effect of MT on performance. MT is extensively used in sports training because of its effect of lactate removal and decreasing edema and pain (Weerapong, Hume, & Kolt, 2005). However, we can also expect the physiological effect through ß-endorphins Statistical analysis showed significant differences between 20 s peak performance (Pre-test: 756.72 ± 54.60 vs. Post-test: 798.89 ± 45.94; $p = 0.0455$). This fact can be explained by neurological mechanisms. A neural-gating mechanism in the spinal cord is activated during massage therapy. In the literature, several theories have been proposed to explain this mechanism. Stimulus from massage stimulates large fast nerve fibers (Hall, 2016). This means that slower nerve fibers can be blocked for detecting the pain (Weerapong, Hume, & Kolt, 2005). The findings of this study support this idea. On the other hand, objective data for supporting this idea is still missing. MT also influence the biochemical process in our body especially the higher production of serotonin. Serotonin has a crucial role in pain modulation in both central and peripheral nervous systems. The higher level of serotonin which is produced during the MT can have a positive effect on peak performance during the tests.

The present study is one the first which analyze the effect of CWI and MT and PAS in one study design. The findings support the idea of using recovery modalities(CWI, MT) in sports practice.

Conclusion

Contrast water immersion and massage therapy as the recovery modalities gained massive popularity in recent years. However, most of the previous studies do not take into account the comparison between recovery modalities. From the outcome of our investigation, it is possible to conclude that MT and CWI as recovery modalities is beneficial for anaerobic type of physical activity.

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MONITORING HEART RATE VARIABILITY AS A BIOMARKER OF FATIGUE IN YOUNG ATHLETES

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Martina Bernaciková, Jakub Mazúr, Martin Sebera, Petr Hedbávný

Masaryk University, Faculty of Sports Studies; Brno, Czech Republic

ABSTRACT

Purpose: Many high performance and especially top athletes are still at risk or suffer from total fatigue. Therefore, sports science seeks to develop an objective, sensitive and reliable method of early diagnosis of this fatigue (e.g. heart rate variability – HRV as a modern objective method). The aim of the study was to evaluate whether the HRV monitoring could be a complementary diagnostic tool for overreaching / overtraining in young athletes. Already introduced "classical" indicators of HRV, such as spectral performance and its density in the established frequency ranges, are a part of athlete monitoring in the scope of overreaching prevention We were monitoring the heart rate variability parameters at three different phases of the year-long training cycle and to find out whether in one of these phases we could find athletes showing symptoms of overreaching.
Methods: 48 young athletes (33 boys 14.8 ± 1.5 years, 15 girls 14.9 ± 1.7 years) were involved in the study, consisting of 38 boys and 10 girls. There were 15 swimmers (with training volume 9x 1.5–2 hours a week), 12 artistic gymnasts (with training volume 9x 2–2.5 hours a week) and 21 badminton players (with training volume 4x weekly 1.5–2 hours a week). Monitoring was carried out in athletes in three training periods: at the end of the transition period, at the end of the prepared period, at the end of the competition period. Measurements were carried out in the morning. The DiANS PF8 system was used to measure the heart rate variability, the measurements were performed at five-minute intervals: lying-standing-lying. Time and spectral parameters of HRV were monitored.
Results: Results of HRV in three periods (HR + rMSSD in lying). Boys: HR (61 ± 8, 64 ± 7, 64 ± 8), rMSSD (85 ± 64; 80 ± 54; 88 ± 59), TS (-0.56 ± 1.53; -0.87 ± 1.4; -0.42 ± 1.44). Girls: HR (65 ± 8; 64 ± 7; 65 ± 8), rMSSD (74 ± 37; 79 ± 35; 83 ± 43), TS (-0.58 ± 1.57; -0.72 ± 1.35); -0.18 ± 0.18). Statistically significant differences (at the significance level α = 0.05) among sports were found in Kruskal-Walls ANOVA by Ranks: boys in LF-standing, HF standing, FV, SVB and TS; girls in HF-lying, HF-standing, rMSSD, TP-lying, TP-standing, FV, VA and TS.
Conclusion: Monitoring of heart rate variability seems to be a practical tool for prevention of overtraining even in young age. To monitor heart rate variability, we recommend monitoring these parameters: RR, rMSSD, VA, SVB, TS.

Keywords: heart rate variability; fatigue; training stress; overreaching; overtraining

Introduction

Many factors lead to young athletes suffering from more frequent fatigue or overtraining these days. This is caused by the times we live in and the lifestyle of young athletes. Apart from the training itself, the state of the fatigue is influenced by other stress factors, especially school, activities on social networks and playing telephone, tablet or PC games. One of the most effective natural regeneration means is sleep. Watching the screen until the late hours influences the quality of sleep. Insufficient regeneration becomes evident in bigger and more frequent fatigue during sports training. In order to achieve good quality and effective training it is recommended to monitor the athletes and detect the first effects of overtraining in time, within the frame of the overtraining prevention.

Authors focusing on the overtraining syndrome diagnostics and prevention deal mostly with the adult population. In their article “Overtraining Syndrome” Kreher & Schwartz (2012) provide comprehensive information on terminology, epidemiology, pathophysiology, diagnosis, treatment and prevention. Kreher (2016) complements this with topical knowledge. A similar overview is published by Meeusen, Duclos, Foster, Fry, Gleeson, Nieman…Urhausen, A. (2012) in the article “Prevention, Diagnosis, and Treatment of the Overtraining Syndrome: Joint Consensus Statement of the European College of Sport Science and the American College of Sports Medicine. The authors agree that when diagnosing overreaching and overtraining there should always be a complex approach and there are no clear boundaries between individual phases of overtraining (functional overreaching, nonfunctional overreaching and overtraining syndrome).

Raglin, Sawamura, Aexion, Hassmen, & Kenttä (2000) noted that 35 % of adolescent (13–18 years old) swimmers had been “over trained“ at least once. Mackinon & Hooper (2000) quote that 7–20% of elite athletes may show signs of overtraining at any given time.

One of the still developing methods which is relatively commonly used with top adult athletes is measuring heart rate variability. The development of the method in the sports environment in the Czech Republic can be attributed above all to Stejskal, Šlachta, Elfmark, Salinger, & Gaul-Aláčová (2002). Stejskal (2008) summarised his findings on using heart rate variability (HRV) in sports medicine in Javorka (2008).

Botek, Krejčí & McKune (2017) can see better HRV usage in the frame of individual sports training preparation (running, cycling, swimming, triathlon, etc.). At the same time, they describe using HRV to detect the beginning fatigue or functional overreaching at team sports. The same authors, based on their findings and studies of literature sources, consider log-transformed root mean square of successive R-R intervals (Ln rMSSD) time domain parameter to be a perspective and reliable indicator of the response of the body to the training load, as it, similarly to the high frequency band (HF) spectral indicator, reflects the level of adaptability. Currently it is accepted that power in the high-frequency band (HF, 0.15–0.40 Hz) corresponds to vagal activity, with power in the low-frequency band (LF, 0.04–0.15 Hz) representing some mix of vagal and sympathetic activity.

The purpose of our study was to evaluate whether the HRV monitoring could be a complementary diagnostic tool for young athletes. Another objective was to compare heart rate variability parameters at three different phases of the year-long training cycle and to find out whether the HRV monitoring could be a suitable tool for timely overreaching / overtraining diagnostics at young athletes.

Methods

48 young athletes (15 ± 1.5 years old) from three different sports disciplines (swimming, artistic gymnastics and badminton) took part in the study. There were 15 swimmers (5 boys and 10 girls), 12 artistic gymnasts (only boys) and 21 badminton players (16 boys and 5 girls). Detailed characteristics of the group are listed in Tab. 1.

Table 1 *Group characteristics*

	n	age	weight	height	% body fat
ALL boys	33	14.8 ± 1.5	57.2 ± 12.0	170.5 ± 10.3	14.5 ± 4.2
ALL girls	15	14.9 ± 1.7	56.0 ± 8.0	166 ± 7.8	24.7 ± 2.0
Swimming boys	5	15.2 ± 1.3	61.7 ± 4.8	178.0 ± 5.6	15.5 ± 4.7
Swimming girls	10	15.4 ± 1.3	57.6 ± 6.0	167.8 ± 7.5	25.5 ± 2.1
Gymnastics boys	12	15.1 ± 1.5	53.1 ± 9.4	163.3 ± 8.9	13.1 ± 1.5
Badminton boys	16	14.5 ± 1.4	57.7 ± 13.6	171.7 ± 9.7	16.2 ± 3.6
Badminton girls	5	13.9 ± 1.7	52.0 ± 9.1	162.4 ± 6.9	23.5 ± 1.5

Heart rate variability monitoring was carried out in these phases of the year-long training cycle: at the end of the transition period, at the end of the preparatory period, at the end of the competition period. HRV was recorded three times a week in each period (there are nine records per athlete). Measurements were carried out in the morning under the supervision of the testing person and in quiet training premises. The DiANS PF8 system was used to measure the heart rate variability, the system records beat after beat with high accuracy.

The measurements themselves were carried out in two positions as follows:

LYING 5 min – STANDING 5 min – LYING5 min

We monitored these time-domain and SA HRV parameters: HR, very low frequency band (VLF), LF, HF, total power (TP), LF/HF, VLF/HF, VLF/LF, RR or NN (normal to normal), square root of the mean of the squares of the successive differences between adjacent NN intervals (rMSSD). We used for evaluating these complex indexes spectral analysis heart rate variability (SA HRV): functional age (FA), sympathovagal balance (SVB), vagal activity (VA), total score (TS).

We set up borders for assumed overreaching: lower TS: less than -1.5 and. higher value of FA: over 5 years than calendar age.

Results

The two tables below present the basic results of the measured data for the individual parameters in the three phases of the year-long training of boys and girls. Tab. 2 lists the basic HRV parameters and Tab. 3 shows the complex indexes SA HRV.

Table 2 *Basic HRV parameters (median ± SD)*

	Training period	**HR**	**RR lying**	**RR standing**	**rMSSD lying**	**rMSSD standing**	**LF lying**	**LH standing**	**HF lying**	**HF standing**
BOYS	I	61 ± 8	0.98 ± 0.12	0.61 ± 0.08	85 ± 64	16 ± 15	856 ± 1127	478 ± 456	2171 ± 4361	181 ± 287
(n=33)	II	64 ± 7	0.94 ± 0.11	0.61 ± 0.07	80 ± 54	19 ± 20	754 ± 735	562 ± 631	1679 ± 3507	196 ± 187
	III	64 ± 8	0.94 ± 0.12	0.64 ± 0.08	88 ± 59	28 ± 15	737 ± 884	602 ± 630	1984 ± 3089	258 ± 284
GIRLS	I	65 ± 8	0.94 ± 0.12	0.58 ± 0.11	74 ± 37	14 ± 27	708 ± 337	442 ± 1570	1578 ± 2411	114 ± 997
(n=15)	II	64 ± 7	0.94 ± 0.10	0.60 ± 0.07	79 ± 35	14 ± 12	640 ± 1203	453 ± 1058	2037 ± 2032	172 ± 319
	III	65 ± 8	0.92 ± 0.13	0.62 ± 0.09	83 ± 43	21 ± 26	642 ± 623	687 ± 845	1994 ± 2235	222 ± 1257

Table 3 *Complex indexes SA HRV (median ± SD)*

sport	Training period	FV	SVB	VA	TS
BOYS	I	17.1 ± 5.7	-2.05 ± 2.05	0.02 ± 1.60	-0.56 ± 1.53
(n=33)	II	18.9 ± 5.3	-2.12 ± 1.48	-0.39 ± 1.41	-0.87 ± 1.40
	III	17.0 ± 5.8	-1.39 ± 1.51	0.298 ± 1.59	-0.42 ± 1.44
GIRLS	I	19.1 ± 5.7	-0.92 ± 1.67	-0.26 ± 1.71	-0.58 ± 1.57
(n=15)	II	18.7 ± 4.9	-1.35 ± 1.17	-0.30 ± 1.46	-0.72 ± 1.35
	III	16.9 ± 4.6	-1.23 ± 1.14	0.28 ± 1.31	-0.18 ± 1.18

The statistical differences (Kruskal-Wallis test) between individual sports are listed in Tab. 4, separately for boys and girls. For boys we found statistical differences for these parameters: LF-standing, HF-standing, FA, SVB, TS. In Fig. 1-2 we can see the differences for parameters SVB and TS. For girls we noted statistically significant differences for the following parameters: MSSD-standing, HF-standing, HF-lying, TP-standing, TP-laying, FA, VA, TS. Fig. 3–4 show these differences using box plots for VA and TS.

Table 4 *Statistically significant differences between individual sports*: *boys: badminton, gymnastics, swimming and girls (badminton and swimming), at the significance level* α *= 0.05. Presented results are averages from all3 monitored training periods*

HRV parameter	Boys (N=99)	Girls (N=45)
RR-lying	p = 0.3870	p = 0.1626
RR-standing	p = 0.1418	p = 0.1120
VLF – lying	p = 0.2293	p = 0.5002
VLF - standing	P = 0.2040	p = 0.2019
LF-lying	p = 0.1510	p = 1.000
LF-standing	p = 0.0375	p = 0.4554
HF-lying	p = 0.4741	p = 0.0123
HF-standing	p = 0.0362	p = 0.0009
MSSD-lying	p = 0.7348	p = 0.1699
MSSD-standing	p = 0.0740	p = 0.0208
TP-lying	p = 0.8583	p = 0.0183
TP-standing	p = 0.1144	p = 0.0572
FV	p = 0.0238	p = 0.0013
VA	p = 0.0793	p = 0.0021
SVB	p = 0.0005	p = 0.3602
TS	p = 0.0211	p = 0.0048

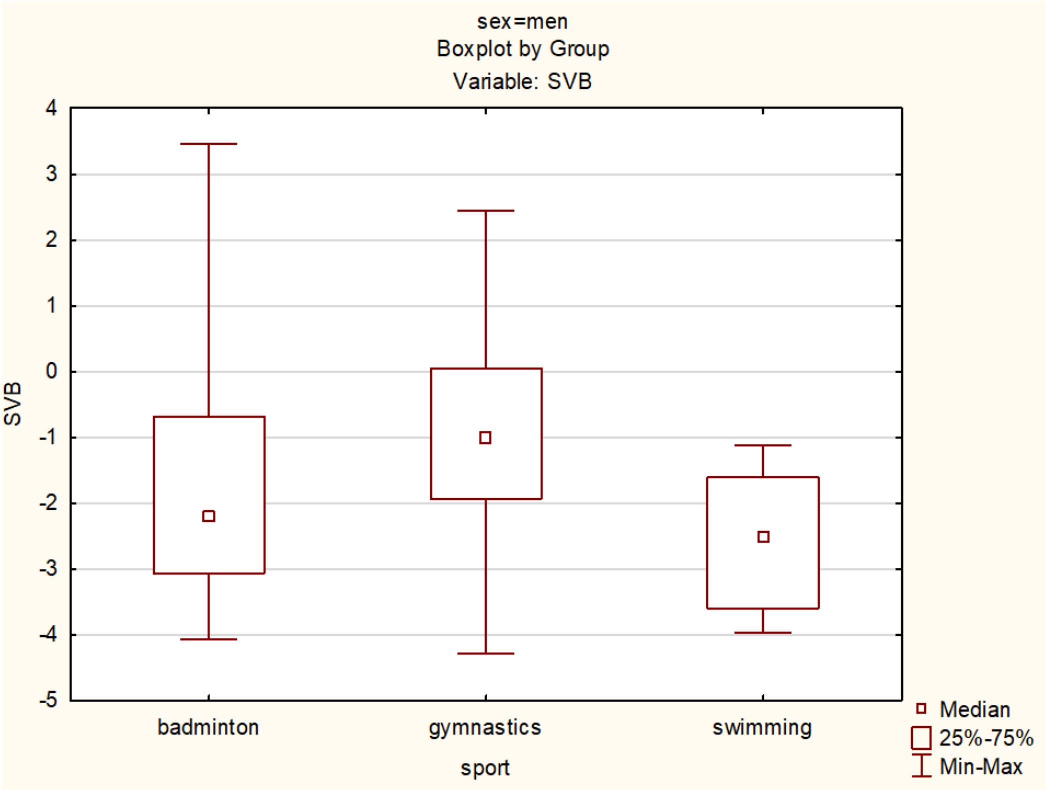

Figure 1 *Differences of SVB among sports in boys*

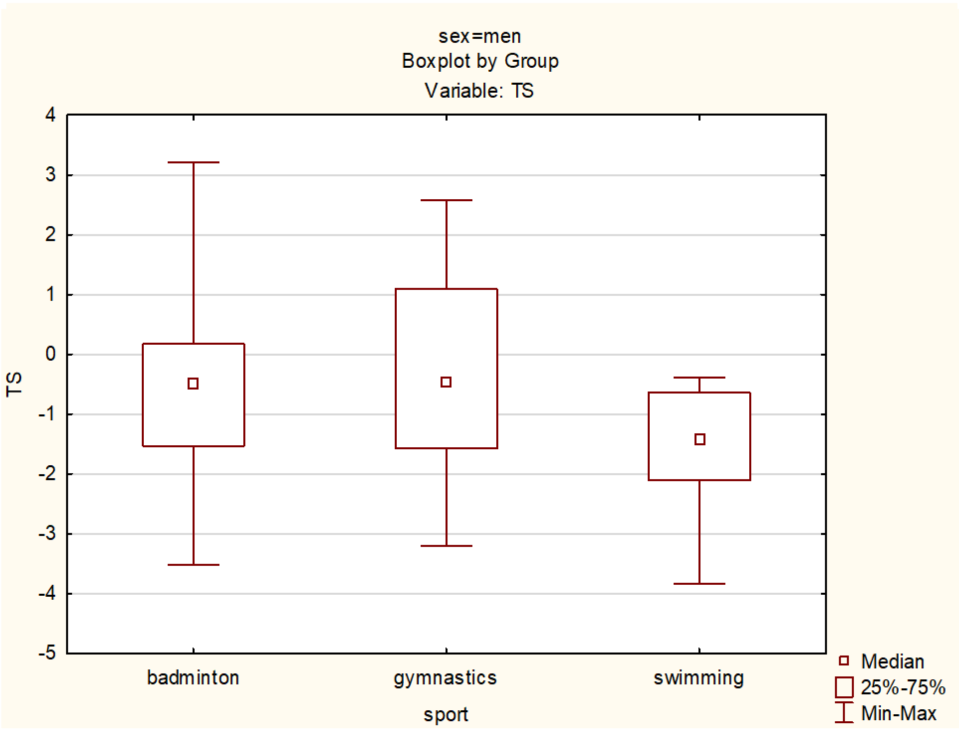

Figure 2 *Differences of TS among sports in boys*

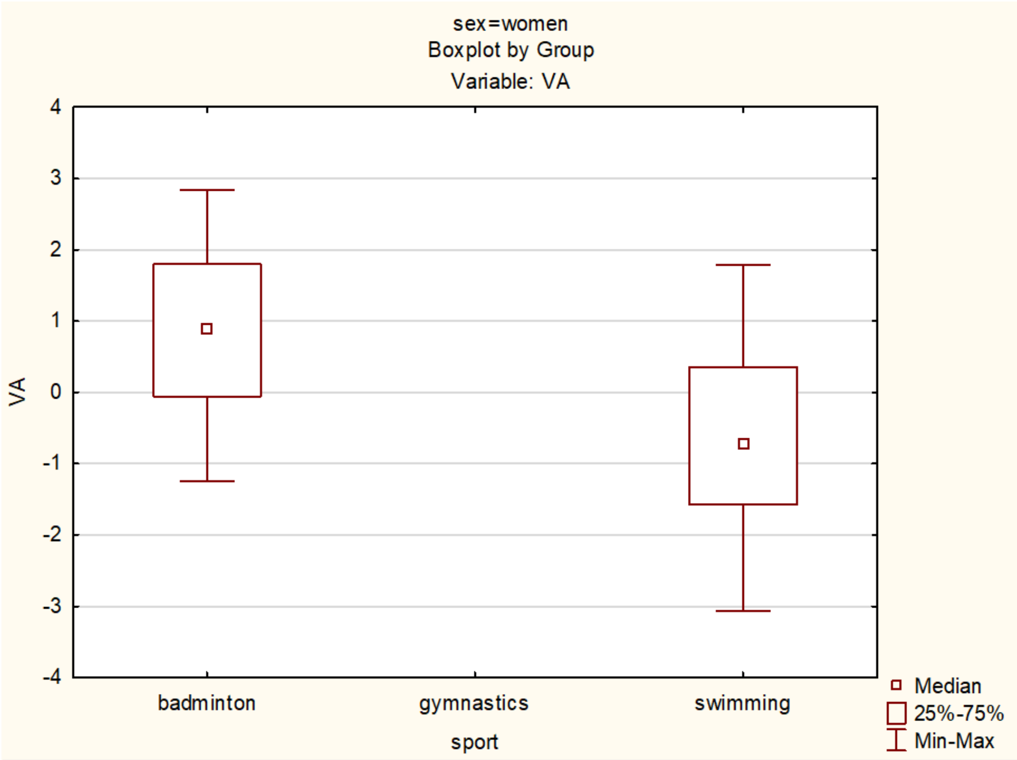

Figure 3 *Differences of VA between badminton and swimming in girls*

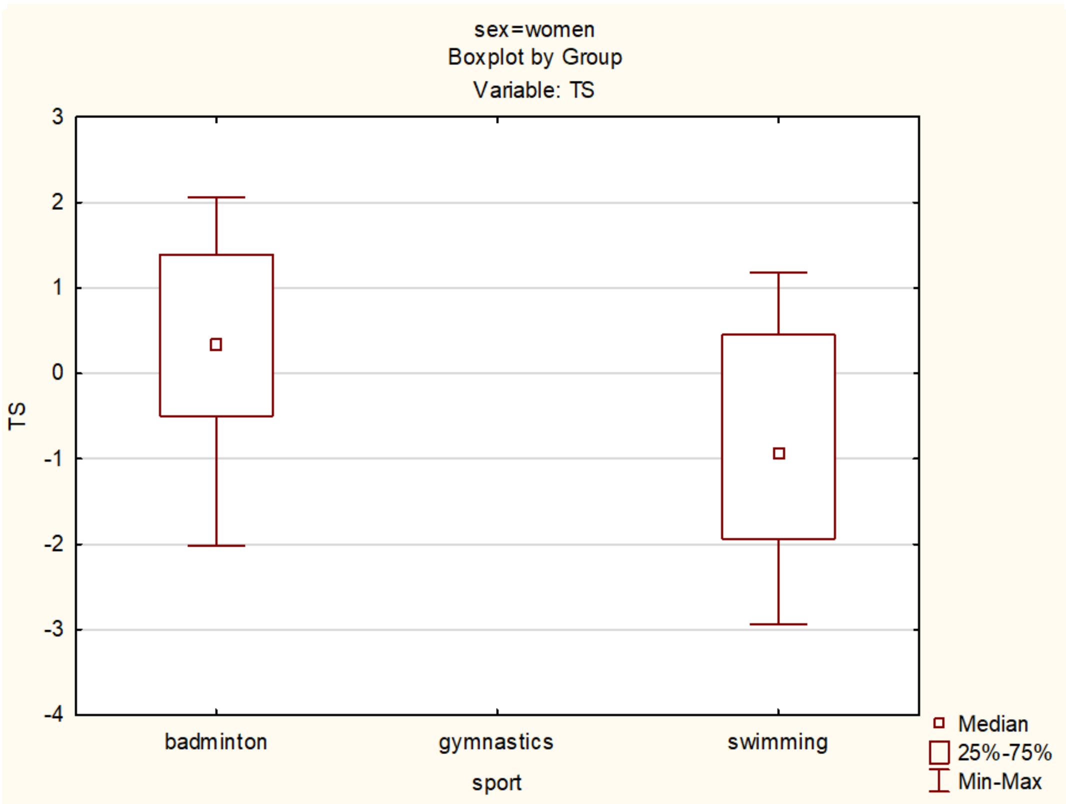

Figure 4 *Differences of TS between badminton and swimming in girls*

Out of a total of 48 young athletes, 4 individuals (2 swimmers, 1 gymnast, 1 badminton player) were found to have a higher overreaching (lower TS: less than -1.5). Higher value of functional age (over 5 years than calendar age) were detected in 7 individuals (5 swimmers, 1 gymnast, 1 badminton player) repetitively.

Discussion

Heart rate variability monitoring at the target group did not encounter any problems. Young athletes quickly understood how the measurements would be carried out and had no problems staying inactive during the resting measurements. Checks during the measurements reassured us that the data could not be distorted at his phase.

When comparing the three phases of the year-long training we didn't find the statistically significant differences in boys and girls (tab. 2 and 3). But the results show that parameters are lower at the end of the transition period than at the end of the preparatory and competition period. Very interesting is evaluation intraindividual differences, we found change for the better or the worse. We recommend more case history and qualitative studies for future.

When comparing the three sports (Kruskal-Wallis test) we found the statistically significant differences for the summative indexes TS for both genders, SVB for boys and VA for girls. As it is clear from the findings listed above, the highest values we found at the badminton players, followed by artistic gymnastics and the lowest values of the parameters were measured at the swimmers. This corresponds to the fact that badminton players have the lowest training loads and on the contrary the highest loads are there for artistic gymnasts and swimmers.

The Tab. 5 compares our measurements with the norm for 12-17-year-old athletes for 10 min lying as published by Sharma, Subramanian, Arunachalam, & Rajendran (2015).

Table 5 *Comparison of our results with the Sharma, Subramanian, Arunachalam, & Rajendran (2015) and Novotný & Novotná (2008) results*

Parameters	**Athletes 5 min lying (our results)**		**Athletes (12–17 years) 10 min lying (Sharma et al. 2015)**		**Nonathletes (13–15 years) 5 min lying (Novotný & Novotná 2008)**	
	girls	boys	girls	boys	girls	boys
HR			80.67	72.27	76.4	79.6
SDNN (ms)			113.00	94.20	70.0	70.0
rMSSD (ms)	86.9	108.6	94.9	100.3		
VLF (ms^2)					3659	2365
LF (ms^2)	640	1274	1465	1211	686	793
HF (ms^2)	1578	2171	2409	2219	1033	1553
Total Power (ms^2)	3717	5797	5202	5273	6639	6274
LF/HF ratio	0.40	0.59	0.63	0.59		

Fortes, da Costa, Paes, do Nascimento Júnior, Fiorese, & Ferreira (2017) monitored HRV parameters at 15–16 year-old swimmers lnRMSSD (ms) 3.6 ± 0.5) mean (SD) – 10 min sitting. HRV measurements at adolescent swimmers (15.5 ± 0.9 years) were also carried out by Vacher, Nicolas & Mourot (2016) – 8 min lying, 8 min standing. rMSSD 76 ± 43 in supine posture and rMSSD 47 ± 33 in standing posture.

For further similar studies we recommend the following: When monitoring the HRV the load intensity should also be recorded (monitoring SF or Borg) and the obtained values should be compared with other diagnostic methods for fatigue monitoring (POMS questionnaire, sleep, immunology markers from saliva / blood, etc.). Only a complex monitoring and analysis have a greater potential to detect athletes who are at risk of overreaching/overtraining.

Conclusion

Based on the obtained data we can claim that HRV monitoring seems to be a suitable tool for overtraining prevention even for young athletes. We believe that measurement can detect the beginning phase of overtraining. Based on the obtained data the following parameters for HRV monitoring are suitable: VA, SVB, TS. For training practice, we also recommend using parameters which are simpler to interpret, such as FUNCTIONAL AGE, as these are more understandable both for trainers and for the young athletes themselves. In order to use this tool as of then as possible by athletes, there is a tendency to shorten the measuring times due to time reasons.

Acknowledgements

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INTERNAL LOAD OF SOCCER GOALKEEPERS DURING A TRAINING PROCESS

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Matej Babic, Miroslav Holienka, Nikolas Nagy

Department of Sports Games, Faculty of Physical Education and Sports, Comenius University in Bratislava, Slovakia

ABSTRACT

Purpose: The main aim of our research was to determine the internal load of goalkeepers in the soccer training process. The internal load of goalkeepers during the training process is examined according to the achieved values of heart rate. Our goal was to expand the knowledge of the impact of different methodical forms on the goalkeepers' internal load in soccer, thereby support the possibilities of improving their training process. The assumption was that the goalkeepers would achieve significantly different heart rate values in different methodical forms.
Methods: The research group was formed by six elite youth soccer goalkeepers (n=6) from U16, U17 and U19 categories. In order to evaluate the heart rate was used the POLAR PRO heart rate monitor and the loading zones of goalkeepers were determined by using a program called POLAR Team[2]. Subsequently, the obtained data were evaluated by using the Wilcoxon Signed-Rank Test and Cohen´s „r "(effect size).
Results: The average difference in HR_{avg} during preparatory exercise and small-sided game was 25 ± 9 beats.min^{-1}, and the average difference in HR_{max} was 35 ± 12 beats.min^{-1}. During preparatory exercise achieved the goalkeepers' value of HR_{avg} 134 ± 8 beats.min^{-1} and in small-sided game was HR_{avg} 159 ± 8 beats.min^{-1}. In individual methodical forms were found significantly different average heart rate values ($z = -2.201$, $p < 0.05$, $r = 0.9$), which statistically and logically confirmed our assumption.
Conclusion: Monitoring of soccer goalkeepers´ internal load in the process of training and improvement of game activities can greatly help the coaches in further planning, optimization and tracking of the training process. Based on our research´s results is recommended to monitor and evaluate the internal load intensity of goalkeepers using sporttesters during entire training process.

Keywords: soccer; goalkeeper; internal load; heart rate

Introduction

The internal load is considered to be some kind of physiological and psychological stress that affects the player´s organism (goalkeeper´s). It is a certain stimulus for adaptation to training´s stimuli with regard to their individual characteristics (Jaspers et al. 2017; Malone et al. 2018). Monitoring of load in training process is the basis for its correct evaluation and subsequent optimization and individualization (Brink et al. 2010; Sannicandro & Cofano 2017; Jaspers et al. 2017; Malone et al. 2018). Players on the field are achieving a higher degree of aerobic persistence than goalkeepers, which means that they have a different structure of training process (Rebelo-Gonçalves et al. 2016; Semjon et al. 2016). This is also confirmed by the research of Gil et al. (2007), who monitored during the particular testing of goalkeepers the highest heart rate values, the lowest VO_{2max} values and thus also the lowest aerobic capacity when comparing to other positions of players. The role of goalkeeper is different from other player´s positions and therefore also the requirements for the level of his individual condition abilities are different.

Aim of our research was to evaluate and compare the internal load of goalkeepers in individual methodical forms. The assumption is that goalkeepers will achieve a significantly higher heart rate values in small-sided game than in preparatory exercise

Material and Methods

Subjects

The research group was composed of elite youth soccer goalkeepers (n=6) with an average age of 16.5 ± 0.6. These goalkeepers are members of soccer academy teams, whose teams play in the highest youth soccer competitions. Goalkeepers in a training microcycle participate during the main period in 5 or 6 trainings.

Table 1 *Basic data and training load zones of the observed goalkeepers*

GK	GK_1	GK_2	GK_3	GK_4	GK_5	GK_6
Age	17.3	17.1	16.8	16.4	16.0	15.6
Body height [m]	187.0	187.6	191.7	186.8	189.6	175.0
Body weight [kg]	83.0	80.1	84.0	91.4	77.6	63.0
HR_{max} [beats.min^{-1}]	197	201	198	198	205	200
100–90 %	197–177	201–181	198–178	198–178	205–185	200–180
89–80 %	176–157	180–161	177–158	177–158	184–164	179–160
79–70 %	156–137	160–141	157–138	157–138	163–144	159–140
69–60 %	136–117	140–121	137–118	137–118	143–123	139–120
59–50 %	116–97	120–101	117–98	117–98	122–103	119–100

Methods of measurement

In order to evaluate the heart rate was used the POLAR PRO heart rate monitor and the loading zones of goalkeepers were determined by using a program called POLAR Team[2]. Based on the ascertained maximum heart rates values, POLAR Team PRO calculated the training zones for every goalkeeper. These zones and their division significantly affect the management, individualization, and effectiveness of a training process.

The maximal heart rate of goalkeepers was measured with the test created by Hipp (2007). It is repeating of certain running distances until the runner switches from the basic slow trotting to the running at highest speed and then to the running at individual maximal intensity.

This test consists of:

The field width run

- run at a low intensity (a short run to warm up) – 6 times;
- run at a moderate intensity – 6 times;
- run at a submaximal intensity – 6 times;
- run at a maximal (subjective) intensity – once.

Statistical analysis

The Wilcoxon Signed-Rank Test was used to evaluate the statistical significance. Afterwards we found out the value of Cohen´s “r” (effect size). The selected level of statistical significance was $p < 0.05$.

Results

In research, we decided to monitor the organism’s functional response to two selected methodical forms.

Table 2. *Heart rate values of goalkeepers during a preparatory exercise and individual training load zones*

Training Session Report										
PE	⏱	HR			Time in sport zones					Above threshold
		Minimum	Average	Maximum	50-59	60-69	70-79	80-89	90-100	
GK 1	00:20:00	93	123	143	00:08:43	00:09:27	00:01:50	00:00:00	00:00:00	00:00:00
Max HR: 197		47,0%	62,0%	72,0%	43,5%	47,3%	9,2%	0,0%	0,0%	0,0%
GK 2	00:20:00	84	137	161	00:07:15	00:03:44	00:07:25	00:01:36	00:00:00	00:00:00
Max HR: 201		42,0%	68,0%	80,0%	36,3%	18,6%	37,1%	8,0%	0,0%	0,0%
GK 3	00:20:00	101	142	159	00:02:01	00:05:13	00:12:37	00:00:09	00:00:00	00:00:00
Max HR: 198		51,0%	71,0%	80,0%	10,1%	26,1%	63,1%	0,7%	0,0%	0,0%
GK 4	00:20:00	105	131	157	00:07:50	00:06:49	00:05:17	00:00:04	00:00:00	00:00:00
Max HR: 198		53,0%	66,0%	79,0%	39,2%	34,1%	26,4%	0,3%	0,0%	0,0%
GK 5	00:20:00	90	124	150	00:12:49	00:05:20	00:01:51	00:00:00	00:00:00	00:00:00
Max HR: 205		44,0%	60,0%	73,0%	64,0%	26,7%	9,3%	0,0%	0,0%	0,0%
GK 6	00:20:00	128	145	163	00:08:10	00:03:42	00:07:00	00:01:08	00:00:00	00:00:00
Max HR: 200		64,0%	72,0%	81,0%	40,8%	18,5%	35,0%	5,7%	0,0%	0,0%

The interval of HR during preparatory exercise was 84 beats.min^{-1} to 163 beats.min^{-1}. During the preparatory exercise reached the goalkeepers the value of HR_{avg} 134 ± 8 beats.min^{-1} and the average value of HR_{max} 156 ± 7 beats.min^{-1}.

Table 3. *Heart rate values of goalkeepers in a small-sided game and individual training load zones*

Training Session Report										
SSG	⏱	HR			Time in sport zones					Above threshold
		Minimum	Average	Maximum	50-59	60-69	70-79	80-89	90-100	
GK 1	00:20:00	112	147	186	00:01:32	00:06:01	00:04:15	00:06:19	00:01:53	00:02:59
Max HR: 197		56,0%	74,0%	94,0%	7,6%	30,0%	21,3%	31,6%	9,5%	14,9%
GK 2	00:20:00	106	167	201	00:00:25	00:03:03	00:04:03	00:02:54	00:09:35	00:09:54
Max HR: 201		53,0%	83,0%	100,0%	1,8%	15,3%	20,3%	14,6%	48,0%	49,6%
GK 3	00:20:00	110	151	179	00:01:36	00:05:32	00:02:59	00:09:31	00:00:22	00:01:25
Max HR: 198		55,0%	76,0%	90,0%	8,1%	27,6%	14,9%	47,5%	1,9%	7,1%
GK 4	00:20:00	102	156	182	00:01:36	00:03:49	00:03:27	00:08:03	00:03:05	00:05:17
Max HR: 198		51,0%	78,0%	91,0%	8,1%	19,1%	17,2%	40,2%	15,4%	26,4%
GK 5	00:20:00	100	164	203	00:01:37	00:04:05	00:02:57	00:02:22	00:08:59	00:09:36
Max HR: 205		49,0%	80,0%	99,0%	7,8%	20,5%	14,8%	11,9%	45,0%	48,1%
GK 6	00:20:00	129	166	190	00:00:00	00:01:32	00:06:09	00:05:18	00:07:01	00:07:57
Max HR: 200		64,0%	83,0%	95,0%	0,0%	7,4%	30,9%	26,5%	35,2%	39,8%

The interval of HR during small-sided game was 100 beats.min^{-1} to 203 beats.min^{-1}. During the small-sided game reached the goalkeepers the value of HR_{avg} 159 ± 8 beats.min^{-1} and the average value of HR_{max} 190 ± 9 beats.min^{-1}.

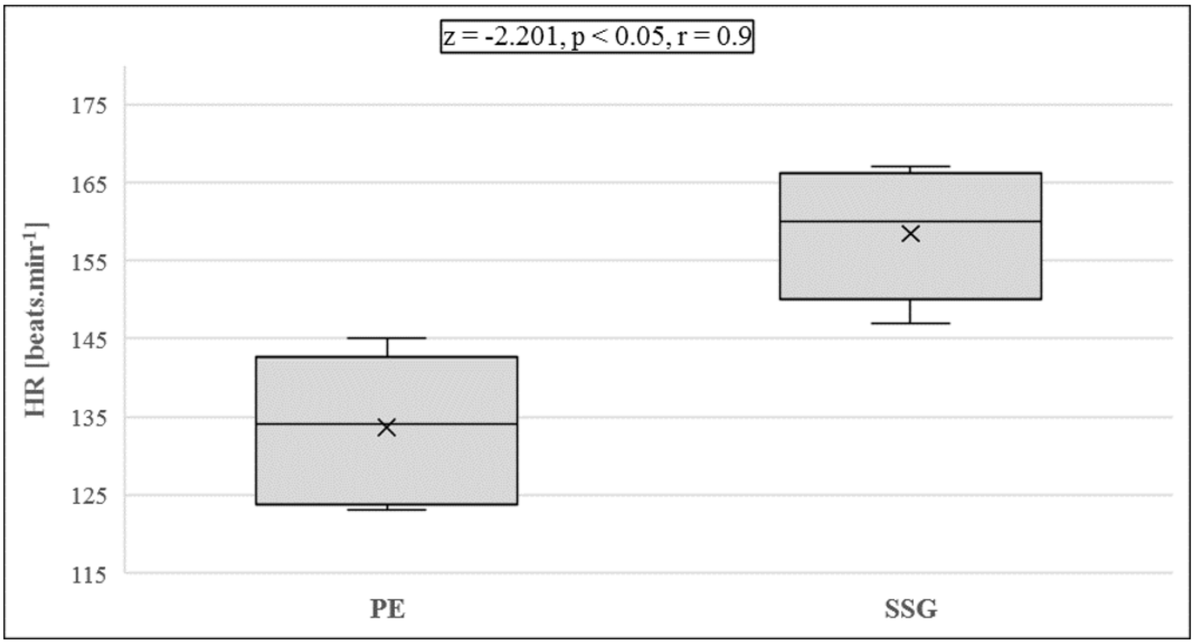

Figure 1 *Comparison of goalkeeper´s internal load in individual methodical forms*

The average difference in HR_{avg} during preparatory exercise and small-sided game was 25 ± 9 beats.min^{-1} and average difference in HR_{max} was 35 ± 12 beats.min^{-1}. During the preparatory exercise reached the goalkeepers the value of HR_{avg} 134 ± 8 beats.min^{-1} and in small-sided game was HR_{avg} 159 ± 8 beats.min^{-1}. There were some significantly different average heart rate values found in individual methodical forms ($z = -2.201$, $p < 0.05$, $r = 0.9$), which statistically and logically confirmed our assumption.

Discussion

Babic, Holienka & Mikulič (2018) found out in their research, that goalkeepers during the small-sided games reached HR_{avg} 159 ± 5 beats.min-1, or more precisely 149 ± 4 beats.min^{-1}. Babic & Holienka (2018) also found similar results and significant differences ($p < 0.05$). Goalkeepers reached HR_{avg} 130 ± 5 beats.min^{-1} during preparatory exercise and HR_{avg} 156 ± 9 beats.min^{-1} during small-sided game. We can only agree with Peráček & Hrnčiarik (2012), that when are creating the conditions for a regular individual training at this stage of the youth sports preparatory in soccer, it is necessary to devoted to the development of physical abilities and game skills. Goalkeepers in the youth categories should improve their technical aspects of defensive and offensive play activities; they should focus on improving conditions under time and space pressure (match conditions) and under fatigue.

Conclusion

Monitoring of soccer goalkeepers´ internal load in the process of training and improvement of game activities can greatly help the coaches in further planning, optimization and tracking of the training process. According to the results of our research, it is recommended to monitor and evaluate the goalkeeper´s internal load intensity by sporttesters during entire training process.

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ECCENTRIC CONTRACTIONS IN THE REHABILITATION OF LATERAL ELBOW TENDINOPATHY: LITERATURE REVIEW

https://doi.org/10.5817/CZ.MUNI.P210-9631-2020-23

Grgur Kovačić, Josipa Antekolović, Ljubomir Antekolović

Faculty of Kinesiology, University of Zagreb, Croatia

ABSTRACT

Lateral elbow tendinopathy (LT) is the most common chronic painful condition affecting the elbow in general population. Research has shown that an eccentric exercise program can be effective modality for treating tendinopathies. The purpose of this review was to determine the effects of eccentric contractions (EC) in comparison to other types of contractions and other therapeutic approaches. Searches were performed using the electronic databases Medline, Scopus and Web of Science. The basic selection criterion was a research methodology in which at least one group of subjects used eccentric contractions in comparison to other methods of contractions or therapy. In conclusion, eccentric contractions are useful method of treating LT in 12 weak period. However, it cannot be stated with certainty whether EC exercises are more or less effective than other forms of therapeutic exercises or specific physiotherapeutic techniques.

Keywords: lateral epicondylitis; lateral epicondyalgia; tennis elbow; elbow tendinopathy; eccentric contractions; physical therapy; exercise

Introduction

Lateral elbow tendinopathy (LT) known as “tennis elbow”, is one of the most often occurring syndromes that affect the soft tissue of the hand (Labelle et al., 1992; Noteboom et al., 1994). The incidence is 1–3% in the general population aged 35 to 54, with no gender prevalence, and is associated with overuse of the fist, forearm and elbow in activities such as manual labor and tennis (Gruchow et al., 1979; Shiri et al., 2006). Clinically, LT is defined as the pain occurring around the lateral epicondyle during the contraction of fist and finger extensor muscles (Harrington et al., 1998; Dimitros, 2016). The pain can be reproduced during physical examination by palpation of the common tendon of the extensor and contraction with resistance of the extensor of the fist and / or middle finger as well as by clenching of the fist (Coombes et al., 2015; Dimitros, 2016). However, defining LT exclusively as mechanical stress-induced tendinopathy is not suitable for explaining the broad clinical image of LT, so more extensive models are being developed lately that include psychosocial factors with new insights into neurophysiology of the pain (Bordachar, 2019).

Numerous studies have confirmed the success of conservative treatment of LT (Nirschl, 1992; Pienimaki et al., 1996; Martinez – Silvestrini, 2005; Croisier et al., 2007; Marcolino et al., 2016; Stasinopoulos and Stasinopoulos, 2017), while the systematic review papers substantiate it as well (Trudel et al., 2004; Cullinane et al., 2014; Menta et al., 2015). Conservative treatment is often multidimensional, while the exercise program is its most often included component (Gruchow et al., 1979; Noteboom et al., 1994; Dimitros, 2016). Exercise programs involving eccentric contractions (ECs) have proven successful due to the potential beneficial effects of stretching, elongation and increase in tendon strength (Murtaugh and Ihm, 2013). Such work modalities are becoming increasingly popular in the rehabilitation of tendinopathies as they are thought to achieve more successful treatment than other exercise modalities (Woodley et al., 2007; Raman et al., 2012). The use of EC in the treatment of LT is not fully understood at present, standardized protocols are not defined, while the results are often contradictory. Nevertheless, the articles reviewed so far indicate promising results in favor of EC as the choice of treatment for LT (Marillas et al., 2008; Cullinane et al., 2014).

The aim of this review paper / report is to analyze the most recent findings on the efficiency of EC as a therapeutic intervention in the treatment of LT compared to other methods, by reviewing the literature to date.

Methods

The Medline, Scopus and Web of Science databases were researched. Existing review papers and major publications were used to select search keywords (lateral epicondylitis, lateral epicondyle, lateral epicondyalgia, tennis elbow, elbow tendinopathy, intervention, management, treatment, rehabilitation, physiotherapy, physical therapy, exercise, strengthening, eccentric and resistance). Research was conducted in February 2019. Out of the total number or papers found, the basic selection criterion was a research methodology in which at least one group of subjects used EC in comparison to other methods of exercise or therapy, patients were diagnosed with LT, there was at least one criterion of functionality of incapacity. The exclusion criterion was the use of steroid injections before or during the study. Out of the total number of papers found, 13 papers were included in the analysis according to the criteria listed above.

Results and discussion

A total of 13 papers were included in the analysis, which compared the efficiency of EC with other types of exercises or other physical methods for improving function in LT. Of the total number of studies, 11 studies (Martinez – Silvestrini, 2005; Nagrale et al., 2009; Söderberg et al., 2012; Viswas et al., 2012; Peterson et al., 2014; Sevier and Stegink Jansen, 2015; Stasinopoulos and Stasinopoulos, 2017; Lee et al., 2018) were randomized controlled clinical trials, one study was a nonrandomized clinical trial (Croisier et al., 2007) and one was a cohort study (Svernlöv and Adolfsson, 2001). Out of 13 studies, two compared ECs with stretching exercises, three compared ECs with concentric exercises, three compared ECs with Cyriax therapy, one study compared ECs with isotonic contractions, one study compared ECs with astym therapy, one study compared EC extensor exercises with shoulder stabilization exercises, one study compared EC with standard physical therapy, one study compared the addition of EC to stretching exercises, one study compared the addition of EC to the physical therapy protocol. Due to the variety of the interventions and the measurement variables used, the results will be discussed narratively.

Comparison of EC and Other Forms of Treatment

In their study Svernlov et al. (2001) compared EC exercises with tolerant pain threshold with stretching exercises over a 15-week period. They determined a positive subjective change in functionality in favor or EC versus stretching exercises. Both groups progressed in reducing pain, with greater progress in the EC group at maximum strength. Martines et al. (2005) also compared EC of an extensor with the addition of pain-free stretching, concentric extensor exercises with the addition of stretching and only stretching exercises in three different groups of subjects. No statistically significant differences were obtained between the groups in any of the variables examined (VAS, maximum painless fist grip strength, subjective sense of functionality). ECs appear to have a more favorable effect than stretching exercises in treating patients with LT, but more research is needed with a longer rehabilitation process to determine clearer causes of differences and better guidelines.

Four studies examined differences in EC rehabilitation and specific manual methods of physiotherapy in the treatment of LT (Stasinopoulos and Stasinopoulos, 2006; Nagrale et al., 2009, Viswas et al., 2012; Savier and Stegink - Jansen, 2105). Stasinopoulos and Stasinopoulos (2006) concluded that ECs have a more favorable effect than the Cyriax method in reducing pain and increasing fist grip strength. Viswas et al. (2012) also compared the two methods listed and obtained similar results in pain reduction, while not examining the strength. Nagrale et al. (2009) obtained opposite results and determined that Cyriax method had a greater effect on increasing strength and reducing pain connected with EC. ECs were performed with pain in all three studies, rehabilitation duration was equal (4 weeks) and exercise protocol very similar. Such contradictory results can be attributed to the examiner bias, but also the quality of manual therapy, which can vary considerably among therapists. Due to contradictory results, we cannot conclude whether EC therapy is more successful than the Cyriax method. Sevier and Stegink – Jansen (2015) examined the difference between the standard physical therapy protocol and EC with astym protocol. They obtained an improvement in all parameters using the astym protocol compared to standard recommended protocol. Additional studies are needed to avoid examiner bias. A potential limitation of these studies is the need for additional therapist education in order for protocols to be implemented.

Wen et al. (2011) compared a group performing ECs with a group performing stretching exercises with the addition of iontophoresis and ultrasound. The authors failed to find significant differences between the groups, which is not in line with the previous findings which define EC as a more successful method of LT therapy than conventional physical methods.

Only one study (Lee et al., 2018) compared EC on fist extensors with an intervention on some other anatomical body location, specifically the shoulder. EC exercises on fist extensors were compared with shoulder stabilization exercises. The group performing shoulder stabilization exercises performed better in fist grip strength and trapezius muscle pressure sensitivity, while the other variables were the same in both groups (lateral epicondyle sensitivity and pain). There results point to the multidimensionality of LT syndrome and tell us that the problem could be observed as a consequence of multiple factors, and the treatment and interventions analyzed in areas beyond the pain site itself.

Comparison of EC with Other Types of Contractions

In a review paper by Raman et al., (2012) authors concluded that the previous studies suggested that an isotonic eccentric modality of work is most favorable as a choice of exercises for LT. Furthermore, they recommended a progressive increase in load over a period of 6 to 12 weeks. Surveys conducted after the review paper offered contradictory results. Martinez – Silvestrini et al. (2005) failed to determine differences in concentric, EC and stretching exercises in reducing pain over a period of 4 weeks. Peterson et al. (2014) found an increase in strength and a decrease in pain in a group performing EC compared to a group performing concentric contractions. Stasinopoulos and Stasinopoulos (2017) compared three groups. One group performed EC, the other a combination of EC and concentric contractions and a third EC, concentric and isotonic contractions. The third group showed the greatest progress in reducing pain and increasing strength which is in line with the earlier findings. Given the results, it can be concluded that it is still not certain whether ECs are a superior mode of exercise compared to other modalities in LT.

EC as an Addition to Standard Protocols

Croisier et al. (2007) compared passive methods of standard physical therapy (TENS, ultrasound, stretching, cross friction massage) without and with the addition of EC. The group performing EC showed progress in all measuring variables (VAS, fist grip strength), so the authors concluded that the addition to the exercise was a mandatory part of the LT treatment protocol. Stretching exercises and wearing a suspensor also produced significantly less progress than a combination of the above listed in addition with EC (Wen et al., 2011). The trend of these results is in line with the earlier findings, suggesting that LT rehabilitation should also include active exercise.

Conclusion

ECs are a useful treatment in treating LT. The 12-week EC exercise protocol achieves beneficial effects on reducing pain and increasing function. However, it cannot be stated with certainty whether EC exercises are more or less effective than other forms of therapeutic exercises or specific physiotherapeutic techniques. People who overuse flexor and fist grip muscles are known to be at increased risk of LT, and all known studies up to date have focused interventions exclusively on the arm extensor muscles where symptoms appear. The involvement of the flexor arm muscles in research would potentially deepen the understanding of how LT is formed and treated. Future research projects that would compare different forms of exercise, different exercise volumes and different forms of contraction would contribute to a better understanding and standardization of exercise protocols in LT.

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SPORT AND SOCIAL SCIENCES

DEVELOPMENT OF EMOTIONAL SKILLS AMONG 15–16-YEAR-OLD ADOLESCENTS IN PHYSICAL EDUCATION CLASSES

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Arturas Akelaitis

Vytautas Magnus University, Academy of Education, Kaunas, Lithuania

ABSTRACT

Background: The aim of this study was to investigate the effectiveness of the 16 weeks educational program of emotional skills in physical education classes on development of emotional skills among 15–16-year-old adolescents in physical education classes. Study hypothesis – the application of 16 weeks educational program would allow expecting more developed emotional skills among 15–16-year-old adolescents in physical education classes.
Subjects and methods: Participants in the study were 51 pupils of the ninth grade (15.15 ± 0.36). Experimental group consisted of 25 and the control group of 26 adolescents. The measures of emotional skills were evaluated using Emotional Intelligence Questionnaire – Short Form (TEIQue – SF), Social Emotional School Readiness Scale (BUSSESR), and self-confidence methodology, developed by Stolin (Пантилеев, Столин, 1989). Educational experiment was used as a method to verify the efficiency of the educational program. Repeated measures (RM) multivariate analysis of variance (2 × 2 (Group × Time) MANOVA) was used in order to analyze the effects of the educational program.
Results: After the 16-weeks educational program (structural physical education classes), a significant improvement was found in emotional skills scores for the experimental group compared with the control group, which had a statistically significant effects: adolescents in the experimental group had more developed self-awareness (F (1,49) = 5.86; $p < .05$; $\eta_p^2 = .11$), self-confidence (F (1,49) = 5.28; $p < .05$; $\eta_p^2 = .10$) skills, and the abilities to express emotions (F (1,49) = 5.95; $p < .05$; $\eta_p^2 = .11$) in physical education classes. These results indicated that the structural physical education classes had a positive influence on adolescents' emotional skills.
Conclusions: It was found that during the 16 weeks educational experiment the applied measures of educational impact had a statistically significant effect on the components of experimental group 15–16-year-old adolescents' self-awareness, self-confidence skills, and the abilities to express emotions in physical education classes.

Keywords: emotional skills; educational program; adolescents; physical education classes

Introduction

Social and emotional learning refers to the process through which individuals learn and apply a set of social, emotional, behavioral, and character skills required to succeed in schooling, the workplace, relationships, and citizenship (Elias et al., 2019).

Emotional competencies are a set of skills and understandings that help children recognize, express, and regulate their emotions, as well as engage in empathy and perspective-taking around the emotions of others. Emotional skills allow children to recognize how different situations make them feel and to address those feelings in prosocial ways (Elias et al., 2019).

Unfortunately, some students do not learn these skills. Students who lack emotional skills are more at risk of engaging in such behaviors as violence and criminality, anti-social behavior, experiencing learning difficulties, and to leave school without any certification or vocational skills, with consequently poor employability opportunities (Adi et al., 2007; Bradley, Doolitte, & Bartolotta, 2008; Colman et al., 2009).

The development of emotional skills is particularly important during adolescence because youth at this stage are going through rapid biological, cognitive, and physiological changes associated with puberty (Yurgelun-Todd, 2007). According to CASEL (2015), adolescents also engage in more risky behavior than younger students and face a variety of challenging situations, including increased independence, peer pressure, and exposure to social media (e.g., „Facebook“, „Twitter“, or „LinkedIn“).

Physical education classes involve many varied and intense emotions. Children's character and personality can be tested in competitive games, and the positive management of feelings may be governed by a particular ability (Tugade & Fredrickson, 2001). For this reason, the development of skills directly or indirectly associated with self-regulation, such as team spirit, collaboration, self-control, patience, adherence to goals, fair-play, acceptance of defeat and respect of one's opponents (Siskos, Proios, & Lykesas, 2012).

After the theoretical substantiation of the assumptions for the emotional skills of 15–16-year-old adolescents in physical education classes it appeared that the following emotional skills components are most important to the emotional development of 15–16-year-old adolescents: self-awareness, self-regulation, self-confidence, and ability to express emotions.

- *Self-awareness* – the ability to accurately recognize one's own emotions, thoughts, and values and how they influence behavior. The ability to accurately assess one's strengths and limitations, with a well-grounded sense of confidence, optimism, and a "growth mind-set" (CASEL, 2015).
- *Self-regulation* – the ability to successfully regulate one's emotions, thoughts, and behaviors in different situations – effectively managing stress, controlling impulses, and motivating oneself. The ability to set and work toward personal and academic goals (CASEL, 2015).
- *Self-confidence* – the ability to belief in one's own abilities to perform (Bandura, 1977).

Ability to express emotions – the ability to express emotions in one's and other people physical states, feelings, and thoughts (Mayer, Salovey, Caruso & Cherkasskiy, 2011).

Taking into account these things, *a hypothesis* is raised in the work that the application of 16 weeks educational program would allow expecting more developed emotional skills among 15–16-year-old adolescents in physical education classes. *The aim of the study* – to investigate the effectiveness of the 16 weeks educational program of emotional skills in physical education classes on development of emotional skills among 15–16-year-old adolescents in physical education classes.

Research methods

Instruments. The measures of 15–16-year-old adolescents' emotional skills were evaluated using:

Social Emotional School Readiness Scale (*BUSSE-SR*), developed by C. Bustin (2007). The questionnaire was developed for assessment of students' self-awareness, self-regulation, social relationships, empathy, and coping skills. The BUSSE-SR comprises 50 statements (in our case 25 statements). In this study, we used only the self-awareness (11 statements, e.g., *„I can tell others what I would like to do"*) and self-regulation (14 statements, e.g., *„I am able to wait turn to speak in a group*") skills assigned parts of the questionnaire. Answering to each statement, the respondents had to choose the variants of their answer by using a 4 - point Likert rating scale with the following categories: „*Never*“; „*Sometimes*“; „*Mostly*“, and „*Always*“. In the current study a Cronbach alpha of .90 was found for the BUSSE-SR total score (self-awareness subscale – .89, self-regulation subscale – .87), indicating high internal reliability.

Emotional Intelligence Questionnaire – Short Form (*TEIQue - SF*), developed by K.V. Petrides and A. Furnham (2006). The TEIQue-SF consists of 15 subscales (including ability to express emotions), organized under four factors: well-being, self-control, emotionality, and sociability. The questionnaire consists of 30 items (two items from each of the 15 subscales). Participants indicate their responses on a 7 – point Likert scale, ranging from 1 – „*completely disagree*“, to 7 – „*completely agree*“. High scores on ability to express emotions subscale mean people are fluent in communicating their emotions to others, they know what the best words are for expressing their feelings accurately and unambiguously. Low scores on this subscale indicate a difficulty in communicating emotion related thoughts, even in situations when this is necessary. People with low scores find it difficult to let others know how they feel (Petrides & Furnham, 2001). In the current study a Cronbach alpha coefficient for the TEIQue – SF total score was .86 (ability to express emotions subscale – .90).

Self-confidence methodology, *developed by Stolin* (Пантилеев, Столин, 1989). A modified questionnaire consists of 14 items, which was constructed in order to determine the impact of physical education classes on students' self-confidence skills. The respondents were asked to choose one of two response options: “*yes*” or “*no*”. Questionnaire reliability and validity procedures were described in the article of Тилиндене и др., (2014).

Participants. Fifty-one adolescents aged between 15 and 16 years were recruited and randomly divided into experimental and control groups. Both groups of subjects were from the same gymnasium of Kaunas district. Twenty-five students (11 boys and 14 girls) were placed in the experimental group in which the structural physical education classes were used as intervention. The other twenty-six students (12 boys and 14 girls) as the control group participated in regular physical education classes. There were no significant differences between the experimental and the control groups by age ($p > .05$) and gender ($p > .05$).

Research Design and Procedures. A quasi-experimental design with a control group and an experimental group was utilized to investigate the effects of the 16-week structural physical education classes on adolescents' emotional skills. The application of the 16-week intervention was selected based on the meta - analysis recommendations, that social emotional learning program, in order to be effective, have to be of a certain length or duration, most probably somewhere between 3 to 6 months (weekly classes) (Diekstra et al., 2008). The present study adopted the pre-test and post-test design. The experimental group participated in educational program of emotional skills that included thirty-two 15 minutes long (total: 8 hours), structural physical education classes. For the each component of emotional skills to develop, were used the same number of training sessions (8 sessions). The experimental and control groups completed the pre-test 1 week before the educational program began, and the post-test was administered one week after the 16-week educational program. Figure 1 is the framework of intervention.

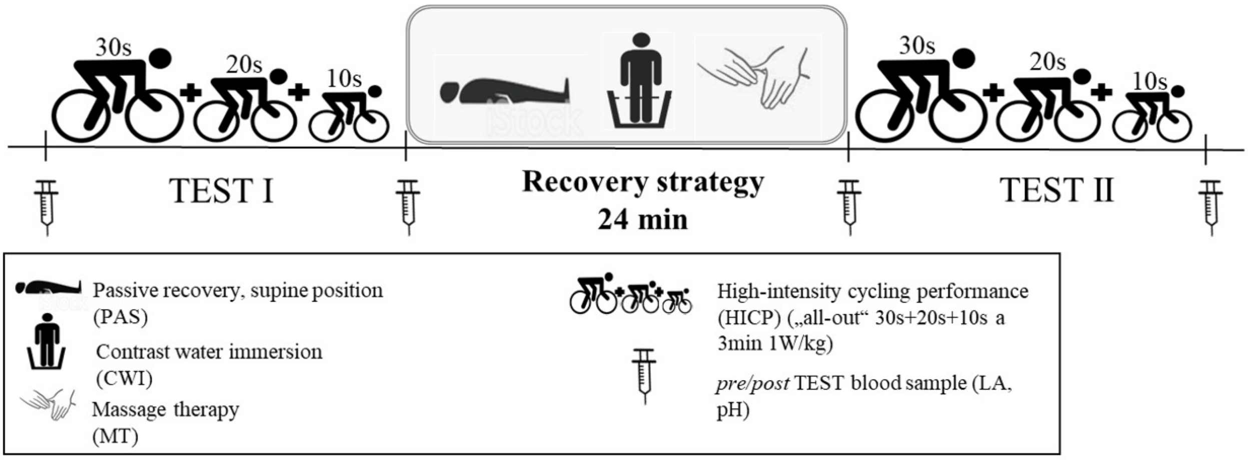

Figure 1 *Framework of intervention*

Educational Program. Several methods have been used to develop adolescents' emotional skills in physical education classes: *modelling appropriate behavior* (can include adults or peers demonstrating the new skills or video based modelling), *role-play* (students have opportunities to see how they might respond to another person who might be sad, hurt and so on), *small groups* (can also be planned where students need to help each other in order to complete a task), *agility games* (a group of games and a conscious human activity in which various movement actions are performed according to established or freely chosen rules: walking, running, jumps, throws) and *group discussions* (students are divided into groups and they are encouraged to discuss on the subject matter given). Statistical Analysis. Research data were statistically processed using SPSS 22.0 (Statistical Package for Social Sciences). Descriptive statistics, namely means, standard deviations, were calculated. The reliability of each dimension given by the index of Cronbach alpha internal consistence was calculated. A preliminary analysis used the Student t test for independent samples, comparing the experimental group with the control group with the aim of checking whether the two groups were homogeneous. Then, considering the recommendation of Arnau and Bond (2008), repeated measures (RM) multivariate analysis of variance (2 × 2 (Group × Time) MANOVA) was used in order to analyze the effects of the intervention program. Wilks's lambda was used to evaluate all multivariate effects; the significance level was set at .05. Effect sizes for *F*-statistics were expressed as partial eta-squared (^{2}). According to Tabachnick and Fidell (2007) effect size based on ^{2} = .01 corresponds to a small effect, ^{2} = .09 corresponds to a medium effect, and ^{2} = .25 represents a large effect.

Results.

Before the intervention, no statistically significant differences were found between the experimental and control groups in emotional skills: self-awareness (t (49) = .68; p= .50), self-regulation (t (49) = 1.11; p= .27), self-confidence (t (49) = .84; p= .41), and the ability to express emotions (t (49) = .04; p= .97).

As shown in Table 1, univariate tests of RM MANOVA confirmed effects of the intervention program on enhancing emotional skills. After the 16-week intervention program (structural physical education classes), a significant improvement was found in emotional skills scores for the experimental group compared with the control group, which had a statistically significant effects: adolescents in the experimental group had more developed self-awareness (F (1,49) = 5.86; p < .05; η_p^2 = .11), self-confidence (F (1,49) = 5.28; p < .05; η_p^2 = .10) skills, and the abilities to express emotions (F (1,49) = 5.95; p < .05; η_p^2 = .11) in physical education classes. These results indicated that the structural physical education classes had a positive influence on adolescents' emotional skills.

The 16-week intervention program had small effects on 15–16-year-old adolescents' self-regulation skills in physical education classes ($p > .05$).
By comparison, no significant differences were found in emotional skills among two testing (pre-test and post-test) periods for the control group ($p > .05$).

Table 1 *The statistical indicators of emotional skills across time by experimental group and control group*

Emotional skills	Control group (n=26)		Experimental group (n=25)		Univariate tests of RM MANOVA Group × Time		
	Pre-test	Post-test	Pre-test	Post-test	F	p	η_p^2
Self-awareness	33.39 ± 4.87	31.31 ± 2.40	32.40 ± 5.53	34.32 ± 5.12*	5.86	0.019	0.11
Self-regulation	41.92 ± 5.84	42.81 ± 2.48	40.12 ± 5.75	44.68 ± 5.09	3.41	0.071	0.07
Self-confidence	9.38 ± 2.53	8.73 ± 2.03	8.80 ± 2.43	10.28 ± 1.99*	5.28	0.026	0.10
Abilities to express emotions	9.15 ± 3.39	9.31 ± 2.26	9.12 ± 1.76	11.40 ± 2.22*	5.95	0.018	0.11

Note. (η_p^2) – effect size, * represented $p < 0.05$, and results are presented as means ± SD.

Discussion

The aim of this study was to investigate the effectiveness of the 16 weeks educational program of emotional skills in physical education classes on development of emotional skills among 15–16-year-old adolescents in physical education classes. In the current study was found that after the end of the educational experiment 15–16-year-old adolescents in the experimental group demonstrated better self-awareness (a medium effect, $\eta_p^2 = .11$), self-confidence (a medium effect, $\eta_p^2 = .10$) skills, and the abilities to express emotions (a medium effect, $\eta_p^2 = .11$) in physical education classes. The findings of the educational experiment confirmed this research hypothesis that the application of 16 weeks educational program would allow expecting more developed emotional skills among 15–16-year-old adolescents in physical education classes. The results of this study were similar to the findings of Durlak, Weissberg, & Pachan (2010), Durlak and colleagues (2011), Taylor, Oberle, Durlak, and Weissberg (2017) whose investigated the effectiveness of the educational programs (interventions) of social emotional skills (effect sizes ranged from medium ($\eta_p^2 = .09$) to large ($\eta_p^2 = .33$).

A meta-analysis by Taylor and colleagues (2017) reviewed 82 school-based, universal social and emotional learning interventions published through 2014 that involved 97,406 children in grades K–12. The study was grounded in a combined social and emotional learning-positive youth development perspective that focuses both on strengths and asset promotion, and protection from negative outcomes. Examining follow-up periods ranging from 56 to 195 weeks, Taylor and colleagues (2017) found that social and emotional learning participants were significantly better adjusted in all seven categories of outcomes considered: social and emotional skills; attitudes toward self, others, and school; positive social behaviors; academic performance; conduct problems; emotional distress; and substance use (effect size ranging from medium (η_p^2 .13) to large (η_p^2.33) across categories). Various reviews of studies have found consistent evidence on the positive impact of school-based social emotional education programs on students of diverse backgrounds and cultures from pre-school to secondary school in social and emotional health (Zins et al., 2004; Durlak et al., 2011; Sklad et al., 2012).

Study limitations. Limitation of the study is that it analyses only 15–16-year-old adolescents' peculiarities of the education of emotional skills in physical education classes, although further study is worth to analyze middle or primary school age students' peculiarities of the education of emotional skills in physical education classes as well and compare data of these age groups students.

Conclusion

It was found that during the 16 weeks educational experiment the applied measures of educational impact had a statistically significant effect on the components of experimental group 15–16-year-old adolescents' self-awareness ($p < .05$), self-confidence ($p < .05$), skills, and the abilities to express emotions ($p < .05$) in physical education classes.

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CHOSEN PROBLEMS OF PHYSICAL EDUCATION IN THE CZECH REPUBLIC

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Kamil Kotlík

Department of Pedagogy, Psychology and Didactics of P.E. and Sports, Charles University

ABSTRACT

The main topic of the paper is the analysis of a state of physical education in primary and secondary education in the Czech Republic. The paper is engaged in an issue of the pupils (and their legal representatives) approach to the physical education as well as of the curricular grounding of the physical education. The next viewpoint is an analysis of a general social and individual value of physical education with the respect to a quality of life of a certain individual. As the last but not the least thing is that the paper evaluates current attitudes to the physical education.

The main goal of the paper is to analyse some of main problems to which the physical education in the Czech primary and secondary education currently is facing (namely big increase of exemption in secondary school and motivation to attend physical education classes). Partial goals are on one hand to uncover less obvious problems connected with above-mentioned, on the other hand point out some of the causes of a current state of physical education. The last partial goal is to offer a possibilities of a solution of the certain state.

The methodological background of the paper has a qualitative character, while the main method is the content analysis when the inductive approach prevails. A reason for using such method is its suitability for processing a new topic. Further, due to the interpretation of gained data we use also the phenomenological approach. Except of aforementioned, we realized open interviews with Heads of schools.

The author finds out that the physical education is currently facing to serious problems when some of them markedly overlaps the sphere of the physical education and their solution is not committed only to the sphere of physical education. Among the other things, these problems may negatively influence a quality of life of the Czech population. Finally, the paper offers possibilities of solution of a current negative evolution.

Keywords: Physical Education; Society; School System; Problems; Legislation

Introduction

Much has been written about the importance and benefits of physical education. Some of the reasons why physical education is a significant and important school subject are evident and do not need to be traced in the literature. These include development of physical abilities and skills, motivation for regular physical activity, knowledge of basic hygiene habits, development of competitive spirit and cooperation, etc. Other benefits comprise, for instance, mental hygiene function of physical activities, knowledge of basic health promotion strategies, increasing mental (for example in case of loss or undesirable development of the game) and physical resistance, development of morals and volition, health-oriented physical fitness, development of social interaction, etc.. Of course, this list is not, and cannot be, complete. We may add, for example, general knowledge and orientation in the sports environment and many other reasons.

These are not the only reasons why physical education is a compulsory national curriculum subject in the Czech Republic, both in primary and secondary education, for the entire period of school attendance with the subject time allocation of a minimum of 2 lessons per week. Many school subjects are incorporated in the curriculum only in certain periods during primary and secondary school attendance, or only at a specific type of schools, with very few subjects being compulsory throughout the entire period of attendance. Physical education is one of them. From the two aforementioned sentences, it is thus clear that physical education is an important and indispensable school subject.

However, the current situation of physical education as well as its perception by students and, by extension, their legal representatives and a number of teachers or Heads of schools is not in line with its proclaimed importance. In reality, frequent exemptions from physical education classes are allowed to students, not only for medical reasons but also due to the students´ leisure activities (activities in sports clubs or other). Participation of the remaining students in regular physical education classes is very low. Its perception by the rest of the Czech population, i.e. people who are not of compulsory schooling age, do not have children of school age or are not bound to the school by work context, is also questionable. It can be stated that intended, implemented and achieved kinds of curriculum does not correspond to each other. School curriculum and its components are in a focus of more authors in last three decades, i.e. Walterová (1994) or Průcha (2017).

The situation and position of physical education in the Czech education system as well as society is currently being discussed by several authors (for example Fialová, Flemr, Marádová & Mužík, 2015, Jansa, Kotlík & Němec, 2014 etc.), however, due to the complexity and topicality of the issue, the discussion is now also held among the professional public. The issue of exemption from physical education in the Czech Republic is quite comprehensively examined by Ješina and Tomoszek (2019a, 2019b), who do not neglect the legal aspects of the situation, and as one of the fundamental solutions, they propose introducing, or more precisely, reinforcing health physical education (or applied physical education) in primary and secondary schools. The first of the two authors deals with the issue of physical education exemption in relation to applied physical education on a long-term basis (Bartoňová & Ješina, 2012; Ješina, 2017; Ješina 2012 etc.).

Other authors approach the current problems of physical education in a more specific manner. Vařeková, Daďová, Levitová and Prokešová (2014) or Válková (2012) see applied physical activities as one of the possible solutions to some of physical education problems (exemption, attendance, motivation) in the Czech Republic. Kalman and Vašíčková (2013) examine health and lifestyle of schoolchildren, Flemr (2018) aims to identify the current problems of physical education.

Apart from the above-mentioned (and other authors), the status of physical education is one of the subjects of interest of state organizations such as the Ministry of Education, Youth and Sports of the Czech Republic (2004), Ministry of Health of the Czech Republic (2013, 2015) and the Czech School Inspectorate (2016).

The National Institute for Education is engaged in physical education in detail, in terms of the curriculum content, required learning outcomes, student competencies, inclusive teaching adjustments, etc.. This organization has elaborated Framework Education Programmes for individual specific types of education (e.g. National Institute for Education, 2017).

In addition to professional circles (Flemr, 2018, etc.), a broad discussion with public participation (e.g. EDUin - Information Centre on Education, 2019) has recently arisen. This discussion is oriented mainly on motivation for physical education attendance and the evaluation in physical education.

In this article, we will attempt to analyze some of problems of the physical education, mainly exemption from the physical education classes, dominantly in the secondary education, and the motivation to attend physical education classes. Additionally, we will analyze also a part of a legislative background of the physical education. Last but not least, we will focus on the causes of above-mentioned problems and their potential interconnection. The last sub-objective is then to propose possible solutions to the current situation.

Methods

Due to the nature of the topic, a qualitative approach was chosen for its elaboration. Content analysis with the predominance of the inductive approach was used as the main method. The reason for choosing the method of content analysis is the fact that it is the primary elaboration of the topic and also, that the examined problem concerns different social spheres and the collected data must be sorted first (Hendl, 2005). The necessity of the inductive approach arises from the fact that the situation of physical education is likely to be affected by many current social processes and phenomena, whether inside or outside the education sector and it is very difficult to approach the issue holistically and not merely some parts of it. The content analysis of legal documents (Framework Education Programmes, Decree No. 391/2013) and Report of Czech School Inspectorate carried out by the inductive approach will in this case also allow assessing the possible mutual influence of individual areas which affect physical education. From this reason, content analysis was conducted by a technique of non-quantitative analysis (Gavora, 2000).

In addition to the above-mentioned method of content analysis, some elements of the grounded theory method are also used when elaborating the topic, not *a priori* in order to present a comprehensive theory but on the grounds of the need to find relations between individual variables (Švaříček & Šeďová, 2007). Not using this option would, in our opinion, significantly reduce the potential of the research.

In terms of the interpretation of the collected data, the phenomenological approach is used because of a deeper understanding and insight into physical education (Hendl, 2005). As part of the enrichment and verification of the thematic analysis results, a total of eight open interviews were conducted with the Heads of primary and secondary schools. Given that this is the primary elaboration of the topic, the headmasters were contacted on the basis of their personal acquaintance with the author; it was not a random selection.

Results and Discussion

Let us begin with the widespread belief that in schools, especially in upper primary schools and in secondary schools, more and more pupils are allowed to be exempted (or partially exempted) from physical education. According to the Czech School Inspectorate (CSI), in the school year 2015/2016 at the second stage of primary school (upper primary school), this was the case of only 2.2 pupils per school (CSI, 2016). However, according to the same report, at secondary schools, it is approximately one average class, i.e. 26 pupils, per each school. This is an upward trend compared to the past. The question is, of course, how many pupils attend a particular school and how the school management approaches the requests for physical education exemption. In any case, according to the CSI, in the school year 2015/2016, there was at least 1 pupil completely exempt from physical education classes in 94.8% of secondary schools, i.e. practically every secondary school, which means that the problem of physical education exemption thus concerns virtually every school (CSI, 216). The increase in the number of exemptions between primary and secondary school is sharp and alarming since the number of exempt pupils in secondary schools is as much as ten times higher. An interesting question arises here as to whether or not the number of pupils exempt or partially exempt at the lower stage of the multi-year grammar school is higher than at the second stage of primary school.

An exemption from physical education is mainly received for medical reasons. Pursuant to the Education Act (Section 50 (2)), the headmaster may "*exempt a pupil, in whole or in part, from a subject on medical or other serious grounds, at the request of his or her legal representative; at the same time, the Head of school determines an alternative way of education of the pupil at the time of teaching this subject. The Head of school exempts the pupil from the physical education classes on the written recommendation of a general practitioner or a medical specialist. The pupil may be exempted from the first or last lesson, with the consent of his or her legal representative, without additional assignments for the unattended lesson*" (MEYS, 2004, p. 22). Here, we encounter several separate problems.

Problem One: Although it is stated in the above paragraph that the Head of school may exempt a pupil from physical education on the basis of a physician's recommendation, it is (above) stated that he or she may decide to do so for other serious reasons. It can be observed from practice that a frequent reason is the pupil's participation in sports competitions of the national scale, which is usually the highest or the second highest domestic sports competition. Here too, the situation further develops in different directions. Firstly, in terms of frequency and sometimes training requirements, there is a difference between a sport with a large membership base and many levels of competitions and a sport which has only one or two youth categories competitions in the Czech Republic and only a small number of individuals practicing it. Further, a question arises as to whether regular trainings really coincide with physical education lessons. Based on the interviews with some of the headmasters, it was found that they often receive requests which are signed by the management of sports clubs stating that the pupils are top level sportsmen or sportswomen, but on closer examination they learn that the pupil is on the 586th position in the Czech Republic (tennis), riding a horse and preparing for his or her very first races, playing the lowest class (football), finished 2 months ago etc.. At one of the grammar schools, the headmistress stated that the legal representatives of a pupil had strongly insisted on receiving a full exemption from physical education as well as other subjects for the pupil because of the proclaimed need for additional individual training (fitness classes – strength and recovery exercises - swimming), when in fact, the pupil (aged 12) had his regular training in the afternoon and the exemption was required for the morning lessons. In principle, the Head of school may exempt a pupil at his or her discretion for virtually any reason. It is not always easy to withstand the pressure from the part of the legal representatives and the pupils themselves. Here, we touch on other problems, which will be addressed later, namely the motivation and educational effect of physical education. On the utilitarian view: what is the use of having a pupil in physical education class who wants to avoid it at all costs? In any case, the aforementioned demonstrates that a not negligible part of parents and pupils consider physical education at best to be an unnecessary, at worst even a counterproductive subject for various reasons.

Problem Two: On the basis of medical recommendation, the Head of school is obliged to allow a student to be exempted from physical education. The medical statement may be questioned by the student´s legal representative, but not by the headmaster (he or she can only recommend a review of the medical statement to the legal representative - but it will most likely meet with little response since the legal representative who seeks exemption from physical education for their child has no interest in the review). Of course, it is also difficult for physicians to cope with the pressure from the part of the applicants for physical education exemption but they undoubtedly have a stronger mandate than the Heads of schools. However, Garkish (2018) argues that a large number of doctors simply conform to the wishes of the parents or students´ legal representatives. Often, obesity of the pupil is the reason for physical education exemption. Needless to say, physical education should counteract the increase in obesity. In this case, the doctor actually suppresses the potential positive effect and the very purpose of physical education (unless, of course, it is a case of obesity limiting the pupil in the basic locomotion).

Problem Three: A pupil may be exempted from the first and last lesson without additional assignments, with the consent of the legal representative - see paragraph above (MEYS, 2004). In most schools, physical education classes are usually scheduled as the first or last lessons for organizational purposes (regarding premises, contracts or schedule). The problem arises especially in the case of afternoon lessons which usually last 2 hours and are thus classified as marginal. Most headmasters stated that in the case of schedule changes after the start of the school year, the legal representatives often argue that they had already running and paid sports clubs.

In terms of the aforementioned paragraph, we consider the wording of the Education Act to be problematic and not addressing the current social needs.

The solution to the problem is offered, for instance, by Ješina and Tomoszek (2019a, 2019b), who see the general introduction of health (or applied) physical education as one of the possibilities. We fully agree with them in this regard. The number of requests for physical education exemption would certainly decrease significantly. Of course, one can only guess to what extent this could be credited to the inclusion of the concerned pupils in the health-physical education programme or because the option of their inclusion in the given programme would discourage them from submitting the exemption request. This case requires adequately educated teachers, and also the willingness of headmasters to introduce the health-physical education programme in their schools, which is, of course, associated with schedule, personnel and, last but not least, financial requirements. Višňa (2017), based on reports from O. Ješina, argues that there is even a number of cases where the legal representatives of pupils with disabilities automatically receive an application form for physical education exemption from the management of the school where their children plan to study.

The situation is not helped by the Decree No. 391/2013 Coll., which deals with medical fitness for physical education and sports, and was elaborated jointly by the Ministry of Education, Youth and Sports of the Czech Republic and the Ministry of Health of the Czech Republic (Ministry of Health of the Czech Republic, 2013). According to this decree, obesity or muscle imbalance can be a reason for physical education exemption. In this case, the decree directly opposes one of the fundamental roles of physical education, which is the health enhancement and health-oriented fitness. It can be stated that the legislative area of physical education is not properly addressed.

Another area which affects the current situation of physical education is the motivation of pupils to actively attend physical education classes. It is necessary to emphasize the word “actively” because physical education lessons can often be only “sat through”. The problem of motivation is not a novelty; in 1992, the then Dean of the Faculty of Physical Education and Sport of Charles University (FTVS UK), prof. Hošek (Hošek, 2019), mentions the problem of new technologies in relation to physical activity. The current situation is fully in line with the implied development since electronic devices, preferably the latest ones, take up a considerable part of pupils’ free time, and less time is left for spontaneous or organized leisure physical activities. It can be inferred that if the pupil does little or no sport in his or her free time, he or she will not develop a keen interest in sports, or this interest will weaken.

Physical education is characterized, among other things, by the fact that pupils should get acquainted with various types of sports and physical activities, which are defined, inter alia, by the individual Framework Education Programmes (FEPs) and further, by School Education Programmes (SEPs) elaborated on their basis by each school. Every pupil has a certain preference in terms of physical activities and possibly sports, and he or she likes some of the activities in physical education more than others. However, it is not possible for pupils to enjoy all the physical activities assigned by teachers within the physical education classes. Thus, internal motivation on the part of the pupils cannot be ubiquitous. At this point, it is very important how teachers approach and motivate their pupils. Of course, there is no clear answer to this problem, and no faculty can fully prepare its graduates to tackle it. Appropriate external motivation of pupils for active and conscious participation in physical education is, however, one of the basic prerequisites for successful work of a physical education teacher, regardless of the type of school. There are different solutions to the problem of unmotivated pupils. If the teacher wants to facilitate his or her work, he or she will allow the students who do not want to exercise (or conceal their unwillingness by claiming that they suffer from nausea, minor injuries or that they had forgotten clothes) sit and watch the physical education lessons. The question is then the efficiency of physical education as well as the activity options in a given lesson, when often fewer than 10 pupils in total are engaged in the physical activity (Flemr, 2018). Another possible solution is to engage pupils in only one or two of the most favoured activities (e.g. football or volleyball) in physical education classes. Some of the pupils may still dislike these activities but they do not have much chance to protest, and the majority of pupils are at least taking an active part in the lesson. The two above-mentioned solutions are parallel to the submission to the pressure from pupils´ legal representatives and the exemption from physical education by physicians. At this point, we certainly do not want to speculate on the number of physical education teachers concerned in this problem, but it is apparent that this phenomenon exists. The third possible solution is to integrate more experience activities into physical education lessons and to accentuate own experience.

A very interesting observation made by Flemr (2018) is that in the interviews with physical education teachers, the second most frequently mentioned topic was security. More specifically, the teachers saw the need to find the right balance between safety and adventure in physical education. At this point, we fully agree with him. If the exercise does not contain at least a small degree of risk or uncertainty regarding the outcome, it has little potential to engage and attract pupils. Such exercise or sport activity is often perceived as pointless and therefore boring. In today’s society, it is generally true that safety standards are gradually becoming stricter and more strengthened; we may even go as far as to speak of a hyper protective society. L. Flemr conducted the above-mentioned interviews mainly at the faculty schools, which implies that in practice, safety issues can cause relatively great difficulties in terms of motivating pupils and teachers. No teacher wishes to fill in the accident report (no to speak of the school management), but sport always carries such a risk. In practice, this may lead to the absence of some specific compulsory exercises (e.g. somersault = overhead exercise, etc.).

The problem of motivation is associated with the issue of approaching the educational role of physical education. Ideally, the pupil should not feel that he or she is being educated, but on the contrary, he or she should perceive the individual educational aspects of physical education (rules, conformity, hygiene, mental resistance, etc.) as very important skills for personal development. However, this is often very difficult for teachers in terms of motivation.

The above-mentioned problem of motivation for active participation in physical education is associated with another social problem. A high number of children at the first stage of primary school do sports in sports clubs or school clubs. At the second stage of primary school, this number decreases and a large number of children quit the sport when they start attending the secondary school. Thus, there is a clear parallel between the numbers of physical education exemptions in primary and secondary schools as well as the motivation to exercise in physical education lessons. These data were obtained by the author during several years of discussions with the students of the Coach study programme at the Faculty of Physical Education and Sport of Charles University (FTVS UK). These coaches, often with a long-term practice in training pupils in many different kinds of sports and levels, admitted that they were unable to do anything about the problem. At the same time, it is the motivation of children and youth for sport activities that the attention is focused on both on the part of the Ministry of Education, Youth and Sports, individual sports unions and the Czech Olympic Committee, for instance in the form of grants for coaching activities or specific activities such as the Badge of Versatility of Olympic Champions (OVOV), Corny Cup, etc., as well as private companies (McDonald Cup, etc.). To summarize this part, it is necessary to state that the problem of motivation of children for active sports is not successfully solved. Yet, many adults return to recreational sport through experience activities. We currently witness a rapid growth in activities such as obstacle course races, cross-country cycling, triathlon, etc.

The issue of motivation is also associated with the evaluation in physical education. There was a moderated panel discussion under the auspices of EDUin dedicated to this subject matter (EDUin, 2019). The discussion was conducted with specialists in music, art and physical education (civics was not represented), with the participation of the public. The discussion and, in particular, the public inquiries showed that in the public opinion, evaluation often equals marking, and that marking in musical, art and physical education is quite problematic. The primary issue relates to the question of what should be marked. In physical education, this concerns adjusting the limits in individual sports or exercises to the physical abilities of the current population, the matter of marking performance, progress or motivation, etc. and especially, the question of whether to give marks at all. The panel discussion also showed that a more appropriate method of assessing the abovementioned subjects would be verbal evaluation, but it is certainly necessary to evaluate them (e.g. because of the educational role of physical education).

The last evaluated aspect is the curriculum position of physical education. Since 2005, the Framework Education Programmes (FEPs) have been binding for basic and secondary education (different for each type of school). Individual FEPs are currently being updated, e.g. the FEP for primary education was last updated in 2017. The FEPs have enabled schools to develop their own School Education Programmes (SEPs) based on their specific needs. SEPs allow schools to differ from one another and thus be more interesting for the future students, and also, to shape in areas which they consider important. The aforementioned FEP for primary education was modified on the basis of an amendment to the Education Act (Act No.82 / 2015, Coll.), the requirements of the European Commission and the Action Plan for Inclusive Education for the period 2016 - 2018 (National Institute for Education, 2017). The changes compared to the previous FEP version mainly concerned the area of inclusion, where, for example, the so-called minimum recommended level for the expected outputs adjustment within the support measures was defined. The FEP provides schools with a tool to assess the output of pupils with specific needs. Nevertheless, it would be appropriate to provide schools with an explicit manual on how to put this into practice. There is, of course, the option of creating and providing the pupils concerned with the so-called pedagogical support plan (referred to as "PSP") or an individual educational plan (referred to as "IEP"). Ješina and Tomoszek (2019a, 2019b) seek to remedy this situation clearly and with guidance, explaining in their article how to create and implement the PSP and IEP and when these tools are suitable. In practice, the problem is primarily the assessment of pupils who do need a PSP or IEP and yet do not have it. Thus, they cannot be assessed adequately to their condition. If they are evaluated in the form of the common marking without supportive measures, it can make intact pupils feel unequal, which is the direct opposite of what the current FEPs aim for.

In addition to the curriculum of physical education, it is also necessary to mention the current discussion regarding an increase in the number of physical education lessons from 2 to 3 lessons per week. However, it must be acknowledged that such a step can only work if the issues of physical education exemption and passive approach to exercising are at least partially resolved (even if the pupil is present in the class). For this reason, we have so far omitted the financial and personnel aspects. In our opinion, the current situation of physical education is not ready for such a step forward.

Finally, one controversial finding made by the author himself: his bachelor degree student, D. Zálešák, worked on his thesis with the title "The Movement Illiteracy of Elementary School Pupils" (Zálešák, 2018). However, the Ethics Committee of the faculty at which the bachelor degree student studied expressed their strong disapproval with the title of the thesis. They subsequently recommended that he should change it to "Movement Literacy", arguing that the word "illiteracy" has a negative connotation and may suggest that the author *a priori* assumes that something is not correct and that pupils may not be sufficiently physically literate.

Conclusions

In the above paragraphs, chosen areas affecting the current situation of physical education were gradually analyzed. By no means, has this initial review study covered all areas concerning physical education in primary and secondary schools as it would go far beyond its format and scope.

Nor can it be argued that any of the analyzed areas has revealed some groundbreaking or completely unexpected data (possibly with the exception of the impact of Decree No. 391/2013 Coll.). Altogether, the findings provide a deeper insight into the current issue of physical education. In the words of the former President of the Czech Republic, Václav Havel, from his first New Year's speech given on January 1, 1990: "Physical Education is Not Flourishing". This situation prevails despite all efforts, whether legislative (inclusion, etc.), educational (training of new teachers), curricular (FEPs and SEPs), educative (Badge of Versatility of Olympic Champions etc.), school (offer of sports clubs) or others.

The individual findings show that we are unable to sufficiently motivate pupils for regular active and conscious participation in physical education. We clearly fail to convey the importance of physical education even to their parents. Of course, it is still too early to make a definitive assessment, as social processes have great inertia and their results may take several years to manifest due to this inertia as well as the society´s reluctance to absorb different impulses. However, the current situation does not give much reason for optimism. Significant changes are needed if physical education in primary and secondary schools is to fulfil its role. So far, the method of consecutive individual steps has been applied.

Another conclusion drawn from this study are the questions whether the current concept of physical education (subject based on upbringing but graded on performance, very important subject but also very easy to avoid it etc.) can fulfil its role at some point in the future, whether it corresponds with the social reality and whether it is possible to change the general public or it is necessary to change the concept of physical education in order to meet the needs not of the present but of the future society.

Therefore, what we should focus on in the future are not the partial changes in physical education (such as the third lesson per week or new competitions, remuneration of teachers, etc.), but it is primarily the paradigm itself.

For the future research it would be suitable to find out the current attitude of individual segments of the Czech population towards physical education in school. Other proper research topic is the determination of an active attendance of physical education classes by different methods of evaluation.

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SPORT PARTICIPATION SHOULD NOT BE OBSERVED AS PROTECTIVE AGAINST SMOKING AND DRINKING IN ADOLESCENCE; CROSS-SECTIONAL CLUSTER-BASED ANALYSIS IN CROATIAN SOUTHERN REGIONS

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Ela Filipovic, Nikolina Catlak, Natasa Zenic,

University of Split, Faculty of Kinesiology, Split, Croatia

ABSTRACT

Purpose: Sport participation in adolescence is frequently observed as being protective against consumption of psychoactive substances (e.g. cigarettes and alcohol), but limited number of studies directly examined this problem while simultaneously observing consumption of cigarettes and alcohol. The aim of this study was to evidence the possible associations which may exist between different factors explaining participation in sports, and consumption of cigarettes and alcohol in adolescents from Croatia.
Methods: The sample comprised 436 adolescents from coastal regions in Croatia (202 females) aged 15–17 years who were tested by previously validated closed structured questionnaire on sport factors (experience in sports [four point scale from “never participated” to “ > 5 years”], sport competitive achievement [four point scale ranging from “never competed” to “national/international competitive achievement”], number of sport training sessions per week [four point scale ranging from “didn’t participate” to “sometimes even twice a day”]), cigarette smoking (four point scale ranging from “never smoked” to “more than 10 cigarettes per day”), and alcohol consumption (measured by Alcohol Use Disorders Identification Test – AUDIT). Cluster analysis calculated on the basis of cigarette smoking and AUDIT results was used to form homogenous groups (substance misuse clusters – SMC). The Kruskall Wallis analysis of variance (KWA) was calculated to identify the differences between SMC in studied sport factors.
Results: Four SMC were formed indicating: (i) high alcohol + high cigarettes (SMC1: n=42), (ii) high alcohol + low cigarettes (SMC2: n=115), (iii) low alcohol + low cigarettes (SMC3: n=226), and (iv) low alcohol + high cigarettes consumption (SMC4: n=53). When calculated for total sample of participants, the KWA revealed significant differences among SMC, with significant post-hoc differences between SMC1 and SMC3 in all sport-factors (H test: 9.5-to-17.5, $p < 0.01$), and higher values for all sport-factors in SMC1, but this was clearly influenced by greater number of boys in SMC1 (> 80% of all SMC1 members). Gender-specific KWA did not reveal significant differences among SMC in studied sport factors.
Conclusion: Study results do not support the theory of protective effects of sport participation against substance misuse in adolescence. Even more, there are some indices that sport participation may be observed risk factor for consumption of cigarettes and alcohol in this age group. Social acceptance of smoking and drinking in sport-society in the region is probable reason for relatively high rates of substance misuse in adolescents who are actively involved in sports.

Keywords: substance misuse; predictors; sport participation; tobacco; alcohol

Introduction

The prevalence of smoking decreases globally, but cigarette consumption is still the leading preventable cause of death worldwide (Bilano et al., 2015). Alcohol consumption is related to significant health problems, but also leads to various negative social consequences as well (i.e. intoxicated driving, violence) (Sanchez-Ramirez & Voaklander, 2018). Therefore, reducing the prevalence of smoking and alcohol drinking is important public health issue worldwide. In doing so, special attention is paid on adolescents, since it is well known that those who do not start to smoke/drink until the age of 21 years, will likely never do so (Zenic et al., 2015). One of the approaches which is globally accepted in prevention of substance use and misuse (SUM) in adolescence is identifying factors associated with SUM in this period of life. In brief, since SUM in adolescence can be observed as a certain "consequence" of various influencing factors, the idea is to identify factors that are positively, or negatively related to SUM, which will consequently allow identification of protective-, and risk-factors of SUM behavior in this period of life. Among, others, factors related to sport participation are frequently observed as being theoretically related to SUM, but with inconsistent findings (Bjelica et al., 2016; Zenic et al., 2015).

The idea of theoretically protective effects of sport participation against smoking and drinking in adolescence is relay on simple fact that sports promote overall well-being, and participation in sport positively influence development of various pro-social behaviors and self-discipline (Eime et al., 2013). Therefore, it is expected that adolescents who are involved in sports are less likely to smoke and drink (Moore & Werch, 2005). However, empirical evidences are not consistent. Specifically, the prevalence of smoking was regularly lower in adolescent athletes than in their non-athletic peers, but when investigations observed regions where smoking was socially acceptable behavior (i.e. southeastern Europe and Balkan countries) the highest prevalence of smoking was found in former athletes, (Idrizovic et al., 2015; Tahiraj et al., 2016; Zenic et al., 2015). Similarly, the investigations which specifically evidenced the associations between sport participation and alcohol drinking in youth frequently identified sport as being risk factor for alcohol consumption in this age, or at least – did not confirm protective effects of sport against alcohol drinking. In brief, although some investigators reported protective effects of sport, other studies highlighted sports participation as a factor contributing to higher risk for alcohol drinking in adolescence. However, it seems that differences in the sport-type (i.e. individual vs. team-sport), gender-specific influence, social factors, parental support, influence of teammates and other covariates must be acknowledged when studying the associations which may exist between sport participation and alcohol drinking in youth (Bjelica et al., 2016; Devcic et al., 2018).

Collectively, the association between sport-factors and SUM in adolescence is not clear. Also, there is an evident lack of investigations which observed "multiple SUM" as factor of interest. Indeed, simultaneous consumption of various substances (i.e. simultaneous smoking and drinking; multiple SUM) is particularly dangerous, while there is no information about associations between sport factors and multiple SUM in adolescence. Therefore, the aim of this study was to investigate the associations which may exist between factors explaining sport participation and multiple SUM behavior in adolescents from Croatia.

Methods

In this study, we observed 16-to-18-year-old adolescents (n=644, 54% females). The sample comprised adolescents from Split-Dalmatia and Dubrovnik-Neretva Counties in Croatia, both located in the south of Croatia, on the coast of the Adriatic Sea. While the idea of the study was to evidence sport factors potentially related to SUM, it was necessary to obtain a sample of participants in the regions with similarity in cultural heritage, specifically, similar in social acceptance of SUM.

The variables included data on questions about sociodemographic factors (gender, age), sport factors, alcohol drinking, and cigarette smoking, and all were questioned by self-administered questionnaire, which was previously applied and found to be valid in a similar sample of participants (Bjelica et al., 2016). Sport factors included following questions: (1) competitive result achieved in sport (never involved/competed - local competitions - national-level/international level competition,);

and (2) experience in sport (never been involved in sport, less than 1 year, 2–5 years, more than 5 years), and (3) number of sport training sessions per week (four point scale ranging from “didn’t participate” to “sometimes even twice a day”). Alcohol consumption was measured using the AUDIT questionnaire, proposed by the World Health Organization (WHO) (Saunders et al., 1993). In brief, the AUDIT consists of 10 items with scores ranging from 0 to 4 resulting in a scale ranging from 0 to 40. Cigarette smoking was tested on a four point scale; from “never smoked” to “more than 10 cigarettes per day”.

The K-means cluster analysis was used to group the participants into homogenous groups (clusters) on the basis of their results on SUM variables (e.g. smoking and AUDIT). Due to differences in scales (i.e. smoking was observed at four-point scale, while the alcohol drinking was measured on scale with large variance [0–40]), the SUM variables were standardized and expressed in z-values prior to cluster analysis. After identifying characteristics of each formed cluster (substance misuse cluster – SMC) throughout inspection descriptive statistic parameters (please see Results for more details), the SMCs were compared on sport factors. Specifically, Kruskal Wallis analysis of variance (KWA) with consequent post-hoc calculation was calculated for sport factors, with SMC as grouping variable, which allowed us to identify unique characteristics of each SMC. The alpha level of < 0.05 was applied and Tibco Statistica ver 13.5 was used for all analyses.

Results

Four SMCs were formed on the basis of cluster analysis indicating: (i) high alcohol + high cigarettes (SMC1: n=42), (ii) high alcohol + low cigarettes (SMC2: n=115), (iii) low alcohol + low cigarettes (SMC3: n=226), and (iv) low alcohol + high cigarettes consumption (SMC4: n=53) (Figure 1).

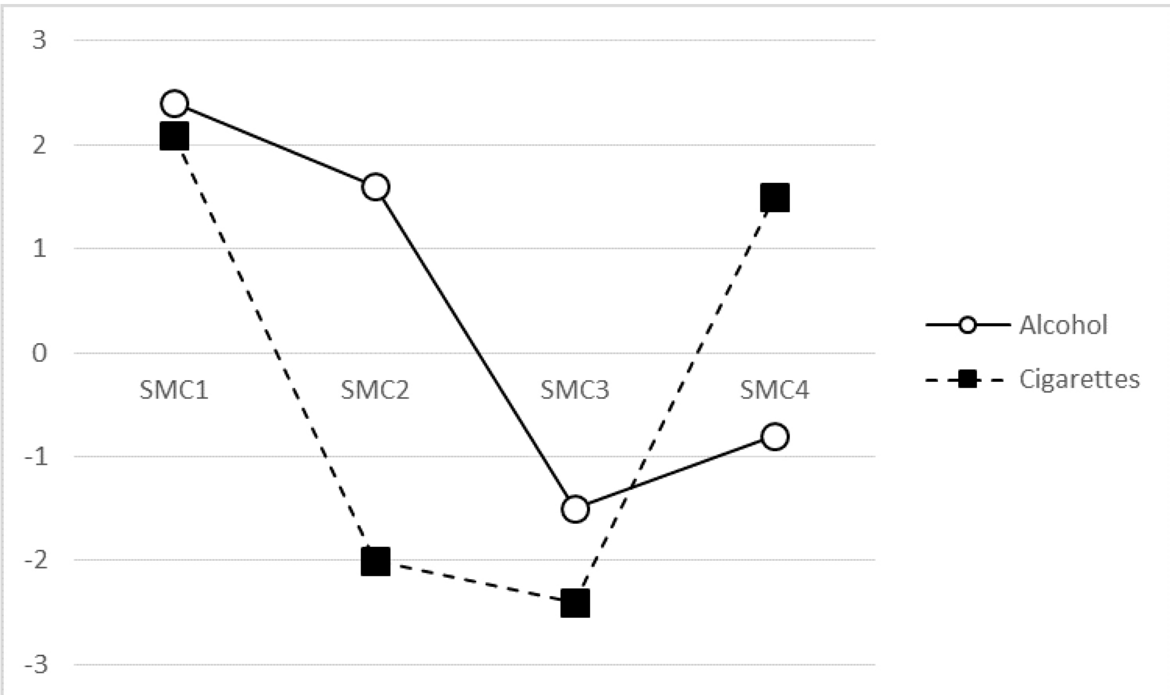

Figure 1 *Results of K-means clustering for alcohol consumption and cigarette smoking in studied adolescents (SMC1 – SMC4 – substance misuse clusters)*

Table 1 *Sport factors in studied adolescents among males and females*

	Males		Females	
	F	%	F	%
Experience in sport				
Never participated	45	15%	100	29%
< 1 year	60	20%	102	30%
2–5 years	135	45%	98	28%
> 5 years	60	20%	45	13%
Competitive achievement				
Never competed/participated	63	21%	156	45%
Local	161	54%	151	44%
National/International	75	25%	38	11%
Number of training sessions				
Didn‘t participate	48	16%	99	29%
1–2 sessions per week	123	41%	134	39%
3–5 sessions per week	99	33%	100	29%
Every day (sometimes even twice a day)	30	10%	12	3%

Sport factors in studied adolescents are presented in Table 1. Evidently, boys were more involved in sports than females.

When calculated for total sample of participants, the KWA revealed significant differences among SMC, with significant post-hoc differences between SMC1 and SMC3 in all sport-factors (H test: 9.5-to-17.5, $p < 0.01$), and higher values for all sport-factors in SMC1. However, additional analyses identified that SMC1 was formed mostly of boys (> 80% of all SMC1 members). Gender-specific KWA did not reveal significant differences among SMC in studied sport factors (Table 2).

Table 2 *Kruskal Wallis analysis of variance calculated for sport-factors among substance misuse clusters for total sample, and separately for boys and girls*

	Total sample	Boys	Girls
	H (p)	H (p)	H (p)
Competitive result	9.5 (0.01)	2.1 (0.21)	7.8 (0.10)
Experience in sports	11.5 (0.01)	2.3 (0.21)	5.6 (0.20)
Number of training sessions	17.5 (0.01)	4.1 (0.11)	7.0 (0.12)

Discussion

Our results didn’t confirm protective effects of sport participation against multiple SUM in studied adolescents. In explaining such findings a short overview of the theoretical influence of sport on SUM in adolescence is needed. According to Wichstrøm and Wichstrøm, sport may be observed from at least five points of view that may positively or negatively affect the risk of SUM (Wichstrøm & Wichstrøm, 2009). The authors identified the following theoretically protective aspects of sport with regard to risk of SUM: (i) age segregation (i.e., age segregation is common in sports, which consequently decreases the possibility of bonding with older adolescents and consequently reduces the risk of SUM), (ii) time occupation (i.e., sports training and competitions take time, and therefore, there is less time for activities associated with SUM), (iii) adult supervision (i.e., adult coaches are regularly involved, which may limit problem behavior), and (iv) orientation toward success (i.e., SUM reduces the physical capacities and therefore alters the sport results and achievement). On the other hand, sport is a social activity that may present a certain risk of a higher likelihood of SUM. Putting it altogether, many but not all sport characteristics may reduce the risk of SUM in adolescents.

Studies have already observed the associations between sport participation in adolescence and SUM, but the relationships were not consistent (Devcic et al., 2018; Moore & Werch, 2005; Zenic et al., 2017). Therefore, our results of "nonsignificant" association between sport factors and multiple SUM are not surprising. In other words, it seems that sport doesn't protect adolescents from SUM but at the same time doesn't put athletic adolescents in higher risk for SUM than their non-athletic peers. Apart from previously discussed hypotheses on theoretically positive and negative influences of sport on SUM consumption (Wichstrøm & Wichstrøm, 2009), in explaining our results some specific contexts of this investigation deserve attention. First, this study was performed in specific environment, where both cigarette smoking and alcohol consumption are socially accepted behaviors. Second, the study involved adolescents in the period of life when majority of athletic adolescents quit sports.

Namely, the age of 16–18 years is regularly considered as critical period for participation in organized sports. In most sports, the professional involvement begins at the age of 18 years. Therefore, in this period of life, the largest sport participation drop-out rate occurs. As a result, only those adolescents who are highly talented progress in sport participation (Sekulic et al., 2014; Zenic et al., 2017). With regard to this study it is important to note that former athletes probably have a certain tendency toward meeting new friends (i.e., those out of sports), and therefore are at "higher risk" of being involved in social circumstances where SUM in more common.

The explained mechanism of "negative influence" of sport on SUM is particularly possible in the socio-cultural environment where SUM (particularly smoking and drinking) is socially acceptable. Indeed, studies already informed about this problem and highlighted potentially negative effects of such social climate on adolescent behavior (Devcic et al., 2018; Zenic et al., 2017). According to social ecological theory in order to understand human development and lifelong changes (including behavioral changes), the entire ecological system in which growth and development occur should be taken into account (Bronfenbrenner, 1994). While adolescents must function in various environments, constantly trying to position themselves in the most comfortable one, the fact that sport participation was not protective against SUM in social environment where SUM is generally accepted, is not surprising.

Conclusion

Due to the cross-sectional design of the investigation we can't speak about cause-effect relationship between variables. More precisely, on the basis of the presented results it is evident that there are no evidence about significant association between sport participation and multiple SUM in older adolescents from Croatia. Most probably, while some factors may decrease the risk of SUM, others may be observed as factors of increased risk for SUM in this period of life. The "negative" influence is particularly possible to occur taking into account that we observed the region where prevalence of alcohol drinking and cigarette smoking is generally alarming, and where are no clear social and/or cultural barriers against such type of substance misuse.

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EFFECTIVENESS OF MANUAL YUMEIHO THERAPY AND EXERCISE ON DEPRESSION AND NEUROPATHIC PAIN IN PATIENTS SUFFERING FROM CHRONIC NONSPECIFIC LOW BACK PAIN

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Neven Gladović, Luka Leško, Martina Fudurić

Faculty of Kinesiology, Zagreb, Croatia

ABSTRACT

Introduction: Chronic low back pain is the leading cause of disability, which reduces quality of life and increases the healthcare costs. Psychosocial factors (depression, kinesiophobia and somatization) may also have an important role in the appearance and duration of chronic nonspecific low back pain. Depression may predispose low back pain, while the chronicity of pain affects the degree of disability, which is also related to mental health. Many studies suggest the association between depression and low back pain by explaining a significant physiological link. Different types of manual therapy are used in the treatment of chronic low back pain, but recent studies suggest that a rehabilitation models which combine manual therapy and exercise, provide better results compared to individual (separate) applications. The aim of this research was to examine the effects of the rehabilitation program, which includes manual yumeiho therapy and exercise, on depression in people suffering from chronic nonspecific low back pain.
Methods: The study included 21 participants, aged 40 to 60 (M=51.1, SD=5.9) who suffer from chronic nonspecific low back pain. The study included the initial and final depression test and the initial and final neuropathic pain test. Between the initial and the final testing, a three-week therapeutic procedure of yumeiho manual therapy and exercise was performed (15 treatments). Repeated estimates of depression and neuropathic pain were tested 30 and 60 days after the implementation of the rehabilitation protocol.
Results: Statistically significant improvements were noted between the initial and the final test in both observed variables. Significant improvements (lower depression and neuropathic pain) have also been noted 30 and 60 days after the implementation of the rehabilitation protocol (in relation to the initial state).
Conclusion: The findings indicate that the rehabilitation protocol, involving manual yumeiho therapy and exercise, is an effective method for treating depression and neuropathic pain in people suffering from chronic nonspecific low back pain. Considering the lack of research on the effects of manual therapy by yumeiho technique, the results contribute to a better understanding of technique which, although used in practice, has not been sufficiently explored. Further research is required, on comparing this rehabilitation model to other methods, as well as longer follow-up in the post-rehabilitation period.

Keywords: rehabilitation program; spine; movement; quality of life

Introduction

During a lifetime period, about 84% of people experience at least one episode of low back pain, which represents 11–12% of the population's disability (Airaksinen et al., 2006). In case of acute low back pain, 75–90% of people recover within six weeks regardless of medical intervention, while about 25% of people develop chronic low back pain. Chronic low back pain is pain, muscle tension and discomfort between the lower rib arch and the lower gluteal furrow, with or without spreading in the leg (Vora et al., 2010). Depending on the cause, low back pain may be divided as nonspecific or specific (Grazio et al., 2012). Nonspecific low back pain is a type without a specific cause such as infection, tumour, fracture, osteoporosis, ankylosing spondylitis, radicular syndrome or cauda equina syndrome (Airaksinen et al., 2006). Psychosocial factors may also have an important role in developing and duration of chronic nonspecific low back pain. It primarily refers to depression, fear of disasters, kinesophobia and somatization (Pincus and McCracken, 2013). Long-term pain that does not decrease despite treatment, prolongation of disability, decreased movement in everyday life, depression, anxiety and sleep disorders are all part of a regular clinical finding in people suffering from chronic low back pain (Schaefer et al., 2014). Depression may predispose low back pain, while chronicity of pain affects the degree of disability, which is also associated to mental health (Wang et al., 2010). Such patients rate their pain higher and more complex than those who do not have depression (Tsuji et al., 2016). Burke et al. (2015) indicate that depression and chronic pain may occur in up to 80% of patients suffering from these disorders. Accordingly, in designing a rehabilitation model, these factors should be taken into account. This assumption is supported by insights suggesting an association between depression and low back pain, and emphasizing that their association may have a more significant biological link than simple cause and effect relation (Elman et al., 2011). Likewise, it is estimated that about 35% of patients with chronic pain syndromes suffer from neuropathic pain also (Bouhassira et al., 2008). Despite the development of modern technology in the diagnosis and treatment of low back pain, functional disability due to back pain has risen in recent decades (Deyo et al., 2014). Due to the complexity of treating chronic diseases, patients often use complementary-alternative medicine as an adjunct or instead the usual medical treatment (Rosenberg et al., 2008). One of the complementary-alternative methods is the manual therapy by yumeiho technique, in which the therapist's hands are the basic tool for the treatment. The main advantage of this technique is comprehensiveness because it combines methods of crushing, pressing and techniques of manipulation and mobilization of bone-joint structures (Saionji, 1990). After the literature overview, it is concluded that no study has been found examining the impact of manual yumeiho therapy and exercise on depression and neuropathic pain in people suffering from chronic nonspecific low back pain. The aim of this research was to examine the effects of the rehabilitation program, which includes manual yumeiho therapy and exercise, on depression in people suffering from chronic nonspecific low back pain.

Methods

A sample of 21 participants (aged 40 to 60) was used. Sample size estimation was made by G*Power 3.1.9.2. The criteria for inclusion in the study were as follows: diagnosed low back pain syndrome for at least 3 months and pain intensity equal or higher than 4 according to the Visual Analogue Scale (VAS, Gould et al., 2001). Exclusion criteria: malignancies 5 years backwards, inflammatory rheumatic diseases, inability to control stool and urine, more severe cardiovascular disease, more severe neurological diseases, applied physical therapy in the lumbar spine 3 months backwards, disc extrusion and pregnancy. The criteria were checked by inspecting the medical records of each subject. Prior to joining the survey, all participants became familiar with the research objectives, protocol and potential risks. All participants received an explanation notice and signed consent of willing participation. The study included initial and final testing of depression level and neuropathic pain. Between initial and final testing, a three-week treatment procedure was performed (15 treatments in total). Depression levels were tested by the Beck Depression Scale (BECK, Beck et al., 1996). The questionnaire is consisted of 21 questions (rated 0 to 3). The minimum score is 0, the maximum is 63. Average results show that subjects with up to 9 points do not have depression; 14–19 points indicate mild depression, while 20–28 points indicate moderate depression. Severe depression is estimated when a score is equal or higher than 29. Neuropathic pain was determined by the LANSS-The Leeds assessment of neuropathic symptoms and signs (Bennett, 2001). The highest possible sum is 24 (higher value means stronger pain intensity), while values equal or higher than 12 indicate that neuropathic mechanisms contribute to the feeling of pain. The longevity of the quality of rehabilitation program was monitored after the end of therapy, as well as one and two months after the end of the program by re-measurement of depression and neuropathic pain. Participants underwent 15 treatments over a 3-week period. The combination of yumeiho manual therapy and exercise was performed 3 times a week for 45 minutes (Monday-Wednesday-Friday), while separate training sessions were performed 2 times a week for 15 minutes (Tuesday–Thursday). Yumeiho therapy consists interchangeable and complementary components (methods of kneading and pressure). Their purpose is to soften and relax soft tissues. The third component involves techniques of manipulating bone-joint structures. Yumeiho therapy and exercise were conducted by an educated yumeiho therapist (master of kinesiology). The treatment is performed on the mat in kneeling position, with some interventions done in sitting or lying position. The exercise program included 30 exercises for improving neuromuscular control and increasing the mobility of the lumbar-gluteal region. The exercise program included specific exercises to strengthen *m. multifidus* and *m. transversus abdominis* and specific stretching exercises for *m. piriformis* and *m. quadratus lumborum*. Variables were presented by arithmetic mean, standard deviation, minimum and maximum values. Non-parametric statistical methods were used, depending on the distribution of the data. The Friedman's test was used to examine the difference between the initial condition and the observed measuring points (final condition, 30 and 60 days after the rehabilitation program).

Results

BECK (depression)

Within those variable, descriptive indicators (Table 2), ranks (Table 3) are displayed first, then the differences between the first and other measuring points (final, 30 and 60 days after therapy), which is shown in Table 4.

Table 1 *Basic parameters*

	Age	Height	Weight
$\bar{x}$	51,10	169,81	77,67
SD	5,941	6,509	16,608
Min	39	160	50
Max	60	179	130

Legend: $\bar{X}$ – arithmetic mean, SD – standard deviation, MIN – minimum, MAX – maximum

Table 2 *Descriptive parameters*

	N	$\bar{x}$	SD	Min	Max
BECK IN	21	10,90	7,483	0	25
BECK FIN	21	4,71	6,230	0	20
BECK 30	21	5,52	6,983	0	22
BECK 60	21	7,00	8,866	0	28

Legend: N – number of participants, $\bar{X}$ – arithmetic mean, SD – standard deviation, MIN – minimum, MAX – maximum

Table 3 *Ranks*

Indicator	Arithmetic mean of ranks
BECK IN	3,45
BECK FIN	1,95
BECK 30	2,17
BECK 60	2,43

Table 4 *Friedman's test*

N	21
Chi-Square	20,594
df	3
Asymp. Sig.	**,000**

The significance of p test is less than 0.05. Statistically significant differences in the BECK indicators were observed between an initial and other measuring points.

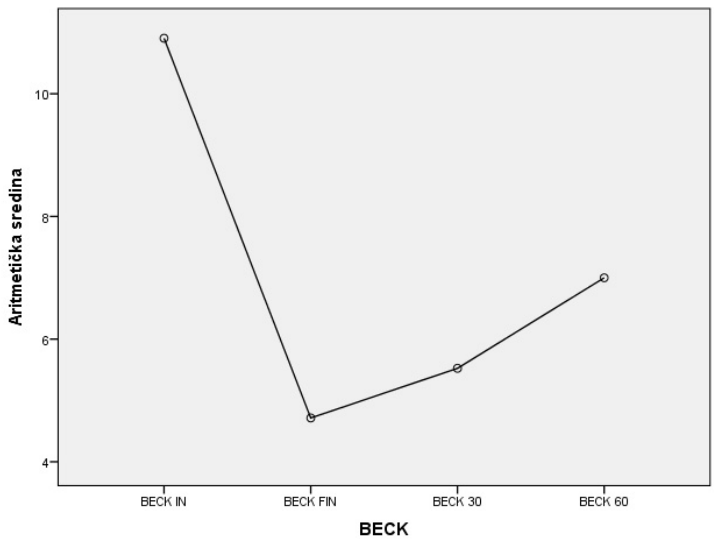

Figure 1 *Differences in depression in people suffering from chronic nonspecific low back pain between the observation points (initial, final, 30 and 60 days after the therapy)*

LANNS (neuropathic pain)

Within that variable, descriptive indicators (Table 5), ranks (Table 6), then differences between the first and other measuring points are shown (final, 30 and 60 days after the therapy; Table 7).

Table 5 *Descriptive parameters*

	N	$\bar{x}$	SD	Min	Max
LANNS IN	21	4,71	3,770	0	11
LANNS FIN	21	1,38	2,459	0	7
LANNS 30	21	1,29	2,261	0	7
LANNS 60	21	1,62	3,354	0	11

Legend: N – number of participants, $\bar{X}$ – arithmetic mean, SD – standard deviation, MIN – minimum, MAX – maximum

Table 6 *Ranks*

Indicator	Arithmetic mean of ranks
LANNS IN	3,29
LANNS FIN	2,24
LANNS 30	2,19
LANNS 60	2,29

Table 7 *Friedman's test*

N	**21**
Chi-Square	20,278
df	3
Asymp. Sig.	**,000**

The significance of p test is less than 0.05. Statistically significant differences in the LANNS indicators were observed between an initial and other measuring points.

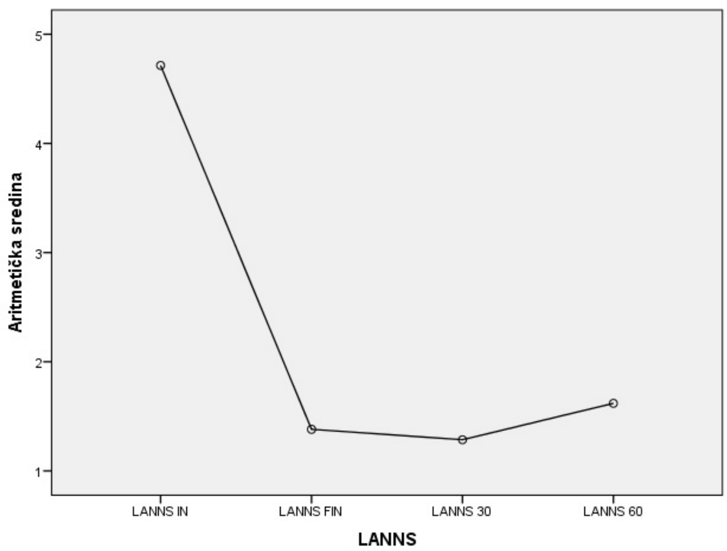

Figure 2 *Differences in neuropathic pain in people suffering from chronic nonspecific low back pain between the observation points (initial, final, 30 and 60 days after the therapy)*

Discussion

Participants who underwent rehabilitation program that included yumeiho manual therapy and exercise, reported a statistically significant reduction in depression and neuropathic pain at all observation points (final, 30 and 60 days after the rehabilitation program), compared to the initial measuring. Study suggests the quality of the used model. The data obtained, in addition to acute improvement, also indicate longer-lasting effect retention, which suggest the importance of continuity in care after the program. According to literature, only one study has compared the effects of manual therapy and exercise to physiotherapy program, in the treatment of depression (Niemistö et al., 2003). That study showed no statistically significant differences. Potential reasons may be caused by the mean age in used sample (24 to 46 years), and only 4 therapies performed in 4 weeks, unlike this study which included the active population of 40–60 years who performed 15 therapies in 3 weeks. In mentioned study, the effects of the therapeutic protocol were measured after 5 and 12 months. This indicates that the high volume of therapies over a short period may significantly reduce depression in people suffering from chronic nonspecific low back pain. A review of the available literature did not identify any research that examined the impact of manual therapy and exercise on neuropathic pain in people suffering from chronic nonspecific low back pain. This research suggests that this combined model should be considered in the future, given the results that indicate significantly reduced neuropathic pain after a rehabilitation program. The effects were retained after 30 and 60 days. Relatively small sample is the limitation of the study and further research is needed to get a clearer picture. Authors recommend comparing this rehabilitation model to other methods, longer follow-up in the post-rehabilitation period and analysing the effects on a larger number of subjects.

Conclusion

The results indicate that a rehabilitation protocol involving manual yumeiho therapy and exercise is an effective method of reducing depression and neuropathic pain in patients with chronic nonspecific low back pain. These results are valid only for this sample and do not allow generalization. Nevertheless, since the results showed positive effects, they may represent a valuable basis for planning further research on a larger sample of respondents.

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RELATIONSHIPS BETWEEN PHYSICAL ACTIVITY, MOTOR PERFORMANCE AND BODY COMPOSITION IN SCHOOL-AGE CHILDREN

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Pavol Čech, Pavel Ružbarský

University of Prešov, Faculty of Sports, Prešov, Slovakia

ABSTRACT

Introduction: Physical activity (PA) performed at recommended levels is associated with multiple health benefits. However, as indicated by the available studies, the volume of habitual physical activity of children continuously decreases.
Aim: The aim of the study was to assess the relationships between physical activity performed by school-age population and indicators of motor performance and body composition.
Methods: The research group consisted of 144 students of the primary school assigned into groups according to the years of study (first, fifth and eighth-year students). The amount of physical activity was examined through a non-direct method, using Fels PAQ, recording four scores, namely sport index, leisure index, work (chore) index and total score. Body composition was tested using a direct segmental multi-frequency bioelectric impedance analysis (DSM-BIA). Motor performance was assessed in four categories. Endurance and strength endurance were assessed using Jacik's motor test; strength abilities were measured using a hand grip test; speed abilities were tested in linear sprints at 5 and 10 meters and in the test of speed with changes of direction at 4 x 10 m and, finally, explosive strength was assessed from results of the countermovement jump (CMJ), squat jump (SJ) and 10-second repeated jumps tests. The strength of association between the selected factors was determined from the results using the Spearman's rank correlation analysis.
Results: The amount of physical activity was mainly associated with the indicators of active body mass (fat free mass, skeletal muscle mass) in all age categories. Low association was found in the parameters of adipose tissue (body fat percentage, visceral fat level). When assessing the strength of association between the characteristics of motor performance and physical activity performed, we observed various courses of associations, based on which it is not possible to determine the tendency. When assessing the relationship between the amount of physical activity and motor performance of students regardless of age, we found medium association only with indicators of strength abilities (hand grip test) and characteristics of speed abilities.
Conclusions: The results are not explicit but they point to some tendencies in relationships between habitual physical performance and body composition indicators. With respect to motor performance, it is not possible to consider these results decisive; therefore, further data collection and more accurate assessment of relationships are necessary.

Keywords: habitual physical activity; Fels PAQ; active mass; adipose tissue; physical performance

Introduction

Generally, children are the most active part of population and this fact is based on their biological needs. Physical activity in any form shall be an integral part of one's everyday life. Physical activity is fundamental to the early development of each child and affects many aspects of a child's health (King et al., 2003). Regular participation in physical activity helps reduce the health risk of childhood obesity and the associated chronic diseases (Gao, Chen, Sun, Wen, & Xiang, 2018). The support for physical activity in childhood is essential since, as declared by Larsen, Kristensen, Junge, Rexen, & Wedderkopp (2015), physical activity habits developed in childhood tend to persist into adulthood.

Positive effects of physical activity have been sufficiently reported. Generally, it is believed that there is a linear relationship between performed physical activity and motor performance (Zapletalová, Antala, Doležajová, Labudová, & Lednický, 2011), when children with higher levels of adiposity display lower motor performance scores, and children with lower motor performance scores participate in less physical activity than peers with higher motor performance abilities (Morrison et al., 2012). Physical activity is a tool for maintaining physical and mental balance that can result in increased fitness, performance, self-confidence and self-fulfilment and self-confirmation (Bendiková, 2014). A direct impact of physical activity performed by children was, in the latest studies, reported in the context of motor performance (Morrison et al., 2012; Larsen et al., 2015), cognition and academic performance (Donnelly et al., 2016) and health (Gao et al., 2018).

The present time offers a broad spectrum of many different kinds of leisure activities. Despite the well-known benefits of physical activity for human health, in recent years, there is an increased number of children who are only physically active in school physical education. Physical inactivity is increasingly becoming a major public health concern in many industrialized countries (Gao et al., 2018). Research in Slovakia showed that up to 70% of school-age children and youth spend more than 4 hours of their free time a day at computers, browsing internet, watching TV, playing computer games or having fun with a phone (Antala, 2012). Afforded by technological advancement and the low demand of physical exertion in living, people in the modern societies, youth and adults alike, have been accustomed to the more sedentary lifestyles (Gao et al., 2018). The current population of children with its volume of performed physical activities approaches or even exceeds the limit, which is characterized as a biological need. The result is that inadequate physical exertion, in conjunction with the easy access to energy dense diet, has led to dramatic increases in the prevalence of obesity (Bauman, Grunseit, Rangul, & Heitmann, 2017).

The aim of the presented study was to assess relationships of physical activity to motor performance and body composition among school-age children.

Methods

Research was designed as a non-random sampling survey. The screened sample consisted of 144 students aged between 6–14 years. In order to verify hypotheses on relationships between the selected variables, the sample was further divided into sub-samples with regard to the subjects' years of study. The research group included students of the first (n=43), fifth (n=51) and eighth year of study (n=50). Characteristics of the screened sample are presented in more detail in Table 1. A participant's legal guardian received a written description of the study procedures before testing, agreed with publishing of the collected data and completed a written informed consent.

Table 1 *Descriptive characteristics of sub-groups of the research sample (average ± standard deviation)*

	Sex / no	Age (years)	Body height (cm)	Body mass (kg)	BMI (kg.m^{-2})	Body fat (%)
1st year (n=43)	B / n=26 G / n=17	7.3 ± 0.34	124.0 ± 5.8	27.2 ± 7.4	17.5 ± 3,8	22.4 ± 10.7
5th year (n=51)	B / n=25 G / n=26	11.1 ± 0.55	146.4 ± 6.8	40.5 ± 9.4	18.7 ± 3.4	22.9 ± 8.5
8th year (n=50)	B / n=16 G / n=12	14.0 ± 0.4	164.8 ± 6.9	57.6 ± 13.6	21.1 ± 4.4	21.6 ± 8.8

To record the volume of the performed physical activity, an indirect method, the self-reported Fels Physical Activity Questionnaire (Fels PAQ), which is focused on assessing the level of habitual physical activity, was used. The original questionnaire was designed without time specification. In our case, we chose a modification by Treuth, Hou, Young, & Maynard (2005), who focus on the evaluation of physical activity in an annual interval. Thus, it appropriately filters differentiations caused by different time of measurement, in terms of climatic conditions in Slovakia in contrast to the self-reported questionnaires based on evaluation over a short time period. Fels PAQ consists of eight items that include three "open" questions for which activities are listed by the participant and the frequency of participation for each activity is obtained. The remaining five questions use a Likert scale to evaluate physical activity (Treuth et al., 2005). Fels PAQ evaluates 4 fields of physical activity, namely Sport index, focused on sporting activities performed both at school and in free-time, Leisure index, evaluating extra-curricular physical activities, Chore index, assessing physical intensity of housework and, finally, Total score, which is the sum of the previous categories. According to Treuth et al. (2005), FELS PAQ achieves moderate reliability for all age groups of children and acceptable validity for monitoring PA of elementary and high schools students.

Body height was measured with a precision of 0.1 cm using a portable stadiometer (SECA 217, Hamburg, Germany). Body mass, together with the percentage of fat mass, was detected using a direct segmental multi-frequency bioelectrical impedance analysis (InBody 230 devices, Biospace Co., Ltd.; Seoul, Korea), maintaining the conditions of bioimpedance measurements (Kyle et al., 2004). The device works on the basis of ten repetitions of impedance measurement using two current frequencies, namely 20 and 100 kHz, in each of five body segments (right arm, left arm, trunk, right leg, left leg). According to Karelis, Chamberland, Aubertin-Leheudre, & Duval (2013), the In Body 230 device shows high validity of results of directly measurable body composition indicators in comparison to DEXA (r = 0.94–0.99). From the perspective of physical development, we monitored the following somatic indicators: body height, body mass and body mass index; indicators of active body mass - fat free mass and skeletal muscle mass; indicators of adipose tissue - body fat percentage.

The last evaluated category was participants' motor performance examined in the selected motor tests. Maximum strength of upper limbs was tested in a hand grip test using Lafayette Hand Dynamometer, model 78011 (Sagamore Parkway North, Lafayette, USA). The participants were measured in the standing position with the tested arm lowered loosely at the sides of the trunk Explosive strength of lower limbs was monitored in 3 tests using Optogait device (Microgate, Via Stradivari, Bolzano, Italy) measuring the time characteristics of the contact and flight phase, based on which performance characteristics are calculated. The participants performed standardized tests of Squat Jump (SJ) and Counter Movement Jump (CMJ) according to recommendations by Markovic, Dizdar, Jukic, & Cardinale (2004). These were followed by a 10-second repeated jumps test, with the hands on hips. The power in the active phase of take-off, expressed as the mean of three best trials recorded in the given time interval, was further processed. A level of speed abilities was evaluated based on the results in linear sprints at 5 and 10 meters, according to the instructions by Malý, Zahalka, Malá, & Teplan (2014). The subjects repeated the test twice, with a rest interval of at least 2 minutes. Another parameter, speed with a change of direction, was tested using a 4 × 10 shuttle run agility test, according to Kasa (2003). Time in speed ability tests was recorded using Brower timing system (Brower Timing Systems, Draper, USA). Endurance and strength endurance were examined using the standardized Jacik's motor test (Cuberek, Jakubec, Hůlka, & Botek, 2012). The order of items in the test battery was intentionally arranged so that performances in successive tests would not be adversely affected.

The obtained data were further processed in a statistical analysis using IBM SPSS Statistics 20. Based on the results of the assessment of normality of data distribution using the Shapiro-Willk test (unpublished data), we chose nonparametric mathematical and statistical characteristics and tests for further analysis. The strength of association between the observed factors was evaluated based on the results of the Spearman's rank correlation coefficient. Results were interpreted according to magnitude presented by Hopkins (2000), when r = 0.0 represents trivial, r = 0.1 small, r = 0.3 moderate, r = 0.5 large, r = 0.7 very large, r = 0.9 nearly perfect and r = 1.0 perfect association. The significance of correlation was assessed with respect to the level of significance $p < 0.05$.

Results

Table 2 presents results of statistical analysis of the volume of performed physical activity and motor performance. Table 3 shows a matrix of results of correlation analysis between indicators of somatic development and body composition with respect to performed physical activity.

Table 2 *Results of correlation analysis of the volume of performed physical activity and motor performance (Spearman's rank correlation)*

Fels PAQ index Jacik´s test		endurance strength / strength			speed abilities			explosive strength			
		hand grip		5 m	10 m	4 × 10 m SRAT	CMJ	SJ	10 s rep. jumps		
		d	*nd*						*P*	*h*	
1st grade	sport	**0.367***	0.184	0.116	**-0.373***	**-0.365***	**-0.456***	0.256*	0.089	0.125	0.263*
	leisure	**0.320***	**0.327***	**0.306***	-0.212	-0.193	-0.253	**0.328***	0.223	0.063	0.123
	chore	0.206	0.118	0.158	0.011	0.038	-0.040	0.082	0.148	-0.166	0.064
	total	**0.400***	0.254	0.251	-0.248	-0.208	**-0.309***	0.243	0.201	0.005	0.188
5th grade	sport	0.261*	0.085	0.066	-0.027	-0.185	-0.200	0.197	0.290*	-0.015	0.231
	leisure	0.145	-0.129	-0.075	**-0.309***	-0.212	-0.107	0.147	0.191	-0.037	0.058
	chore	0.166	0.269*	0.287*	-0.102	-0.209	**-0.354***	**0.303***	**0.312***	-0.206	0.114
	total	0.233	0.160	0.157	-0.251*	**-0.338***	**-0.344***	**0.308***	**0.359***	-0.167	0.170
8th grade	sport	0.095	**0.364***	**0.359***	**-0.397***	**-0.417***	**-0.309***	0.018	0.168	0.073	0.094
	leisure	0.182	-0.067	0.011	-0.174	-0.221	-0.288*	0.047	0.154	0.268*	0.050
	chore	-0.232	**0.438***	**0.478***	-0.273*	-0.238*	-0.081	0.061	0.133	-0.043	0.135
	total	-0.017	**0.343***	**0.395***	**-0.377***	**-0.419***	**-0.332***	0.074	0.224	0.184	0.141

Note: d – dominant hand (writing hand), nd – non-dominant hand, 5 m – linear sprint at 5 m, 10 m – linear sprint at 10 m, 4 × 10 m SRAT – 4 × 10 m shuttle run agility test, CMJ – counter movement jump, SJ – squat jump, P – power at the concentric jump phase, h – height of jump

Table 3 *Results of correlation analysis of physical activity volume and body composition parameters (Spearman´s rank correlation)*

Fels PAQ index		somatic parameters		active tissue		adiposity indicators	
BM		BMI	FFM	SMM	BFM	% BF	
1st grade	sport	0.074	-0.081	**0.315***	**0.305***	-0.260	-0.016
	leisure	0.013	-0.035	0.244	0.250	-0.197	-0.005
	chore	0.099	0.087	0.080	0.089	-0.010	-0.087
	total	0.121	0.058	**0.306***	**0.308***	-0.145	-0.107
5th grade	sport	-0.031	-0.016	0.040	0.044	-0.125	-0.035
	leisure	0.009	-0.085	0.104	0.101	-0.138	-0.110
	chore	-0.041	-0.041	0.004	0.006	-0.136	-0.021
	total	0.011	-0.034	0.125	0.127	-0.181	-0.034
8th grade	sport	0.217	0.122	**0.402***	**0.399***	-0.093	-0.127
	leisure	-0.087	-0.182	0.122	0.118	-0.268*	-0.183
	chore	**0.320***	0.238*	**0.478***	**0.472***	-0.005	-0.199
	total	0.183	0.041	**0.462***	**0.455***	-0.219	-0.029

Note: BM – body mass; BMI Quetelet´s index; FFM – fat free mass; SMM – skeletal muscle mass; BFM – body fat mass; %BF – body fat percentage; * statistical significance of correlation

Discussion

In fact, motor skills in young children are considered to be linked with various health outcomes (Zeng et al., 2017). Physical activity may be the foundation of a healthy lifestyle and motor performance has been shown to be positively associated with physical activity in cross-sectional studies (Larsen et al. 2014). Results of the analysis of the relationship between physical activity and motor performance show the ambiguity of our findings, since across the selected age period, the strength of association differs considerably. The relationship between motor performance and the volume of performed physical activity was demonstrated only to a small extent.

In the 1st year students, we found a positive moderate correlation in comparison of the results in the Jacik's test and the volume of physical activity (sport index), leisure activities and total physical activities performed. In this subgroup of participants, we also detected a moderate correlation between the hand grip test and the volume of leisure activities. In the 5th year students, we only recorded low associations between strength and strength-endurance performances in relation to the values of particular Fels PAQ's indices. Moderate positive correlation was found in the 8th year students between strength parameters (handgrip test) and leisure index, chore index and total score of Fels PAQ.

Moderate, but negative, correlation in this group was recorded between the amount of sporting activities and speed indicators. We believe that it could have been caused by a higher volume of exercise at a lower intensity.

In all sub-samples, results of tests focused on speed abilities and indices of physical activity have shown negative correlations. A noticeable relationship was recorded in the 1st and 8th year students, when moderate correlations between all three tests of speed abilities and sport index of Fels PAQ were found. In the group of 8th year students, this result was also confirmed in the total score. In the group of 5th year students, a moderate negative correlation was found between the total score and 10 m linear sprint test and 4 x 10 shuttle run agility test. When referred to the published results, Reed, Metzker, & Phillips (2004) and Blaes, Baquet, Fabre, Van Praagh, & Berthoin (2011) state that, not the volume, but the content of physical activities is decisive. At the same time, only a very small amount of physical activities are performed in vigorous intensity and only a low percentage of children meet the recommendations for performing physical activity.

Regarding indicators of explosive strength of lower limbs and the volume of performed physical activity, only few significant correlations between the compared pairs of data were found. In this case, they can be considered random and, thus, we can state that the relationship between the explosive strength of students of the selected age categories and the performed physical activity was not confirmed. Zeng et al. (2017) in their systematic review reported that, in 10 studies, they found an impact of physical activity on motor skills in the early childhood. In eight of them, the effect was significant. Our findings are consistent with the statement by Malina (2001) that from childhood to adolescence, the literature has generally shown a weak to moderate relationship between PA and physical performance. Similarly, a partial agreement can be noticed with findings by Larsen et al. (2014), who examined a group of children aged between 6 – 12 years in a three-year longitudinal study and concluded that motor performance has been shown to be positively associated with physical activity in cross-sectional studies. Furthermore, Wrotniak, Epstein, Dorn, Jones, & Kondilis (2006), in their study dealing with a relationship between motor proficiency, which is closely related to motor performance, and physical activity, reported that motor proficiency is positively associated with physical activity and negatively related to percentage of time in sedentary activity in children. In both studies, results of physical activity were obtained through a direct method using accelerometers, or actigraphs, respectively, which can be the reason of inconsistency with our findings. In contrast to these studies, Blaes et al. (2011) present an insignificant relationship between physical activity and motor performance in the group of 6–12 years old French children. Similarly, Reed et al. (2004) describe a weaker relationship between these variables.

Results listed in Table 3 show that physical activity is dominantly related to the active body mass. Moderate positive association was found between the parameters of the amount of muscle mass and fat free mass in relation to the sport index and total physical activity in the group of 1st year and 8th year students. Moreover, in the oldest tested group, the relationship between these parameters and chore index was detected. Pantelič & Došič (2018) reported a moderate positive correlation between Fels PAQ total physical activity and muscle mass in boys, while correlation in girls was only weak. A negative correlation between the amount of physical activity and adiposity parameters was found across all tested age categories. However, these values only achieved the level of low correlation. This is in line with a study by Dencker & Andersen (2008), who reported only low to moderate inverse relationships between moderate to vigorous PA and body fatness with a comparable population. On the contrary, study by Ness et al. (2007), who tested 11-years-old children, showed a strong negative correlation between directly measured physical activity and fat mass and obesity.

Conclusion

Since the results are ambiguous, we have to be careful in their interpretation. Firstly, because the sample was not representative and, secondly, the self-reported method of assessing physical activity can show errors. In the case of body composition, it is possible to determine the tendency between physical activity and characteristics of active body mass. Regarding the relationship between physical activity and motor performance, results are not clear. It only is possible to determine a tendency of a positive effect of the strength of upper limbs and tendency of a decreasing performance in speed tests with respect to the increase of leisure time activities. We suppose that it could be caused by a large amount physical activities performed in low to moderate intensity.

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Aleš Sekot

Faculty of Sport Studies, Masaryk University, Czech Republic

ABSTRACT

An essay is rooted in the exploration of broader complex context of the phenomenon of physical motion and sportive activities in contemporary sedentary society. It is at that time the topical problem of pointed parenting styles that is freshen and enliven in the context of educational support aiming to active life orientation, including regular sportive activities. The specific accents and educational methods of parenting are playing crucial role in this respect at the level of authoritative, authoritarian, liberal and neglecting styles (Sekot, 2019). Parenting styles prefiguring motivation of children to regular sportive activities and responsible attitude to life. And such process is going under way of socialization factors and impacts, bringing up to date the sociological links and context of mutual relation to motivation of children and youth to sport also in the context of organizational sportive activities out of the family. Nowadays we face forming socially and culturally determined relation child – parents – trainer (coach). Like this relation yields in the context of the climate of consumerist postmodern society adoring top elite athletes. Such cultural milieu forms potential conflicts of interests of motivation, experience and pointing separate participants of such „triangle". Given situation aim our effort to the crucial topic of parental responsibility as well as to growing educational and socialization importance of trainers and coaches. During the synergic process are pervaded practical aspects of the importance of age and motivation; but parental role is in this respect utterly essential and indispensable. Parental role is growing when parents play modelling role by way of mutual sportive activities with children. Thus, as it is in the essay substantiate with relevant research pieces of information and empirical data on parental role in motivation of children to regular physical activity and sport.

Keywords: parenting; sport; physical activity, trainer; sedentary

This text addresses the broader context of the phenomenon of exercise and sports activities in contemporary sedentary society, in which the determined education of children by their parents to adopt an active approach to life is becoming increasingly important, and regular exercise forms an integral part of it (Sekot, 2015). The issue of parenting styles is relevant, since whether the style adopted is authoritarian, authoritative, liberal or neglectful, it has influence on children's and young people's motivations for doing sport. This takes place within the concurrent process involving socialization factors; thus updating the sociological contexts of young people's relationships with sport, in particular the context of motivation for sports activities outside the family framework, in an organized sporting environment. Hence a new, socially and culturally conditioned relationship is created between the child, the parents and the trainer, which – in a consumer society climate and its adoration of elite sportspeople – brings possible clashes of motivations, experiences and directions of the actors involved in this triangle. This focuses our attention on both the issue of parental responsibility and the growing educational and socializing importance of the trainer. In a synergic process, linked issues emerge that are connected with the importance of age and motivation for the purposeful guidance of the child towards sports, where the influence of the parents is absolutely essential and irreplaceable, and strong also in these cases where parents influence their children by undertaking regular joint sports activities with them. This is shown in the book's empirical findings about parental approaches to children's and young people's sports.

Sport is inescapably linked with the culture of society. It is thus an expression of specific notions, ideas, values and perspectives, through which people assume their positions in the world, seek their place in it, explain its workings to themselves and measure the importance of the things around them. They consider what is and what is not right and natural; what is advantageous and disadvantageous; what can bring a material profit and what 'merely' brings joy from healthy exercise. In itself, sport is usually not the cause of particular changes in character, attitudes or behaviour. It is always involved in a coaction with the influences exerted by the specifics of the given social and cultural environment, in the broader context of socialisation and education processes (McElroy, 2002).

The topic of *parental education* and authority for the *motivation*, intensity, level, direction and, last but certainly not least, *adherence* of children to sporting and physical activities is certainly directly or indirectly linked with the cultural and social climate. Thus we face in our society the issue of substantial cultural change that generates fundamental shifts in the sphere of value orientations of socially and economically differentiated groups, layers or classes of the population. This change is substantially stimulated by the culturally revolutionary phenomenon of a *consumer society*, reflecting the essence and the ethos of its modern or post-modern characteristics, accompanied by a number of ambiguous or crisis-generating processes, exposing masses of people to transformations in individual consumption, the existence of mass culture and a growing tendency to consumerism and economic egocentrism. Viewed through the prism of the situation and developmental trends in sporting and physical activities, one of the most serious indirect consequences of consumerism for both the individual and society is a process that has been described with a global perspective as *sedentarism.* It is a phenomenon concurrent with a technologically advanced, consumer and materially rich society, where the need for physical exertion gradually disappears and so does, subsequently, the level of regular physical activity in the everyday lives of masses of people. Thus we speak of *sedentary society*, in which in consequence of the dynamic development of technology in all areas of social life the traditional demands placed on people in terms of physical exertion decrease, particularly in three areas that concern practically everyone: in the majority of employments, that is in the field of *work*, in the *home* and in the *individual forms of transport.* Instead of physically strenuous activities, most people in our cultural sphere today are placed, especially at work and in individual transport, in sedentary activities, which are characteristic of a sedentary consumer society. In this and other contexts, the issue of *insufficiency of physical activity* is thus grounded in the elementary question: Why is physical activity important? The answer is clear and fundamental: Because humans are genetically programmed for physical activity and a sedentary way of life is detrimental to them, being an unnatural form of physical passivity and accelerating the progress of our civilisation diseases as heart attacks, diabetes and high blood pressure (McElroy, 2002).

This creates a situation where regular healthy physical and mental development, supporting regular physical activity, becomes a matter of individual choice, personal will and perceptiveness towards the socialising and educational influences of the environment. This updates in a specific way the educational role of the family and parents as the primary opinion leaders, who are able powerfully to form and influence the values of their children and thus to contribute to the relations they create for themselves towards physical activities, which in our cultural sphere largely take the form of sports, in activities often undertaken outdoors, in participation in sporting games and leisure-time activities linked with physical exertion and movement. Just in sedentary society mostly children and youth are involved in prolonging capacity of leisure time in passive physically position in front of PC screen as a loss of natural regular sportive physical activity and as an independent part of healthy individual complex development and active attitude to life.

If we study the process of how an individual's values are formed, then in our culture in particular two highly stimulating processes are acting together on children and young people. *Socialisation* is a life-long, all-pervading and spontaneous process by which individuals or groups adjust themselves to the world around them, adopting its fundamental values, norms, rules, habits, customs and cultural patterns in everyday life, especially in contact with other individuals and groups. Unlike socialisation, e*ducation* is a purposeful action on an individual by parents, the wider family, teachers, educators, trainers and institutions and organisation, with the aim of influencing the development of the individual and their personality.

Family plays a key and decisive role in the purposeful upbringing of children. In line with their cultural, educational, economic and social level, parents influence their children, and theory distinguishes four parenting styles. A parenting style here means a theoretical construct reflecting the fundamental and characteristic strategies and methods used by parents primarily to form the lives of their children. The quality and importance of these educational activities are usually amplified by the amount of time parents spend with their children. This is particularly so when at least one of the parents shares leisure-time activities with their child, thus persuasively demonstrating to them their interest in and care for them. A parenting style is thus an expression of a *special behaviour of parents towards children*, which reflects the broader conception and strategy of parental educational practices. Diana Baumrind was the pioneer in conceiving a typology of parenting styles. Her research has established a basic three-step model of parenting styles (authoritative, authoritarian and permissive), which was then developed further by other scholars, usually into four-step models. Baumrind's research was informed by two bipolar fundamental constituents – responsiveness vs non-responsiveness and demandingness vs non-demandingness – that generate the forms of parenting styles (Baumrind, 1967, p. 43–88). Current theoretical models of parenting styles tend to distinguish four of them: authoritarian, authoritative, liberal (or permissive) and neglectful.

Authoritarian: Parents emphasise unconditional obeisance and discipline, and this is enforced by punishment. They pursue the principle that the child needs to be overseen, not heard out or even have their worries and problems empathetically shared. Authoritarian parents prefer the use of punishment over the child's inner adoption of discipline, and fail to appreciate the irreplaceability of the feedback between their decision-making and their child's feelings and opinions. Motivation of parents for sport of their children is mostly rooted in success in the field of performance sportive activities focused on respective profitable career of sport star; in some cases as a consequence of unrealized sportive aspirations of father of mother.

Authoritative: Positive relations between parents and the child are created, and binding precepts and rules that cannot be overstepped are asserted. There is an emphasis on creating positive values and an active approach to life. Parents always take care to create a positive, friendly relationship with their child; they not only emphasise the necessity of respect for rules and order, but also consider the child's inner life and derive their parental authority in part from respecting the opinions, feelings and needs of the child. They seek to prevent problems in upbringing rather than dealing with them in an authoritarian manner. Where parents are consistently demanding yet perceptive of the child's values, a beneficial form of cultivating the child is gradually created, giving the child in later life a greater chance of being a successful, well-received, magnanimous and competent independent individual, one able adequately to determine and co-create their active life path. Generally speaking, this parenting style is considered the *optimal* way to bring up responsible adults who freely express their opinions and actively approach the challenges and obligations of life (Spera, 2005). Parents mostly as a highly esteemed opinion leader share sportive activities with their children forming natural way for whole life adherence to regular physical activities on the levels responding naturel, talent, and desire or value orientation of their children.

Liberal: This style is based on not enforcing respect for the code of family life and the rules of desirable behaviour and actions, in line with the principle 'children are just children, let them have freedom'. Although the rules that have been established may often be strict, they are not always consistently enforced and respected. Coercion is only used in extreme cases of truly serious problems. A liberal, permissive style of parenting that is not based on giving orders is characterised by a low expectation threshold as far as the following are concerned: the child's behaviour and aspirations, the satisfaction of their basic needs and creation of life-long stabilising values. As such, this parenting style does not lead systematically to an inner awareness of correct behaviour. The adequate parental role slips into that of 'friendship' or 'camaraderie', lacking the vital function of natural authority and 'opinion leadership', remote from fixed, irreplaceable rules, rewards and punishments. However, under certain circumstances this can open the way for an independent

– or perhaps self-sufficient - development of the child in adulthood. Motivation relating to regular sportive activities is not systematic, more “space” in this respect is hold on to children contemporaries, schoolmates, school trainers or motivation rooted in admiration of mass media sportive stars.

Neglectful: Under this style, parents entirely fail to inculcate in their child the fundamental positive values of life, disregarding not just their needs and interests, but also education and professional training, ignoring the rules of healthy eating habits and an active life style. Parents show no interest in their child’s school duties and do not consider it necessary to be informed about where or with whom their child spends their leisure time. The child lacks sufficient adequate counsels, impulses and *stimuli* to create the preconditions for a meaningful and responsible life in adulthood; lack of parental interest frequently also affects the areas of nourishment and hygiene habits. Often there is a significant gap between the parents’ interest in their child and the energy needed to satisfy their needs, often including their fundamental needs. General lack of interest of parents regarding motivation or even adherence for systematic sport of their children leave “broad colourful space” for impact of the street and bad or good luck.

Naturally, in many actual cases there is an overlap between these academically constructed categories, or their boundaries become blurred. Evidently, however, one thing is true: the building and maintaining of a *positive* relationship with the child and the stabilising of a natural and healthy *parental authority* demonstrates most clearly a correct and positively directed parenting style, and is of cardinal importance for the bringing up of children (Sekot, 2019).

It is important to note that in the creation of parenting styles factors such as the child’s temperament and medical condition and especially the cultural level of the parents often play crucial roles. Parents who provide adequate care to their children lead them to healthy dietary habits, emphasise the importance of personal responsibility for health, while allowing for an adequate measure of independence and decision making, create good conditions for the establishment of life-long social competencies and an active approach to life. This form of *positive parenting style* is also beneficial for the ability to maintain solid interpersonal relationships.

Leisure time is an important platform for a wide spectrum of activities that importantly affect people’s lives, the maturing of their values and their physical development. It is therefore also irreplaceable, providing a unique basis for the creation of feelings of life satisfaction and personal welfare, for the cultivation of a healthy and actively thinking and acting personality. For children and young people, this may on the one hand mean increasing consumption of their leisure time ‘permanently connected’ to electronic media; but on the other it opens the options for active leisure, especially via sports and other physical activities; cultivating the ability consistently and systematically to maintain good health and peak physical and mental condition.

Beyond its fundamental educational functions, aimed at purposeful influence over the child’s values, the family is usually also intimately linked with the process of *socialisation*, that is the adjustment of a person to the habits, customs and norms of the surrounding world, the given cultural environment. As a rule, parents seek within their own norms and values for their child to become an independent, sovereign adult. The participation of children and young people in sports activities is generally influenced by the availability of opportunities, support given by family members, friends, opinion leaders and role models, the closest community and finally also the perceptiveness of the potential child participant in sports activities (Stassen et al., 2011, p. 273–278) .

The study of the broader frames of socialisation, education and leisure time focuses on its two forms: organised leisure and non-organised leisure. Participation in organised activities is generally seen as a factor in the development of an individual’s strong traits in the sense of their healthy maturing towards the ‘ideal adulthood’; while socially-focused activities taking place out of the sight of adults are, by contrast, seen as a context for potential multidimensional involvement in risky or delinquent behaviour. Multiple involvements in *organised forms of leisure* potentially increase the educational and socialisation effect that contribute to comprehensive personal development (Campione & Smetana, 2014).

These effects are made stronger still by the *breadth* of the wide spectrum of organised leisure activities (for example, a combination of sport with an interest in artistic activities), their *intensity* (for example, time spent in sports training), *internally grounded interest* (for example, looking forward to training time or a family cycle trip at the weekend) and *duration* (for example, persistence in football or athletic training). Thanks to parental authority, such efforts stand the greatest chance of initiating and developing children's leisure time activities, their focus, intensity and aspirational expectations. With age, the participation of adolescents in organised leisure time under adult supervision gradually decreases, as, for example, intensive training in competitive sports might become remote from the original desire for victory and performance. Furthermore, other options for self-actualisation are open to young people, especially in the field of professional training. However, young people usually carry the valuable assets of activeness, respect for authority, purposefulness, life-long friendly relationships and collective cooperation from the arena of organised leisure activities into their future lives. These are compatible with the demands of the contemporary world, necessitating not just the pursuit of personal ambitions but also an ability to adjust and be flexible (Amato & Fowler, 2002, p. 703).

In extreme cases, permanently or largely unstructured, *non-organised leisure* tends to be typical of a non-stimulating family environment. Leisure time spent without proper supervision by, or even lack of interest from, parents may lead to often aimless after-school-hours meetings with friends and peers and directionless loafing around, producing feelings of futility, pointlessness and obliviousness. Patterns of behaviour are adopted that are in sharp contrast to the ethos and the principles of an active approach to life. Overall, active participation in organised leisure time activities under the leadership or supervision of adults can be seen as a suitable environment for the healthy personal development of adolescents in the context of extracurricular forms of socialisation and educational activities, where *forms of parental motivation* usually play a primary initiating role (Telama, Yang, Vikari, et al., 2005).

An unmistakable, and in fact irreplaceable, source of relevant information in this area of sports – that is, the uncovering and investigation of many colourful influences of parental models of behaviour in the environment of the organised sports of their children – are the trainers, coaches, teachers, managers of sports grounds and organisers of sports events for young people. Despite this fact, the voices of the trainers and young people's sports organisers are not heard loudly enough. Scholars in this field are therefore increasing their efforts to describe and understand the role of *trainers* in the context of the often colourful attitudes and behaviour of parents, which reflect parents' educational methods or styles that they apply in a promising ambitious environment, dynamically developing the potential sporting career of their child. An adequate degree of parental encouragement, to achieve a higher level of ability and performance, and the sharing of joy from participation in sports, certainly help to create harmonic educational and socialising effects. By contrast, unrealistic parental demands and expectation can be a source of stress and fear of failure, thus weakening the natural enjoyment of sports, causing children a loss of faith in their own abilities and deteriorating self-confidence. Parents do not always well understand, or are willing or able adequately to share, the sporting experiences of their children. The evaluations of participation in sports by parents on the one hand and children on the other can differ considerably, even if there are cases where the child outwardly declares motivations and objectives that are identical with the parents'. Such impulsive positions on sport can be moderated and compensated for by interactions with trainers, who with their expert insight can contribute towards adequate harmony between parents' and children's positions, especially in the field of organised sports' meaning and objectives, which can often be problematic (Côté & Hay, 2001).

Here, the optimal educational style, appropriately supporting the sporting career of the child, is that where the parents provide suitable, appropriate and effective logistical, financial and emotional support. By contrast, a sustained critical approach on the part of the parents, impatiently awaiting the fulfilment of high aspirations, tends to be counterproductive. Such an approach overestimates the value of victory, and creates inappropriate pressures on targets being met that have been set by the parents, but which neither the children involved in sports nor their trainers have fully identified with.

Highly *negative expressions* of the parental relationship with their children's sports include, first of all, complaints about the progress and outcomes of sports training, pursued in a manner that undermines the authority of the trainers, and in many cases also the relations between parents and children (Gould, Lauer, Rolo, et al., 2006a, b). Examples include such protests – they are not necessarily rare and are often tactless – against alleged underrating of the sporting child in team nominations, or concerning the quality of the training, or even questioning the abilities of the trainers themselves, who might be accused of incompetence or unwillingness to accommodate methods conductive to an effective increase in sporting performance. The child's confidence or trust in their own ability to enter and establish themselves in the field of sports depends on a number of everyday experiences: the family environment, school, the time spent shared with peers and, more recently, the perception of sports in the media as the most popular form of mass culture. In cases where the parents in their education methods emphasise the value of performance that is grounded in learning, enjoyment of the result and directing the child towards the management of tasks and achieving victory, there is a greater likelihood of the child inclining towards sporting and physical activities, which by their very nature are associated with endurance, performance and victory ((Ross, Mallett, & Parkes, 2015).

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Contact Information

sekot@fsps.muni.cz

DOPING KNOWLEDGE AND DOPING ATTITUDES IN COMPETITIVE BODYBUILDING

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Dora Marić[1,2], Šime Veršić[2], Šimun Vasilj[2]

[1]*PhD Program in Health Promotion and Cognitive Sciences, Sport and Exercise Research Unit, University of Palermo, Palermo, Italy*

[2]*Faculty of Kinesiology, University of Split, Split, Croatia*

ABSTRACT

Purpose: Bodybuilding becomes more visible and acceptable within mainstream society thanks to social media, which is promoting, and developing grooving interest in bodies, fitness and active lifestyle. However, this is concerning knowing that according to the latest world anti-doping agency report bodybuilding is one of two sports with the highest number of Anti-Doping Rule Violations (ADRVs) committed by athletes. This study aimed to evaluate doping attitudes and correlates of doping attitudes in top level body builders.
Methods: Study included 26 competitive bodybuilders form Croatia. Variables were collected by a previously validated Questionnaire of Substance Use (QSU). Statistical procedures included means and standard deviations (for parametric variables), frequencies and percentages (for ordinal and nominal variables). Spearman's correlations were calculated to determine associations between studied variables.
Results: The most positive attitudes are found towards injectable anabolic steroids (mean ± standard deviation; 4.00 ± 1.52), followed by fat burners (3.73 ± 1.46), growth hormone (3.69 ± 1.64), and estrogen blockers (3.60 ± 1.22), oral anabolic steroids (3.58 ± 1.27). Significant correlation was identified between: (i) result achieved in bodybuilding (RBB) and alcohol consumption, ($R= -0.57$ $p < 0.05$) (ii) RBB and subjective knowledge on nutrition ($R=0.66$, $p < 0.05$), (iii) RBB and subjective knowledge on doping ($R=0.72$, $p < 0.05$).
Conclusion: The lack of correlation between self-perceived competence and objectively evaluated knowledge on nutrition is alarming due to the possible "anchoring effect", accordingly even though objective knowledge is not correlated with attitudes towards doping substances, it is important to properly educate athletes who are in the misconception of their true knowledge.

Keywords: bodybuilding; doping; knowledge

Introduction

Doping is one of the most dangerous and health-threatening behaviors in contemporary sports (Maravelias, Dona, Stefanidou, & Spiliopoulou, 2005), it occurs when athletes use prohibited substance or methods to unfairly improve their sporting performance. Health hazardous effects of doping include altered liver and kidney function, cardiac hypertrophy, infertility, acne, virilization, subdural hematomas, tendon injuries, peripheral edema, myocardial ischemia, thrombosis, cardiovascular disease, many other negative health consequences, and ultimately death (Honour, 2016; Ljungqvist, 2014). That being said it is clear that negative health-related consequences, even death, and corruption of the main essence of sport and fair play, make the fight against doping highly prioritized in all organized sports societies (Ljungqvist, 2014; Sajber, Rodek, Escalante, Olujic, & Sekulic, 2013).

Bodybuilding can be defined as a sport in which athletes compete to show aesthetic qualities of extreme levels of muscular development, symmetry, and low body fat while maintaining muscle mass (Helms, Aragon, & Fitschen, 2014). In the last decade bodybuilding becomes more visible and acceptable within mainstream society thanks to social media, which is promoting, and developing grooving interest in bodies, fitness, and active lifestyle (Monaghan, 2002). Even though their dedication to follow strict training schedules and nutritional plans can be a positive influence on society in general the fact that they are also strongly associated with frequent abuse of doping substances is alarming. Specifically, according to the latest world anti-doping agency report bodybuilding is one of two sports with the highest number of Anti-Doping Rule Violations (ADRVs) committed by athletes (WADA). This is also supported with studies suggesting that up to 40% of competitive bodybuilders regularly consume doping substances (Delbeke, Desmet, & Debackere, 1995).

Several researchers have illustrated that bodybuilders are pretty open to confess their abuse since use of anabolic steroids, and other doping substances is seen as an integral part of their sport culture by most of them (Brand, Heck, & Ziegler, 2014; Perry, Lund, Deninger, Kutscher, & Schneider, 2005). Research show there is a high number of bodybuilders who experiment with drugs irresponsibly, knowing that it is a plausible fact that bodybuilding is often a ground for innovations in doping, which oftentimes spill over into Olympic sports (Brand, Wolff, & Thieme, 2014). Accordingly, understanding factors influencing their doping attitudes is crucial in order to understand how to influence them and prevent health hazardous outcomes, therefore the aim of this study was to evaluate doping attitudes and correlates of doping attitudes in top level bodybuilders.

Methods

Subjects: Study included 26 competitive male bodybuilders, from Croatia (age: 28.0 ± 9. 2 years).

Variables: The data was collected by previously validated questionnaires: (i) Questionnaire of Substance Use (QSU), (ii) Knowledge of Doping and sport nutrition (KD&KSN) (Sajber et al., 2013; Sekulic et al., 2016).

The QSU includes questions about sociodemographic background, sport-related factors, doping factors, questions about subjective assessment of knowledge of doping and nutrition (“I have no knowledge about it”, “poor”, “intermediate”, “good”, “excellent”).

The KD and KSN questionnaires (used for evaluation of objective knowledge of doping and nutrition) consisted of 10 questions each. Each question (statement) was in a “true (T) or false (F)” format; if the answer was correct, the athletes scored one point. The final results ranged from 0 to 10. The correct answers were based on WADA standards. The detailed explanation of questionnaires used can be found in following papers published by Sajber et al., and Sekulic et al. (Sajber et al., 2013; Sekulic et al., 2016).

Statistics: Normality of distribution was assessed by Shapiro-Wilk W test, the means, and standard deviations were reported for age and doping substance attitudes, while frequencies, and percentages were reported for other variables. Spearman’s correlations were calculated to determine associations between studied variables.

Results

Frequencies of responses on variables derived by questionnaire (Table 3) on substance use are showing that self-education is reported as a primary source of information about nutrition and doping in 53.85% of bodybuilders, while only 7.69% of them consider formal education as a primary source of information on these topics. Almost 92.31% of bodybuilders were of the opinion that doping is used regularly in their sport while no one responded that doping is not used in their sport, or that is being used rarely. Further, concerning doping penalties 73.08% answered they think doping should be allowed, while only 3.85% thinks there should be lifelong suspension for doping offender. Doping was stated mostly as health-threatening behavior by 53.85% of participants, while only 7.69% considered it as a problem of fair play. Alcohol is not consumed by 46.2% of bodybuilders while only 3.85% stated they consume alcohol once a week or several times a week. As regards to attitudes towards doping substances (table 1.) the most positive attitudes are found towards injectable anabolic steroids (mean ± standard deviation; 4.00 ± 1.52), followed by fat burners (doping substances used in bodybuilding exclusively for fat burning) (3.73 ± 1.46), growth hormone (3.69 ± 1.64), estrogen blockers (3.60 ± 1.22), and oral anabolic steroids (3.58 ± 1.27).

Pearson's correlation coefficient was significant (table 2.): (i) result achieved in bodybuilding (RBB) and alcohol consumption, ($R= -0.57$ $p < 0.05$) (ii) RBB and subjective knowledge on nutrition ($R=0.66$, $p < 0.05$), (iii) RBB and subjective knowledge on doping ($R=0.72$, $p < 0.05$).

Table 1 *Responses on variables derived from attitudes towards doping substances (Mean, Std.Dev. – standard deviation)*

DOPING SUBSTANCE ATTITUDES	Mean	Std.Dev.
Injectable anabolic steroids	4.00	1.52
Fat burners	3.73	1.46
Growth Hormone	3.69	1.64
Estrogen blockers	3.60	1.22
Oral Anabolic Steroids	3.58	1.27
Performance enhancers (ephedrine, amphetamine,…)	3.19	1.41
Diuretics	3.00	1.67
Insulin	2.92	1.35

Table 2 *Pearson's correlation coefficients between result achieved in bodybuilding, alcohol consumption, subjective knowledge on nutrition, subjective knowledge on doping, objective knowledge on nutrition, and objective knowledge on doping*

	RBB	ALC	S/KN	S/KD	O/KN
ALC	-0.57*				
S/KN	0.66*	-0.46*			
S/KD	0.72*	-0.23	0.60*		
O/KN	0.04	-0.04	-0.03	-0.02	
O/KD	0.16	-0.15	-0.18	-0.08	0.52*

LEGEND: RBB – result achieved in bodybuilding, ALC – alcohol consumption, S/KN – subjective knowledge on nutrition, S/KD – subjective knowledge on doping, O/KN – objective knowledge on nutrition, O/KD – objective knowledge on doping, * denotes statistical significance of $p < 0.05$

Table 3 *Responses on variables derived by questionnaire on substance use (F – frequency; % – percentage)*

	F	%
PRIMARY SOURCE OF INFORMATION ON SPORT NUTRITION AND DOPING		
I have no knowledge about it	0	0
Coach and doctor	10	38.46
Formal education	2	7.69
Self-education	14	53.85
DOPING IN BODYBUILDING		
I don't think doping is used in bodybuilding	0	0
Don't know/Not sure	0	0
Used, but rarely	0	0
Doping is frequent	2	7.69
Doping is used regularly	24	92.31
OPINION ABOUT PENALTIES FOR DOPING OFFENDERS		
Lifelong suspension	1	3.85
First time milder punishment, than lifelong suspension	2	7.69
Suspension for couple of seasons	2	7.69
Financial punishment	2	7.69
Doping should be allowed	19	73.08
THE MAIN PROBLEM OF DOPING IN SPORTS		
It is mainly health-threatening behavior	14	53.85
It is against fair play	2	7.69
I'm not sure it should be banned	2	7.69
Doping should be allowed	8	30.77
ALCOHOL CONSUMPTION		
I don't drink alcohol at all	12	46.15
I drink alcohol but almost never enough to get drunk	5	19.23
1–2 times a month I get drunk	7	26.92
Once a week	1	3.85
Several times a week	1	3.85

Discussion

When it comes to bodybuilding, it is hard to distinguish factors influencing doping behavior. Knowing that bodybuilding is indefinitely associated with doping abuse, and bodybuilders are in general, fairly open when it comes to doping consumption (Brand, Heck, et al., 2014; Perry et al., 2005). Therefore, it is reasonable to assume that doping behavior is most certainly impacted by the bodybuilding community in general. This is one of the reasons why our questionnaire included attitudes oriented towards specific doping substances and not only towards doping attitudes in general, which is not common approach in other sports and physical activities (Sekulic et al., 2016). However, our initial assumption was further supported by the facts that none of the studied athletes is of the opinion that doping is not used in their sport (or that is being used rarely), and that 73.08% athletes believe that doping should be allowed. Furthermore, our results support previous findings stating that anabolic steroids are most commonly abused doping by bodybuilders (Perry et al., 2005). Additionally, it is important to emphasize that athletes examined have highly positive attitudes towards almost all doping substances questioned, which is supporting previous findings implying high doping consumption in bodybuilding.

Lack of correlation between self-perceived competence and objectively evaluated knowledge on doping and nutrition is alarming. In short, lack of objectivity/self-averseness regarding knowledge on doping and nutrition puts those athletes in higher danger of inappropriate usage of DS and possible detrimental consequences (Maughan, 2018). More precisely, there is a high probability that athletes with high self-perceived knowledge will be "anchored" by their self-rated knowledge on a topic. This phenomenon is known as "anchoring effect," and it is defined as a type of cognitive bias that leads individuals to focus on the first available piece of information (the "anchor") given to them when making decisions. According to sociopsychological studies it is clear that the anchoring effect is moderated and decreased by advanced knowledge and the level of "true knowledge on a problem (Smith, Windschitl, & Bruchmann, 2013). Therefore, in order to avoid negative health consequences and possible detrimental consequences caused by inappropriate use of doping in highly doping contaminated society (also known as a mediator of doping to other sports) it is important to diminish the negative impact of discrepancies between self-perceived competence and objectively evaluated knowledge. The best approach is to educate athletes on this topic, as we may expect they won't do it by themselves "anchored" by the false perception of their truth knowledge.

Result achieved in BB is correlated with alcohol consumption. There are two plausible explanations for this. First, alcohol consumption is known to have a direct impact of muscle synthesis, recovery, etc. and therefore, it affects result directly. There is a high number of researches implicating negative health consequences of excessive alcohol consumption; it is estimated that 40 up to 60% of all alcoholics have skeletal muscle disease (Trounce et al., 1987). Plausible reason for skeletal muscle diseases could be a disturbance in protein balance, which is process opposing protein synthesis and degradation and it leads to the erosion of lean body mass and progressive proximal myopathy (Trounce et al., 1987). When it comes to athletes, it is reasonable to assume that they're not immune to the negative consequences of alcohol consumption/abuse. Studies are suggesting that post-match alcohol ingestion can have the potential to slow down recovery because of its depressant nature on the neuromuscular and circulatory systems. Alcohol consumption can cause a reduction in skeletal muscle force, especially after exercise-induced muscle damage over the first 36 and up to 60 hours post-exercise which is likely to result in the delayed recovery of performance (Barnes, Mundel, & Stannard, 2010). Also, ingestion of alcohol has been shown to decrease the stimulatory effect of exercise on muscle glucose uptake, inhibit glucose uptake into skeletal muscle, and impair glucose utilization (Shelmet et al., 1988).

Second, alcohol consumption is an indicator of athletes' lower determination and dedication to training and nutrition, and all that leads to sports results in the future. As previously stated bodybuilding is a sport in which athletes compete to show aesthetic qualities of extreme levels of muscular development, symmetry, and low body fat while maintaining muscle mass (Helms et al., 2014)

That being said it is understandable that result in bodybuilding is highly influenced by the lifestyle, habits, and especially training, and nutritional plans that should be strictly followed in order to keep the muscles aesthetic for the competitions. Lack of dedication and determination could be pointed out by consumption of alcohol if we have bodybuilders who are willingly undermining effort they put in the gym by consuming something that stands out of their nutritional plans, in this case, alcohol. Thus, we may presume that alcohol is not the only thing that stands out from their highly planed routine (training, nutrition) and affects their competitive results.

Conclusion

It is well known that bodybuilding is highly contaminated with doping, and there for the fact that there is a lack of correlation between self-perceived competence and objectively evaluated knowledge on nutrition is alarming due to the possible “anchoring effect”. It actually means that there is a probability that athletes with high self-perceived knowledge will be “anchored” by their self-rated knowledge on a topic. Even though objective knowledge is not correlated with attitudes towards doping substances, it is important to properly educate athletes who are in the misconception of their true knowledge.

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THE RELATIVE AGE EFFECT IN THE TOP 100 ATP TENNIS PLAYERS 2016–2018

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Michal Bozděch[1], Adrián Agricola[2], Jiří Nykodým[1], Antonín Zderčík[1], Tomáš Vodička[1]

[1]*Masaryk University, Faculty of Sport Studies, Brno, Czech Republic*

[2]*University of Hradec Králové, Faculty of Education, Hradec Králové, Czech Republic*

ABSTRACT

The issue of the Relative Age Effect (RAE) has been monitored in the field of sports for more than 30 years. Its theoretical framework is based on the premise that during the pubescent period athletes born at the beginning of the year experience earlier biological acceleration resulting in a higher level of physiological, mental, morphological and psychological attributes than their later-born peers. A number of publications show that this temporary advantage often manifests itself in elite competitions at the junior level, but gradually disappears during the transition to professional senior competitions. The aim of this work was to determine the level of the RAE in the elite 100 ATP tennis players (ATP Rankings) in 2016–2018. To assess the influence of the RAE, the Chi-Squared (χ^2) test in the variant of Goodness of Fit was used for the assessment of the conformity of expected and observed frequency distribution due to the categorical character of the research data and the large sample size. The Cohen's *w* value calculation was used to assess the effect size (ES, since it is not a random representative selection of elements of the research set) of the χ^2 test values. The odds ratio (OR) was used to assess the chance of players from the Q_i individual quarters to get among the best 100 players. The results show that, in terms of effect size (ES), the effect of birth date in all the Top 100 players is small (w = .22) during the entire observed period 2016–2018; the influence of RAE is therefore dismissed. The ES in the individual years is again small (w = .21–.25); the influence of RAE is also dismissed. In analysing the effect of birth date, the mean rate of effect size was found in tennis players in positions 1 to 25 (w = .46) as well as in tennis players in positions 51 to 75 (w = .37); the RAE influence is therefore not rejected. Only a small measure of effect size was found between positions 26 to 50 and 76 to 100 (w = .21–.25); the RAE influence is rejected. No statistically significant difference has been found between the observed and expected distribution of birth date between the observed quarters of the year (odds ratio test, p > .05) and it has not, therefore, been proven that tennis players from any of the quarters Q_1–Q_4 had a better chance of getting among the Top 100 tennis players. It can be concluded that professional senior tennis had not shown the RAE influence to the extent usual in junior categories during the observed period of 2016–2018.

Keywords: biological acceleration; birth date; sports talent; professional; ATP Rankings

Introduction

In one of the oldest publications considering the influence of the Relative Age Effect (RAE) Green and Simmons (1962) found a significant difference between the study results attained by primary school pupils born at the beginning and at the end of the academic year, i.e. between relatively older and younger pupils in the same class. A difference between mental and chronological age was also demonstrated by the authors Jeronimus, Stavrakakis, Veenstra and Oldehinkel (2015). In one of the first publications considering the distribution of birth date in sport, Grondin, Deshaies and Nault (1984) confirmed the influence of birth date in hockey players (U11–U18, n=3,826), but not in volleyball players (n=1,391). The expression RAE – i.e. a larger chance of being selected among the elite group thanks to accelerated biological maturity – was first used in the area of sport in the study by Barnsley, Thompson and Barnsley (1985); a significantly greater representation of players born in the first half of the year (S_1 = 61.8–71.5 %) than of players born in the second half of the year (S_2 = 28.5–38.3 %) was found in a set of ice hockey players in two junior leagues (OHL, n=350; WHL, n=698) and one senior league (NHL, n=715) in Canada. Giacomini (1999) is apparently the author of the first publication considering the influence of RAE in tennis, in which he found a statistically significant difference in the frequency of tennis players born in the first half of the year as opposed to tennis players born in the second half of the year in the categories U14 and U16, though no difference was found in U18 boys or in girls (U14, U16, U18). Similar findings concerning the influence of RAE in tennis players (boys and girls) were also found by Filipcic (2001), who studied the Top 60 male and female Slovenian tennis players U12–U18 (n=460, national representation). A statistically significant influence of RAE was found in male tennis players U12–U16 (though not U18) and in female tennis players in the category U12–U14 (though not U16 or U18). The author ascribes the differences in the influence of RAE between boys and girls to the earlier completion of the biological development of girls. Although there are studies in which no statistically significant gender difference in the influence of RAE has been found (Agricola, Zháněl & Bozděch, 2017; Gutiérrez Aguilar, Saavedra García & Fernández Romero, 2017), a more pronounced influence of RAE is found in boys/men than in girls/women in the majority of the publications (Edgar & O'Donoghue, 2005; van den Honert, 2012; Werneck et al., 2016; Müller, Müller, Hildebrandt & Raschner, 2016). In spite of the fact that Edgar & O'Donoghue (2005) found a significant influence of birth date in Grand Slam participants in the years 2002–2003 (237 male, 211 female), recent studies more often come to the conclusion that the influence of RAE is demonstrable first and foremost in junior age categories and less frequently in senior categories, both in tennis and in other sports such as, for example, basketball (García, Aguilar, Galatti & Romero), handball (Sánchez-Rodríguez, Grande, Sampedro & Rivillagarcía, 2013) and football (van den Honert, 2012). The influence of RAE in tennis has been studied by, for example, Bozděch, Nykodým, Agricola and Zháněl (2017) at the World Junior Tennis Finals (WJTF) tournament in the years 2012–2016 (U14, boys, national representation, n=240), and they found a statistically significant influence of RAE. The predominance of tennis players born at the beginning of the year has also been confirmed by the study by Koloničný, Bozděch and Zháněl (2018) who monitored the influence of birth date in the Top 100 Czech junior tennis players (aged 10–12, n=1,500) in fourteen consecutive years (2003–2017). Pacharoni, Aoki, Costa, Moreira and Massa (2014) also found a significant influence of RAE at the junior level (U12–U18), though they did not demonstrate any influence of RAE in South American professional tennis players (ATP Rankings). The given conclusions are in agreement with the results of Agricola (2013) indicating that RAE has no influence on placement among the Top 100 tennis players according to the ATP rankings in 2011 (n=100). In junior age categories (U12–U18, n=128,454) Ulbricht, Fernandez-Fernandez, Mendez-Villanueva and Ferrauti (2015) found that the influence of RAE grows both with growth in performance level and with a higher age category in a large group of German tennis players. It is clear from the given synthesis of the knowledge that the issue of RAE is a widely and abundantly published topic, and not merely in tennis, for which reason we selected our research goal and formulated research questions within the scope of long-term research into the influence of RAE in tennis.

Methods

The aim of the research conducted was to determine whether the influence of RAE is demonstrable among elite professional tennis players who ranked in places 1–100 in the ATP Rankings in the years 2016–2018 (Top 100). We formulated the following research questions with a view to the synthesis of knowledge and the research goal:

1. Is it possible to demonstrate the influence of RAE in male professional tennis players in the individual years studied and in the entire studied period?
2. Can the influence of RAE be demonstrated in the placement of players in the individual quarters of the ATP rankings in the entire studied period?
3. Can the influence of RAE be demonstrated in the odds ratio of players to get among the 100 best tennis players (ATP Rankings)?

The research data was obtained from publicly accessible sources (https://www.atptour.com). The whole research set (n=300, male) was divided according to the research criteria (year of competition, year of birth, month of birth, ranking) and analysed by methods of descriptive (absolute and relative frequency) and inferential (Chi-Squared, Cohen's *w* and odds ratio test) statistics. The tennis players were assigned to the individual quarters on the basis of date of birth: Q_1 (January–March), Q_2 (April–June), Q_3 (July–September), Q_4 (October–December). To assess the influence of the RAE, the Chi-Squared (χ^2) test in the variant of Goodness of Fit was used for the assessment of the conformity of theoretical (expected, Qi = 25%) and empirical (observed) frequency distribution due to the categorical character of the research data and with a view to the large sample size (Albuquerque, Lage & da Costa, 2012; Müller, Hildebrandt, Schnitzer & Raschner, 2016). With a view to the intentional selection of elements of the research set, we assessed the material significance of the results (effect size, ES) by the Cohen's *w* and odds ratio (OR). The effect size (Cohen, 1988) can be expressed in word form as small (w = .10), medium (w = .30) or large (w = .50). To assess the odds of players getting among the 100 best tennis players (ATP Rankings TOP 100) from the individual quarters ($Q_{1–4}$) we used calculation of the odds ratio (OR) and the 95% confidence interval (CI). The odds ratio test compares the observed odds (research data) with the expected odds (population; Q_i = 25%). Assessment of the statistical significance of the results of the OR test was performed on the basis of the determined level of significance p (α = .05). The confidence interval (CI) then enables quantification of the uncertainty of measurement and shows the range of values in which 95% of the true value for the whole population is found (Cobley, Baker, Wattie & McKenna, 2009).

Results

The results of data analysis are presented in the results section according to the individual research questions.

The influence of RAE throughout the observation period and in individual years

The values of the χ^2 test and the effect size (Cohen's *w*), including verbal interpretation (ES), are presented in Table 1 in addition to an overview of the relative distribution of birth dates in individual quarters.

Table 1 *The influence of RAE in individual years and throughout the research period 2016–2018*

ATP	Birth quarters				n	χ^2	p	w	ES
	Q_1	Q_2	Q_3	Q_4					
2016	24.0%	35.0%	19.0%	22.0%	100	6.04	.11	.25	Small
2017	20.0%	35.0%	23.0%	22.0%	100	5.55	.14	.24	Small
2018	22.0%	33.0%	26.0%	19.0%	100	4.46	.22	.21	Small
2016–2018	22.0%	34.3%	22.7%	21.0%	300	14.41	.00	.22	Small

Note. Q_i = quarter; χ^2 = Chi-squared test; p = level of probability; w = Cohen's w; ES = effect size expressed in word form

While the distributions of the frequency of birth date in junior elite athletes in various sports often have a character that can be expressed as $Q_1 > Q_2 > Q_3 > Q_4$ (which expresses the possible influence of RAE), such a distribution of birth dates was not demonstrated in the set of elite professional tennis players we studied. It can be stated from the results given in Table 1 that, from the viewpoint of effect size (ES), the influence of RAE in individual years and throughout the research period is small (w = .21–.25, small) with a relatively large homogeneity of w values (diff = 0.04). Assessment of the influence of birth date (RAE) by means of statistical significance demonstrated that the effect of the influence of RAE cannot be rejected ($p < .01$) in the entire research period (2016–2018), which is influenced by the large size of the research set (n=300). The influence of birth date (RAE) in individual years is rejected from the viewpoint of statistical significance ($p > .05$). We can, therefore, state that, from the viewpoint of effect size and statistical significance (with the exception of the entire research period 2016–2018), no influence of RAE among elite tennis players (Top 100, ATP Rankings) was demonstrated either in the whole research period or in individual years.

The influence of the Relative Age Effect on ranking position

Table 2 contains an overview of the relative distributions of the birth dates of all tennis players in the research set (n=300) divided into quarters by placing in the ATP Rankings, as well as the values of the χ^2 test and effect size (Cohen's w), including its verbal interpretation (ES).

Table 2 *The influence of RAE on the ranking position of tennis players in the ATP rankings*

Ranking	Birth quarters				n	χ^2	p	w	ES
	Q_1	Q_2	Q_3	Q_4					
1–25	13.3%	42.7%	28.0%	16.0%	75	16.13	.00	.46	Medium
26–50	22.7%	29.3%	17.3%	30.7%	75	3.44	.33	.21	Small
51–75	17.4%	40.0%	25.3%	17.3%	75	10.32	.02	.37	Medium
76–100	34.7%	25.3%	20.0%	20.0%	75	4.71	.19	.25	Small

Note. see Table 1.

It can be seen from the results given in Table 2 that the largest influence of RAE was found in players in places 1–25 (w = .46; medium) and the smallest in tennis players in places 26–50 (w = .21; small). It can, then, be stated that from the viewpoint of effect size (ES) a medium influence of RAE was found in players in positions 1–25 and 51–75, while a small influence of RAE was demonstrated in players in positions 26–50 and 76–100. From the viewpoint of statistical significance, good agreement was shown between the observed and expected distribution of frequencies in players in positions 1–25 (χ^2 = 16.13; $p < .01$) and 51–75 (χ^2 = 10.32; $p < .05$), and the hypothesis on the influence of birth date cannot be rejected. We reject the hypothesis on the influence of RAE in tennis players who ended in positions 26–50 ($p > .05$) and 76–100 ($p > .05$).

Differences in the chance of placement among the Top 100 tennis players according to birth quarter

The overrepresentation of athletes born in Q_1 as compared to Q_4 is a frequent phenomenon in junior categories (particularly at a higher performance level), which means that athletes born at the beginning of the year have a greater chance of becoming professional athletes than individuals born in Q_4. The results of evaluation of these chances by means of calculation of the odds ratio test (OR) and 95% CI, which quantifies differences in the chance of placement in the ATP Rankings (Top 100) of tennis players born in various quarters, are given in Table 3.

Table 3 *The influence of RAE by different birth quarters*

ATP	Q_1:Q_2 (OR) [95% CI]	Q_1:Q_3 (OR) [95% CI]	Q_1:Q_4 (OR) [95% CI]	Q_2:Q_3 (OR) [95% CI]	Q_3:Q_4 (OR) [95% CI]
2016	0.66 [0.31, 1.41]	1.36 [0.61, 3.07]	1.26 [0.56, 2.86]	2.10 [0.95, 4.54]	0.80 [0.35, 1.82]
2017	0.55 [0.25, 1.21]	1.00 [0.43, 2.21]	1.00 [0.43, 2.24]	1.79 [0.83, 3.84]	1.01 [0.45, 2.23]
2018	0.64 [0.29, 1.39]	0.88 [0.40, 1.94]	1.16 [0.51, 2.65]	1.38 [0.65, 2.93]	1.32 [0.59, 2.95]

Note: CI = confidence interval; * = $p < .05$.

It is clear from Table 3 that tennis players born in Q_2 had a greater chance of a better placement in the ATP Rankings (Top 100) than tennis players born in Q_3 in each year. In contrast, tennis players born in Q_1 always had a smaller chance as opposed to tennis players born in Q_2. None of the OR values were, however, statistically significant ($p > .05$) and it cannot, therefore, be said that tennis players bon in a certain quarter have a significantly greater chance of getting among the best 100 tennis players (ATP Rankings) than tennis players born in another quarter.

Discussion

The results of our study demonstrate that the majority of male professional tennis players that ranked among the best 100 tennis players in the ATP Rankings in the years 2016–2018 were born in Q_2, though this finding is not in agreement with the results of studies concerning the influence of RAE in junior categories. The majority of these studies found a predominance of players born in Q_1 with a falling trend of the frequency of players born in the individual quarters up to Q_4 (Agricola et al., 2017; Bozděch et al., 2017; Koloničný et al., 2018; O'Donoghue, 2009; Ulbricht et al., 2015). As an example, we give the results of Bozděch et al. (2017) who studied the influence of RAE at the World Junior Tennis Finals (WJTF, male, n=240) in the years 2012–2016. The authors demonstrated the influence of RAE on the basis of assessment of the statistical significance of c^2 values in individual years and throughout the whole period ($p < .01$). Following calculation of the values of Cohen's w (w = .58–.83), this influence of RAE among junior players can also be considered significant also from the viewpoint of effect size (ES). With a view to the conclusions of the available studies, we therefore expected a significantly weaker influence of RAE in senior categories than in junior categories. It is true that Edgar and O'Donoghue (2005) found a statistically significant influence of RAE ($\chi^2 = 8.7$; $p = .03$) in players at senior Grand Slam tournaments (n=237, 2002–2003), though following calculation of the value of Cohen's w ($w = .21$) the influence of RAE from the viewpoint of ES must be considered small. The differing results of the assessment of the influence of RAE with the use of the effect size (more correct from the methodological perspective) and statistical significance are evidently affected by the relatively large size of the research set. In the case of the study by O'Donoghue (2009), who studied the influence of RAE among those taking part in Grand Slam tennis tournaments (n=193) in the years 2008–2009, the author showed a statistically insignificant influence of RAE (χ^2 = 1.8; p = .61), which can also be considered insignificant following calculation of Cohen's w (w = .10). Loffing, Schorer & Cobley (2010) likewise did not demonstrate any influence of RAE on male professional tennis players ranked in the year-end ATP Top 500 for 2000–2006 (n=1,027; w = .17) and found a small influence of RAE in left-handed tennis players (n=138; w = .10) and right-handed tennis players (n=889; w = .19).

Similarly as in our study focusing on male professional tennis, a small influence of RAE (w < .30) has also been found in research into Olympic Taekwondo competitors (Albuquerque et al., 2012), the NHL, NBA, MLB and PGA (Cote, Macdonald, Baker & Abernethy, 2006), and French professional football, basketball, handball, volleyball, rugby and ice hockey players (Delorme, Boiché & Raspaud, 2009). The above conclusions confirm that the effect of the RAE is most evident during adolescence and is partially or not at all transferred to the senior (professional) categories. The reason for this phenomenon is that junior athletes often (unknowingly) take advantage of their relative age, which disappear after the end of adolescence. As a result, influence of the RAE is not so evident in the senior categories.

Although assessment of the odds of a successful tennis career by birth quarter showed the highest OR values in all studied years between Q_2:Q_3 (OR = 1.38–2.10), these values were statistically insignificant. In contrast, Müller, Gehmaier, Gonaus, Raschner and Müller (2018), for example, found that the largest association between variables is between Q_1:Q_4 (OR = 4.86) in young footballers (U9), which confirms the influence of RAE.

Conclusion

It was found during the analysis of research data (birth date) on elite professional tennis players that ranked among the Top 100 (positions 1–100) in the ATP Rankings in 2016–2018 that the influence of RAE was not demonstrated from the perspective of effect size (ES) or statistical significance in the individual years studied. The influence of RAE throughout the studied period was not demonstrated from the viewpoint of ES, but cannot be rejected from the viewpoint of statistical significance.

Assessment of the influence of RAE on the positioning of players in the individual quarters of the ATP rankings throughout the studied period demonstrated a medium influence of RAE in the seasons 2016–2018 among tennis players who ranked at the end of seasons (2016–2018) in positions 1–25 and 51–75, and just a small influence in players in positions 26–50 and 76–100.

Assessment of the influence of RAE on the chance of players getting among the 100 best tennis players (ATP Rankings) showed that no statistically significant association between expected and observed frequencies in individual quarters was found among male professional tennis players, and the influence of RAE was not, therefore, proven.

While a number of studies focusing on tennis have demonstrated the influence of RAE in junior categories, the results of our research have shown that its influence is not expressed in adulthood (in our case among Top 100 players in the ATP Rankings). Trainers, educators, parents and other experts working in sport for the young can be recommended to devote greater attention during the selection of sporting talent to the differences between the biological and chronological age of their charges and thereby help reduce the waste of possible sporting talent.

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THE INFLUENCE OF THE MAIN FINANCIAL RESOURCES OF NON-PROFIT SPORT ORGANISATIONS ON THEIR STRATEGY

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Martina Honcová

University of Economics, Prague, The Czech Republic

ABSTRACT

Non-profit organisations play a critical role in many societies because they fulfill the needs in areas that are not covered by the public or private sector. The primary purpose of all non-profit organisations is not generating income and, in most cases, the income from their own activities is not enough to survive. Therefore, they are forced to look for additional ways of funding and are dependent on them. These types of financial resources can be divided into two main groups – internal and external resources. Income from own activities and membership fees can be an example of internal resources. Subsidies from the state or municipalities, sponsorship money, and donations are part of organisations' external resources. The main aim of this paper is to reveal the influence of different types of financial resources of non-profit sport organisations on their strategy. The article applies general findings for non-profit organisations from the paper of Stone, Bigelov, and Crittenden (1999) on *"Research on strategic management in non-profit organisations"* on the organisations from the sport area. Funding and financial resources may influence the components of a strategic process: formulation, content, and implementation. This paper focuses on the extent in which funding and financial resources affect the organisation's strategic management and describes the influence of different types of financial resources on non-profit sport organisations' strategy by reviewing a range of studies on the strategic process and funding of non-profit organizations that are applicable in sports. The article summarizes different findings and issues that have been described and published in the pre-reviewed academic journals with no restriction on the date of the issue.

Keywords: non-profit sport organisations; strategic management; funding

Introduction

According to Maier, Meyer & Steinbereithner (2016), non-profit organisations have experienced notable changes from the 1980s onwards, rendering them more similar to profit-making firms. But still, there are typical features related to non-profit sport clubs, e.g. voluntariness of membership, democracy, autonomy, volunteer work, the common interest of their members, identity of member roles, non-profit orientation, autonomous revenues, and the principle of solidarity (Horch, 1994). Maximizing profit is not the primary goal of these organisations, even though they can make profit, but in accordance with the non-distribution constraint, they are not allowed to distribute the profit among the members. Members of non-profit sport organisations need to perform many potentially conflicting roles. They are decision-makers, producers, consumers, and at the same time, financiers of the organisation's sport supply.

Nowadays, there are several challenges that non-profit sport clubs have to face and meet in order to survive, such as decreasing subsidies, increasing energy costs, and demographic change (Wicker & Breuer, 2011). These challenges may affect the structure and the behaviour of the sport clubs.

Non-profit sport clubs are an essential part of sport environment and accomplish tasks that would be otherwise performed by the state. They provide sport opportunities for the population, form the base of the voluntary sports systems, have an integrative function, spread democracy, and have a significant health function. These organisations contribute to social purposes and therefore, they are eligible to be supported by the state through public subsidies. These public subsidies are an important external financial source for non-profit organisations. Next to the public subsidies also sponsorship money is common external source of income for non-profit sector. There are also internal sources of funding, such as membership fees and commercial income from organisation's own activities. According to Wicker & Breuer (2011), members with their membership and admission fees are the main source for these organisations. Financial resources are essential for organisations to survive and are the second scarcest resource for non-profit sport organisations, following human resource shortage being the most significant problem.

Non-profit organisations can face their problems through developing a workable strategy that is indispensable for organisation's success. The strategy must fit the organisation's environment. It is usually the task for managers of an organisation who need to understand the situation in which sport organisation operate before undertaking the process of strategy formulation (Thibault, Slack & Hinings, 1993). No universal set of strategic choices exists that is optimal for all organisations (Slack & Hinigins, 1994). And no single 'blueprint' strategy can be productively adopted by all organisations, even if they operate in the same sector. (Berrett & Slack, 2001). Therefore a process of continuous planning, monitoring, analysis, and assessment is necessary for an organization to meet its goals and objectives – all that called strategic management – to be a successful organisation. According to the review of Stone et al. (1999), strategic management has three main components: strategy formulation, content, and implementation. In the process of strategy formulation, the organization's mission, philosophy, and goals are assessed or reassessed, and the organisation's goals and objectives consistent with its mission and philosophy are developed (Shortell, Morrison & Robbins,1985). Strategy implementation can be described as the realization of the selected strategy and what the firm does (Håkonsson, Burton, Obel, & Lauridsen, 2012).

The aim of this article is to reveal the influence of different types of financial resources of non-profit sport organisations on their strategy. The article applies general findings for non-profit organisations from the paper of Stone, Bigelov and Crittenden (1999) on *"Research on strategic management in non-profit organisations"* on the organisations from sport area. Funding and financial resources may influence the stages of a strategic process: formulation, content, and implementation. Financial resources can be determinants influencing these three stages, and they can affect the organisation's outcomes and performance.

Methods

This article is based on the findings of Stone et al. (1999) and their paper *Research on strategic management in non-profit organisations".* The results from the area of non-profit sector were applied to a specific sector - non-profit sport sector - and supported by the findings of another studies. The studies are mostly from pre-reviewed articles with no limitation on the date of issue.

Results

Stone et al. (1999), in their paper, described three components of strategic management and developed a framework to organize the discussion of the findings. The framework includes three broad dimensions: determinants, outcomes, and performance. Determinants of strategy consist of organisational and environmental factors. Outcomes include both internal changes and external relationships. The third dimension – performance – is a critical variable within the field of strategic management and was also added because nonprofits are facing increasing pressures to specify performance indicators.

Funding influences strategic management in the components of strategy formulation and strategy content, and acts as a determinant or affects the organisation' outcomes. The authors do not mention any influence of funding in the implementation stage and effects on performance.

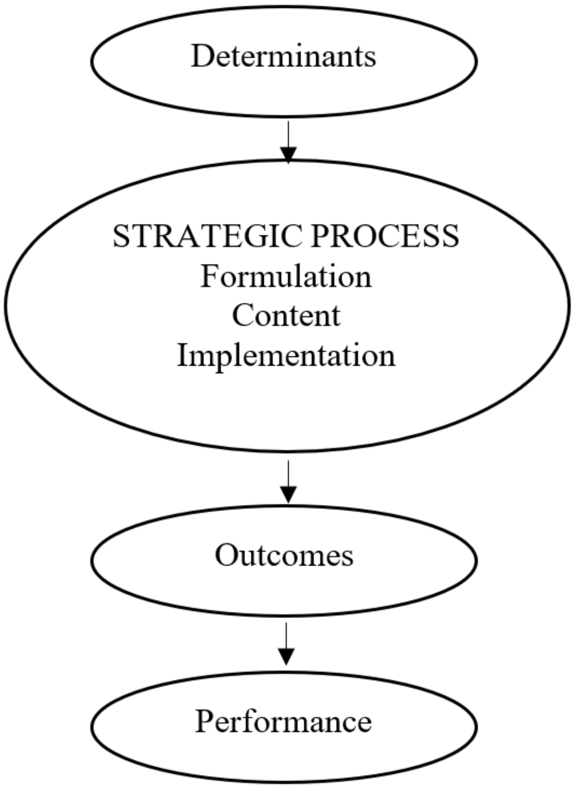

Figure 1 *Organizing framework (Stone et al., 1999)*

Strategy formulation

External funding is one of the determinants affecting strategy formulation and also can influence organisation's outcomes.

Many non-profit organisations do not use strategic planning at all (Crittenden, Crittenden & Hung, 1988). They are more likely to rely on a variety of planning methods, such as operational planning, the use of some elements of long-range planning, and informal planning. For those organisations that do adopt a strategic planning, there are certain determinants affecting the planning process. From the area of organisation's funding, the determinant is a funding source's requirements. Funding source requirements to submit a plan of action is the most critical external factor influencing the use of formal planning. This fact can result in the conclusion that non-profit organisations plan when they have to plan. The specific and direct demands from funders to plan are even more important stimuli than a general characteristic of environments (Stone et al., 1999). What also makes non-profit organisations plan is the funding source diversity. Non-profit organisations with more diversified funding streams are more likely to plan (Hwang & Bromley, 2015).

According to Vos et al. (2011), sport clubs with a high share of revenues from government subsidies are more likely to adopt subsidy conditions regarding the staff qualification, including volunteers. Clubs also incline to submit their strategic plans when applying for subsidies, because the subsidies are linked to conditions of their use (Coates et al., 2014). The process of creating a public subsidy application may overreach the capabilities, qualifications, and time possibilities of volunteers. Nevertheless, the overall institutional pressure on sport clubs and expectations associated with public funding was found to be relatively low (Vos et al., 2011). In addition to this, the advantage of public subsidies is their stability, when there is no change in government and funding decisions. Also, this kind of funding is less volatile than other external revenue sources like donations (Gronbjerg, 1991). In addition to this, subsidies increase total revenues and help clubs to provide and maintain services and perhaps survive (Wicker, Longley & Breuer, 2013).

Funders influence also outcomes of the non-profit organisations. Managers of these organisations perceive an obligation of planning (or at least present a written document) to be taken seriously by most funders (Crittenden et al., 1988). These funder requirements can interfere with organisation's autonomy and result in diversion from their original mission and goals in a way that the plans reflect current or perceived funder priorities (Stone, 1989).

The dependence on external resource provider can exert their power over the non-profit organisations (Coates et al., 2014). According to Berrett and Slack (2001), part of each sport's agenda should be to reduce the dependence on government funding and to broaden the resource base – it means to diversify the resources and find the new creative.

On the other hand, external funding is for a lot of non-profit sport organisations significant money source. Moreover, the organisations receiving public subsidies can be highly accepted in their community, because they are able to attract external money from recognized institutions. Next to the community acceptance, another benefit lies in the reality that "money attracts money" in the meaning that also other bodies can perceive such organisations as fundable. Contrary, public funding may crowd out private contributions to non-profit organisations (Coates et al., 2014)

Strategy content

The structure of funding sources provides a critical context within which non-profit organisations' decision-making takes place (Gronbjerg, 1991). It means, for example, marketing-oriented strategies differ based on the type of funder – strategies used for generating individual donor revenues differentiate substantially from strategies used to manage the complexities of government funding. The uncertainty of funding flows also influences the strategy of non-profit organisations. Organisations having significant income from their own activities tend to be less successful in reducing uncertainty than those being funded from external sources (both private and public).

Relying strongly on external revenues increases the probability of financial problems because the changes in external revenues are less foreseeable than internal revenues and out of the clubs' control. They are all-or-nothing. It means the club can be successful in receiving a public subsidy or sponsorship money or nothing at all (Coates et al., 2001). Non-profit sport organisations that try to attract sponsors must become more responsive to the needs of the corporations and need to gain a greater understanding of the reasons why corporations become involved in sponsorship (Berrett & Slack, 2001). What attracts sponsors the most, is the media exposure of the organisation's teams (or events) or the number of participants within the sport, who come into contact with events or programs run under the auspices of the organisation. Sponsors perceive direct access to participants as very important. (Berrett & Slack, 2001).

In addition to this, it has been proved that sponsorship money leads to both greater financial problems and greater volunteer problems. Sponsorship money is more sensitive to changes in the economy than are subsidies (Coates at al., 2014). The sport organisations with the predominant percentage of private funding emphasise achieving top sport results more than the development of the local environment and other local community aims. They also prefer cost reduction to the growth aims, focus on fast results, and are ready to take a higher degree of risk (Ivašković & Čater, 2018).

General turbulence in resource environments and the structure of the funding environments lead to both competitive and cooperative strategies, which can be both used by organisations. These two strategies are not mutually exclusive. Competitive strategies are used in the situations of the organisation's aim to gain new revenue streams through the use of commercial income or fees. These strategies are more likely to raise concerns regarding mission or goal displacement and are associated with serving fewer poor clients and drop-in employee morale. In cooperative strategies, central organisations are linked to others to seek common funding flows or client referrals, and are more linked to increasing power or centrality in resource or client flow networks, coalition formation, and financial stability. This type of strategy includes mergers that are associated with problems between organisations with different cultures (Stone et al., 1999). Also, the structure of specific funding environments leads to both cooperative and competitive strategies (Gronbjerg, 1991).

Conclusion

According to Stone et al. (1999), there are three components in the strategic management process: strategy formulation, strategy content, and strategy implementation. The authors use determinants, outcomes, and performance to create a framework for discussion. The authors describe all three components, and by using the framework, explain the findings.

The aim of this article is to reveal the influence of different types of financial resources of non-profit sport organisations on their strategy by using the framework of Stone et al. (1999). It was found that issues related to funding affect non-profit organisation' strategy formulation and strategy content. There are a lot of organisations that do not use strategic planning at all. Those, who adopt strategic planning, usually plan when they have to plan. They are often required by funders to submit a plan as a part of the subsidy application process. Although completing the application can overreach the capacity of volunteers, public subsidies are an important source of funding that is relatively stable. Non-profit sport organisations trying to attract sponsorship money must understand the drivers of sponsors to be active in sponsorship and must be responsive to their needs. The threat of external funding is the possibility of losing autonomy because external bodies can exert their power into non-profit sport organisations. The uncertainty of funding flows, and the type of funder also affects organisation's strategy. General turbulence in resource environments and the structure of the funding environments lead to both competitive and cooperative strategies, which can be both used in the organisations.

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BOOM OF ROAD RACES IN THE CZECH REPUBLIC – SPORT FOR ALL OR LUXURY AMUSEMENT?

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Irena Slepičková, Pavel Slepička

Charles University, Faculty of Physical Education and Sport, Czech Republic

ABSTRACT

Nowadays, similar to worldwide trends, running has become very popular in the Czech Republic. Since the mid of 1990s, the business sector has become very active in this area. Private companies organise many road races for the public, including participation of top level runners (i.e. Prague International Marathon). In 2016, within the framework of the international project IRNIST, we realised an empirical descriptive study of the Mattoni ½ Marathon in Ústí nad Labem, a middle size town. The IRNIST questionnaire was used. Analysing data on 491 runners (of 2,238 runners finished the race) we found that concerning socio-economic status of respondents, 56.9% of runners have a university education, one third advanced secondary education; and 63% earn more than the average wage. Participant were able to spend quite a lot of money for participation costs. These results raise the issue if the privatization and commercialization of running for the masses does not cause limit for sport participation for all.

Keywords: IRNIST; half-marathon; sport participation; socio-economic status

Introduction

The biggest global trend in mass sport events with competitions for public concerns running. Running is no longer a competitive athletic discipline tied to traditional sports facilities and clubs. In the 1960's and 1970's various sports and physical activities started to be promoted and presented to the public as a means to prevent civilisation diseases. Running gained popularity as a physical activity that did not require special equipment or skills or space. Thanks to K. H. Cooper's research, running or jogging has been used as an aerobic activity suitable to improve the health and fitness of "modern" people. This has been helped by an "informalisation" process where people became less and less embarrassed to engage in sports in public outside of sports clubs. This (r)evolution has been greatly beneficial for running and launched the first wave of longer running events and, most importantly, marathons (Scheerder et al., 2015).

The global running boom reached former Czechoslovakia, too. But this trend is also based on the rich Czech tradition of running and running competitions which started more than one century ago. We may take the example of the Běchovice run (Bečvář, 2011), which was first held in 1897 (a 10-km route starting in a small town outside of Prague and terminating in the capital city). Much later, amateur running was popularised as part of physical training programmes for the general public as well as a growing number of open running events attended by members of sport clubs and amateur runners alike. The Czech Republic has become one of the world's running superpowers in terms of mass events. In Prague, the first marathon was held in 1963 and there was an even earlier marathon event in the city of Ostrava in the region of North Moravia. Brochures for amateur runners, published by Sportpropag, the enterprise of the former unified sport organization (Czechoslovak Sport Union) provided advice how to perform various sport activities including running with the aim to improve physical fitness and health of sporting people.

According to the study of Scheerder et al. (2015), the second wave of the running boom came to Czechia at the turn of the millennium and continues until today. Running's "emancipation" from the space of amateur sport clubs and the private sector's involvement in the production of goods and services for runners thus represent a positive example of sport privatisation and professionalization. This trend has helped to spread participation in physical activity throughout the population, not only in running activities.

With the current boom in running, however, comes the organisation of numerous races by various organisations, many of which have found success in this business aimed at sport and running events for the public. Finding precise figures on the number of events organised each year is very difficult. But existing sources prove the widespread popularity of running events. For example, according to the www.behej.com website (běhej.com, 2018), there were 900 races of various types (road, cross, running with dogs, relay, etc.) and lengths (from 3 to 111 km) held within 100 km of the capital city of Prague in 2018 alone, including 75 half-marathons and marathons. Other information on running popularity is showed by the findings of the Czech Athletic Federation. In 2015, there were over 1,300 races with 133,000 participants in the Czech Republic (Český atletický svaz, 2015). Marathons and half marathons enjoy a particular popularity and take place either as special events or as part of running series.

It is in society's interest to involve as many people as possible in sport, or in sport for all, due to its positive health-related benefits in terms of its necessity for a good life[1] (European Commission, 2008; Česká republika, 2016, etc.).

The above characteristic of new trends in the population's participation in sport, however, raises a couple of issues. The interconnection of professionalization and commercialization of sport results in the fact, that recreational athlete must pay for their participation unless they practise sport and exercise completely outside any organization. This applies both to sporting activities running under the auspices of associations (membership and club fees), which do not have to be so high depending on the type of sport and locality, but, in particular, to sporting activities offered and organized by the for-profit sector. The organizations engaged there try to provide professional sporting services and, quite understandingly, charge adequate financial amounts to their "clients", recreational athletes, for this activity not only to cover the costs of the respective activities, but primarily for profit, which this activity brings them.

The financial costs related to a sporting activity (organization of a lesson, competition, etc.) rely on the ability and willingness to pay the required amount (in the form of an entrance or participation fee plus a series of accompanying expenses like travel, sporting equipment, etc.) on the "clients'" part. Here, we are getting to the problem that is the focus of interest of many specialists, mainly in the field of sport sociology, but also general sociology. In each society, there are social inequalities resulting in different access to some social assets, less favourable for some social groups, or some groups may even be excluded from using these assets. Research into social inequality has gone through some development in the last decades. As stated by Šanderová and her research team, the issues at the forefront of concern in the second half of the 20th century were classes or strata, ethnic origin and gender. Classes and strata were studied particularly with respect to socio-economic inequalities, while research into ethnic inequalities and inequalities between men and women,

1 Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Retrieved from: https://www.who.int/about/who-we-are/constitution.

so-called socio-cultural inequalities, concentrated on their symbolic or cultural rooting. The above study assesses later research projects that described the decline of social classes, but other authors started to perceive the social structure as a culturally rooted construct and keep working with the concept of class (Šanderová, Šmídová a kol., 2009). The original socio-economic approach accentuating the economic aspect of differences among people is gradually complemented by the issue of recognition and morally cultural assessment (ibid). The French sociologist Bourdieu brought the above approaches closer to each other by defining inequalities as a social position of people where they can be placed in mutual relationships and where inequalities are understood as relationships between social positions in the sense of "above" and "below". This concept was also applied in the research studies on Czechoslovak and later Czech society by Machonin (Machonin & Tuček, 1996, Machonin, 2004). Like Bourdieu, he also stressed the importance of leisure time, including sport, in terms of individuals' position in the society social structure and their place in the life style of the population.

The topic of the relation between social stratification and participation in sport with respect to the openness of access to sport for any member of society (regardless of their socio-economic and socio-cultural characteristics) has been investigated by numerous studies. Political documents, on the one hand, call for the necessity of making sport accessible for all and promotion of social justice (White paper on Sport, European Commission, 2008 etc.), while, on the other hand, research studies manifest that many people are excluded from participation in sport, from its consumption (e.g. Pociello, 1981; Davisse & Louveau, 1991; Slepička a kol., 2001; Collins & Kay, 2003; Muller, 2003) and that social inequality exists here. From the studies investigating different aspects of sport at a local level in the Czech Republic, it is evident that socially underprivileged groups include people in manual jobs, unemployed, people with elementary education, pensioners, housewives, female secondary school graduates from non-gymnasium schools and adolescents commuting to school for longer distances (Slepičková a kol., 2010). These results correspond with foreign findings where, in addition, the situation of ethnic minorities is pointed out, which still does not represent a significant problem for the Czech environment and has not been studied yet.

If we accept the theoretical definitions of inequalities that try to interconnect the approaches, the exclusion from sport or limited possibilities for its consumption mostly result from socio-economic factors (income/wealth, power and professional success), while, at the same time, socio-cultural factors (education, intelligence, cultural taste), play their role as well, which was also indicated by the above research studies addressing this topic, although they did not always cover all the factors. Therefore, in sociological research studies focusing on sporting activity of the population, we encounter basic variables characterizing individuals (income, job, education, gender, sporting equipment) and variables characterizing their close social environment with respect to sport (partners, children, friends, etc.) or demographic variables (place and type of housing, etc.).

As already mentioned, new trends in sport and its commercialization in the positive sense of the word contribute to extending the possibilities for sporting activity among the general public. This is the reason why we are interested in which part of the population takes advantage of these possibilities, in particular in relation to the running boom. In keeping with theoretical approaches aiming at complexity in the social stratification concept and with the latest findings on participation in sport among the adult population[2], we would like to know whether running events for the general public organized in the Czech Republic also attract people with a rather higher socio-economic and cultural status.

2 Different research studies tend to specify the age limit of adulthood in relation to participation in sport differently. Some consider the minimum age limit of 15 years, others of 16 or 18. We do not solve this issue here.

Methods

To answer the above question we have conducted a follow-up to the Road Races international research whose participants cooperate within the IRNIST (International Research Network in Sport Tourism) informal group consisting of researchers from 10 European countries, 3 North African countries and Canada; the Czech Republic is represented by the Faculty of Sport and Physical Education of Charles University. The research was primarily focused on economic and environmental aspects of such running events, particularly half-marathons, in medium-sized towns. The study was based on a questionnaire established by all members of the IRNIST project. This questionnaire contained several series of questions (travel to the race, costs of participation, motivations to join the race, quality of the event's environment and the efforts of the organizers to prevent any environmental impact, thoughts on the touristic appeal of the town).

A questionnaire was compiled in English and in national versions to survey different areas characterizing the participants and their opinions on holding the events. This type of questionnaire is frequently used in the field of sport tourism to estimate the impact of a sport event, a festival, etc. (Daniels & Norman, 2003; Getz, 1991; Veltri, Miller & Harris, 2009). On the Czech part, the questionnaire was extended by monitoring life satisfaction and contained a total of 69 questions. The data were collected electronically with a very friendly support from the organizer of a half-marathon from the Tempo Team Prague, Ltd. organization. They use email addresses of all participants and via these emails, all participants were kindly askes to fulfil the on-line questionnaire.

In here presented study, we have focused on the issues of the socio-economic status of those participating in the run for the reason if these commercially organized events do not exclude a certain part of the population from participation. This is also outlined in the presentation of corresponding results from the research. The questions of a mostly scale type were primarily processed by means of basic statistical methods.

Results

Participants of the Mattoni ½ Marathon Ústí nad Labem Run, part of the RunCzech series, co-organized by Prague International Marathon, Ltd., were examined. The RunCzech brand and its running events have become very popular and known even at the international level. The 6th annual Mattoni ½ Marathon Ústí nad Labem took place on September 17, 2016. Organisers and partner organisations make use of various media and social networks. Online registration and result tables are a matter of course as is information about various aspects of the race. According to organizers, the capacity of the race was 3,600 in 2016 and it was reached several weeks before the event (Prague International Marathon, 2016), which testifies not only to interest in such running events, but also to participants' confidence in the RunCzech brand. The half marathon can also be run as a relay of two- or four-member teams where each member runs a given portion of the marathon. The event was also attended by elite runners including many African athletes. Based on registration data, there were participants of 36 nationalities; 66% men and 34% women; mostly university graduates (58%) and secondary school graduates 34%. There were 645 volunteers working at the event. A specific feature of the half marathon is a 3-km part of the race that runs through the area of the Spolchemie factory.

The result table listed the performances of 2,238 participants but a total of 3,577 runners taking part in the race. The questionnaires were filled in the few days immediately after the race. Fully filled questionnaires were returned by 491 participants (2/3 men, 1/3 women), or 22% of those listed in the results table. One third was local residents. Respondents considered themselves to be "locals" if they lived in the city or within 60 km of the city. This is probably due to the fact that many people commute to the city for work and thus considered themselves "locals". More than 60% of runners travelled over 60 km to attend the Ústí race and half of this group travelled more than 100 km. This is also a testimony to the good promotion of the event. Most participants travelled by car (67%) while others travelled by train (22%) and bus (4%). City residents, naturally, came on foot (6%).

The socio-demographic profile of the respondents corresponded to that provided by the organiser based on information stated in runner registrations – the majority of participants attained higher and highest educational levels (table 1). This aligns with the participant structure based on registrations (see above). Given the average age of respondents, we may assume that most of them have completed their education and were active in the labour market. Most respondents, both men and women, were in the 30–39 and 40–49 age categories. There were relatively few respondents (and half marathon participants in general) younger than 25 years of age (7.3%). The oldest male participant was 72 years old and the oldest female participant was 71 years old.

Table 1 *Educational level of participants (%)*

	Men	**Women**
Elementary, vocational school without academic diploma	7.1	5
Secondary with academic diploma	36.3	31.5
University – Bc.	10.5	20.5
University – Mgr., PhD.	45.1	39.1

The data on education aligns with data on employment and revenues. Concerning the type of employment/job, three quarters of participants were salaried employees, 10% businessmen, 5% self-employed and 1.7% unemployed. The majority were married people (65 %) and only 10 % divorced. The rest of 23 % were widowed single.

The income of the respondents was in the higher tiers for the Czech Republic (they were split into deciles according to their income). Less than a fifth of the respondents fell to the first 5 deciles with the lowest income, otherwise all participants had incomes above the national average and the earnings of a half of the respondents even fell to the top two deciles. For a half of the respondents, the race fee of CZK 850 (EUR 33) was the biggest expense in relation to the race. Many respondents participate in the entire running series of which the Ústí event is part, which means they pay race fees at other events, too. The data shows that most respondents (and participants in general) were adults (only 2% were students) with a relatively stable social situation and higher socio-economic status.

The financial cost of participation is an important factor for runners, too. The respondents stated that travel was the most costly expenditure (table 2), followed by registration fees and food. Given the location of the city of Ústí and the overall size of the Czech Republic, most participants were able to attend the race without having to stay overnight. However, with the exception of registration (CZK 850), the average expenditure per respondent was relatively low (travel 385 CZK, food and beverages 295 CZK, accommodation 182 CZK).

Table 2 *Importance of respondents‘ expenditures related to the ½ marathon (mean)*

Travel	2.02
Registration	2.59
Food and beverages	2.70
Equipment	3.97
Overnight	4.26
Others	5.50

Scale from 1 to 6; 1- the most important, 6- the less important

Low expenditures were naturally stated by “local” participants, mainly for travel and accommodation. Some of those who did not live in the vicinity of the city paid 500-999 CZK for travel (20% of respondents) or 1000 CZK and more (9%). The accommodation capacity of the city was not used by 4/5 of the respondents (of the total number of participants app. 360 runners could be accommodated, which might have had some economic impact. However, the question is whether these runners did not replace tourists who would have come if the event had not taken place – but the issue of the economic impact of sport events is not solved here). Roughly 20% of the participants paid more than 500 CZK for food. As for total expenses, about a half of the respondents spent between 1000 and 4999 CZK and 8% stated expenses exceeding 5000 CZK (10 respondents over 10,000 CZK). It is evident that the respondents significantly varied by their expenses and higher expenses were incurred by non-local participants.

It must be mentioned that the run is sponsored by numerous companies and organizations (“titular” partners - Volkswagen, Adidas, Sportissimo, Birell, 02, Mattoni) and that it receives not only social and political, but also financial support from the municipality (memorandum of long-term partnership) and the region. This undoubtedly contributes to the profitability of the event and potentially also to the relatively not too high participation fee, even though many comparable, less popularized runs are cheaper.

Conclusion

Running events have become hugely popular in the Czech Republic in recent years. The Internet and social networks help spread the necessary information to potential participants. This has allowed many private companies to venture into the organisation of such events. These businesses contribute to the flourish of sport for all while generating profit.

The results of a part of the Road Races international research presented here and conducted using the case of the Mattoni ½ Marathon Ústí nad Labem Run indicated that the problem of sport accessibility to the general public still exists. The profiles of the participants, testifying to their socio-economic status and a more detailed analysis of the related expenses paid by the runners, including other complementary questions, showed that the participants are recruited from higher educational tiers of the Czech population, with significantly higher incomes than the Czech Republic average earnings and, thus, a willingness and potential to spend more money on their hobby. We have not presented the results testifying to the regularity or the reasons for participating in such events here. Looking at the overall results (which are presently being finally processed), however, it is evident that the Ústí nad Labem race attracts mainly participants with a higher socio-economic status in the productive age of 30-50 years and relatively stable family state. The run may be described as a “family” or “social” event because a large number of participants come with family members or friends, which might, after all, be the reason why the organiser offer a family run as well.

The education level and the reasons for taking part in the race indicate that most respondents consciously reflect on their own life. People with lower educational levels may face many obstacles of both subjective (lower cultural capital) and objective (higher cost) character. The event attracts local residents and people from the vicinity of the city but it also has a national and even international dimension. The race is very popular with non-residents also due to its inclusion in the RunCzech series and, undoubtedly, thanks to easy access from many parts of the country and from abroad.

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THE RELATIVE AGE EFFECT IN TOP 100 FEMALE TENNIS PLAYERS (2014–2018)

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Adrián Agricola[1], Michal Bozděch[2], Martin Zvonař[2], Jiří Zháněl[2]

[1]*University of Hradec Králové, Faculty of Education, Hradec Králové, Czech Republic*
[2]*Masaryk University, Faculty of Sport Studies, Brno, Czech Republic*

ABSTRACT

The theory of Relative Age Effect (RAE) works on the assumption that athletes born at the beginning of a calendar year are more successful than athletes born in the end of the year. The athletes born early have a significant probability of a higher level of physiological, morphological and psychological abilities than later born athletes. Several studies show that the RAE was not found in females or it was significantly lower than in males. The research objective was to find out the influence of RAE in WTA Tour TOP100 female professional tennis players (n=500) in 2014–2018. Cohen's effect size (ES) *w* was calculated to assess the level of the influence of RAE. To assess the differences between the observed and the expected relative age quarter distribution, Chi-Square test (χ^2) was used. In terms of effect size (ES), a medium influence of RAE has been proven in 2016 and 2017 (w = 0.33, resp. w = 0.30); a small influence has been proven in years 2014, 2015, 2018 and in the whole observed period 2014–2018. Based on statistical analysis, the influence of RAE cannot be rejected in years 2016 ($p < 0.05$) and 2017 ($p < 0.05$) and also in the whole period of 2014–2018 ($p < 0.01$). The influence of RAE can be rejected in 2014, 2015 and 2018 ($p > 0.05$). The next step was to assess the influence of RAE on the final WTA ranking in 2014–2018. Players have been divided into four intervals: 1–25, 26–50, 51–75 and 76–100 positions. ES has showed the medium influence of RAE in 76–100 positions (w = 0.34); only small influence of RAE was found in other positions. Statistical analysis showed that the influence of RAE cannot be rejected in 1–25, 26–50 and 76–100 positions ($p < 0.05$): it can be rejected in 54–75 positions. The results of the research have shown the medium influence of RAE in 2016 and 2017: in the recent years (and in the whole observed period of 2014–2018), the influence of RAE was small. The influence of RAE on the final WTA ranking is also small, except the 76–100 positions.

Keywords: Women´s Tennis Association; date of birth; chronological age; talent; rankings

Introduction

Researches emerged in the mid-1980s pointing to an unusually high representation of individuals born at the beginning of calendar years in various sports selections. This phenomenon, later referred to as Relative Age Effect (RAE), still permeates through various age categories, various performance levels both in collective and individual sports (Agricola, Zháněl & Hubáček, 2013; Helsen, Van Winckel & Williams, 2004).

The issue of RAE (Musch & Grondin, 2001), also referred to as Birth Date Effect (Karcher, Ahmaidi & Buchheit, 2014) or Birth Quarter (Larouche et al., 2010), points to a deviation in the frequency distribution of birth dates of selected groups of athletes from normal frequency distribution in the general population (Agricola et al., 2013). This deviation is probably caused by the fact that, especially in pupil and youth categories, the individuals born earlier are more successful than individuals born in the later months of the year (Parent-Harvey, Desjardins & Harvey, 2014). Higher success is mainly caused by developmental lead which can be almost 12 months within one category. This developmental lead is a considerable advantage mainly in the area of physiological, psychological and morphological preconditions (Gibbs, Jarvis & Duffur, 2012). There are even two-year categories in some sports, i.e. the difference between team mates can be as much as 24 months (Lames et al., 2009). As a result, individuals born in the later months of the year often have much less chance to compete successfully with the biological older athletes (Andrade-Souza, Moniz & Teoldo, 2015). A number of studies have reported that this developmental advantage is lost over time (Bjerke, Pedersen, Aune & Lorås, 2017; Ford P & Williams, 2011) and the 'talented' individuals from the past become only average athletes (Lames et al., 2009). Biologically younger – and perhaps truly talented individuals – have often terminated their sports career by then (so called burnout effect), because they have not got time or space to develop their talents (Abbot & Collins, 2004; Arrieta, Torres-Unda, Gil & Irazusta, 2015).

As mentioned in the introduction, RAE influence has been proven in various sports. A number of researches has also aimed at the differences of RAE influence between the sexes, resp. directly at RAE in girls (Delorme, Boiché & Raspaud, 2010; Hancock, 2017; Molenaar, et al., 2015; Sofia, Barreiros & Fonseca, 2016; Stenling & Holmström, 2014; Weir et al., 2010). Based on the presented results, it is possible to say that the RAE influence is not as dominant in girls in junior categories as it is in boys: the main reason the authors state is that during the period when the selection pressure is at its strongest in most sports, the puberty period of girls is often over and the differences caused by different stages of ontogenetic development are not so distinct. Another reason is possibly the fact that girls are not so much interested in physically demanding sports (where the RAE influence appears most) as boys are. Therefore, the competition is smaller and the selection pressure is not so strong (Cobley, Baker, Wattie & McKenna, 2009).

The issue of RAE in tennis appears in scientific studies approximately since the late 1990s and focuses mainly on youth and junior categories. Recent studies include Pacharoni, Aoki, Costa, Moreira, & Massa (2014), Romann & Fuchslocher (2014), or Ulbricht, Fernandez-Fernandez, Mendez-Villanueva, & Ferrauti (2016). With regard to the issue we are dealing with, some important studies include also the results of RAE influence in girls/women. Giacomini (1999) found in young male and female US tennis players that the RAE influence is significantly weaker in categories over 16 years than in U16, resp. U14 categories. Results of research have also shown a significantly weaker influence of RAE in girls. Study by Filipcic (2001), which focuses on the best Slovenian male and female tennis players in U12 – U18 categories, has confirmed RAE influence in tennis players in the U12, U14 and U16 categories, but not in the U18 category. There has been a significant RAE influence found in female tennis players in the U12 and U14 categories, but not in the U16 and U18 categories. Pacharoni et al. (2014) report that there is almost no evidence of RAE influence in adult male and female professional tennis players in Brazilian and South American tennis leagues. The RAE influence in female professional tennis players at Grand Slam tennis tournaments in 2002–2003 (Edgar & O'Donoghue, 2005), resp. in 2008–2009 (O'Donoghue, 2009) was proven in both studies in terms of material significance, but not in terms of effect size (ES).

Based on the results of these studies, it could be assumed that RAE influence will not be significant in senior female categories. The aim of this research was to find if the influence of RAE is demonstrable in female professional players, who took 1–100 positions (TOP 100) in the WTA Rankings in 2014–2018.

Methods

The best 100 female tennis players (TOP 100) in 2014–2018 (n=500) were chosen for the analysis of RAE influence. Research data were obtained from public Internet sources at the official WTA website https://www.wtatennis.com/rankings. The division of players into individual quarters was performed according to their date of birth as follows: Q_1 (January to March), Q_2 (April to June), Q_3 (July to September), Q_4 (October to December). With respect to the research problem to be solved, we formulated two research questions:

1. Is it possible to prove the influence of RAE in female tennis players in individual years, resp. during the whole observed period?
2. Is it possible to prove the influence of RAE on the positions of female tennis players in individual quarters of the WTA rankings during the whole observed period?

To assess the match of the theoretical (expected) distribution of frequencies and the empirical (observed) distribution of frequencies, Chi-Square (χ^2) test in the Goodness of Fit variant was used. The expected frequency distribution was based on assumptions of equal distribution for each of the four quarters (Q_i = 25%). With regard to the deliberate selection of the elements of the research set, we assessed the material significance (effect size, ES) of the results using the Cohen´s *w* coefficient (Cohen, 1988); it can be interpreted as small (*w* = 0.10), medium (*w* = 0.30) or large (*w* = 0.50). The research data were processed using STATISTICA 10 software and Microsoft Office Excel.

Results

RAE influence in individual years and in the whole monitored period

Figure 1 shows an overview of the distribution of relative frequencies of birth dates in individual quarters (Q_1–Q_4) in individual years.

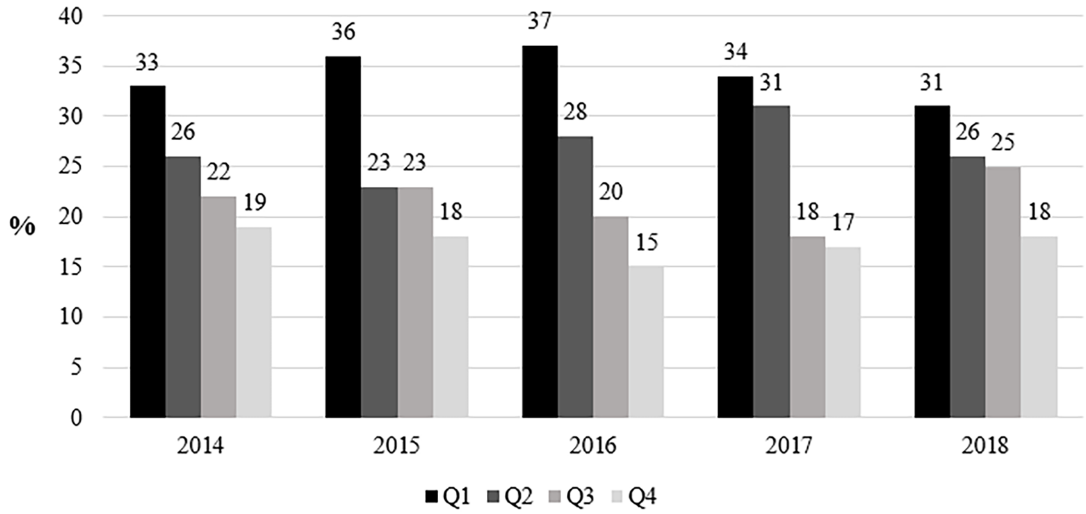

Figure 1 *Distribution of relative frequencies in individual quarters (Q_i) in 2014–2018*

The number of female players born in the first quarter (Q_1) prevails in each of the monitored years; on the other hand, the least female players were born in the last quarter of the year (Q_4). Except for 2015, where the frequencies are same in Q_2 and Q_3, it is possible to see a typical manifestation of RAE influence in each of the monitored years – frequencies in individual quarters have a clearly decreasing tendency from Q_1 to Q_4.

Table 1 shows the relative frequencies (%) in individual quarters Q_i for each year and throughout the whole observed period (2014–2018).

Table 1 *Influence of date of birth in TOP 100 female tennis players in 2014–2018*

Year	Q_1 [%]	Q_2 [%]	Q_3 [%]	Q_4 [%]	χ^2	p	w	ES
2014	33.0	26.0	22.0	19.0	4.40	0.22	0.21	Small
2015	36.0	23.0	23.0	18.0	7.12	0.69	0.27	Small
2016	37.0	28.0	20.0	15.0	11.12	0.01	0.33	Medium
2017	34.0	31.0	18.0	17.0	9.20	0.03	0.30	Medium
2018	31.0	26.0	25.0	18.0	3.44	0.33	0.19	Small
2014–2018	34.2	26.8	21.6	17.4	31.44	0.00	0.25	Small

Note: Q_i = quarter of the year, χ^2 = Chi-square test, p = p value, w = Cohen's w test, ES = verbal interpretation of effect size.

In terms of material significance (ES) (Tab.1), a medium influence of RAE was demonstrated in 2016 and 2017 (*w*=0.33, resp. *w*=0.30), but only a small influence of RAE in 2014, 2015, 2018 and in the whole period of 2014–2018. Due to the deliberate selection of elements of the research group, we prefer the assessment with the use of effect size; however, the assessment of RAE through statistical significance has shown similar results. The impact of RAE influence cannot be rejected in the years 2016, 2017 ($p<0.05$) and during the whole period of 2014–2018 ($p<0.01$), which is probably influenced by the large size of the sample (n=500); the RAE influence is rejected in 2014, 2015 and 2018 ($p>0.05$).

RAE influence on WTA Rankings during the whole monitored period

The assessment of RAE influence within the WTA ranking is shown graphically in Figure 2. The positions of 100 best female players in the WTA Rankings were divided into four intervals: 1–25, 26–50, 51–75, 76–100 position.

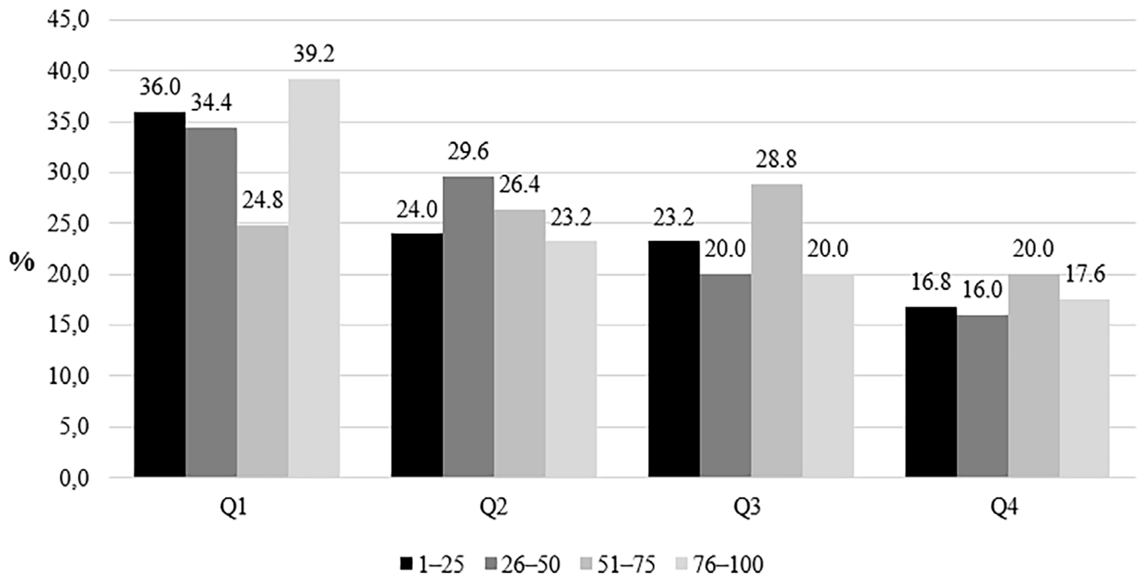

Figure 2 *Distribution of frequencies (%) in individual quarters (Q_i) according to positions in the WTA Rankings (TOP100) for the whole monitored period (2014–2018)*

It is clear from the graphical representation in Figure 2 that of the players placed in positions 1–25 in the WTA rankings in 2014–2018, the highest number is in the Q_1 quarter (36%), then in Q_2 (24%), Q_3 (23.2%), and least in Q_4 (16.8%). A similarly decreasing tendency of relative frequencies can also be seen in players in 26–50 positions and in players in 76–100 positions. A different tendency of frequencies in Q_1–Q_4 was found in female players in 51–76 positions (24.8%, 26.4%, 28.8%, 20.0%).

Table 2 shows the results of statistical analysis of the influence of date of birth on the WTA ranking in 2014–2018.

Table 2 *Influence of date of birth on WTA ranking in 2014–2018*

Ranking	Q_1 [%]	Q_2 [%]	Q_3 [%]	Q_4 [%]	χ^2	p	w	ES
1–25	36.0	24.0	23.2	16.8	9.62	0.02	0.28	Small
26–50	34.4	29.6	20.0	16.0	10.78	0.01	0.29	Small
51–75	24.8	26.4	28.8	20.0	2.07	0.56	0.13	Small
76–100	39.2	23.2	20.0	17.6	14.23	0.00	0.34	Medium

Note: Q_i = quarter of the year, χ^2 = Chi-square test, p = p value, w = Cohen's w test, ES = verbal interpretation of effect size.

In terms of material significance (ES) (Tab.2), a medium influence of RAE was shown only in female players in 76–100 positions (w = 0.34); a small influence of RAE was found in female players in 26–50 positions (w = 0.29), 1–25 positions (w = 0.28) and 51–75 positions (w = 0.13). Assessment of RAE influence by statistical significance gives a somewhat different evaluation; it has been proven that some influence of RAE cannot be rejected for players placed in 1–25, 26–50, 76–100 positions ($p < 0.05$), while RAE influence is rejected for players in 51–75 positions. Due to the deliberate selection of elements of the research group, we prefer the assessment with the use of effect size (methodologically more appropriate); it can therefore be stated that the influence of RAE on the position of female players in the ranking is small and, with the exception of the players in 76–100 places (medium RAE influence), materially insignificant.

Discussion

Most studies devoted to RAE issue focus on team sports, especially ice hockey and football (soccer). However, there are also numerous studies devoted to individual sports such as gymnastics (Hancock, Starkes & Ste-Marie, 2015), swimming (Costa, Marques, Louro & Marinho, 2013) or skiing and figure skating (Baker, Janning, Wong, Cobley & Schorer, 2014). Research works aimed at tennis (for instance Agricola et al., 2013; Edgar, & O'Donoghue 2005; Filipcic, 2001; Giacomini, 1999; O'Donoghue, 2009; Pacharoni et al., 2014, Romann & Fuchslocher, 2014) are mainly devoted to junior tennis; the influence of RAE in senior tennis is paid much less attention. The results of our research showed that a medium RAE influence in terms of effect size was found in female professional tennis players (n=500) only in 2016 (37% in Q_1) and 2017 (34% in Q_1); it was small in other years and in the whole observed period. A study by Edgar and O'Donoghue (2005) dealing with the RAE influence in female players in Grand Slam tournaments (n=211) in 2002–2003 showed that most players were born in Q_1 (33.1%) and, according to the authors, the significance of RAE influence cannot be rejected (χ^2 = 12.9, $p < 0.01$). However, when calculating the Cohen ´s w value (w = 0.25), we have to state only a small material significance (ES) of RAE influence (Tab.1). A similar study by O'Donoghue (2009) on female players in Grand Slam tournaments (n=193) in 2008–2009 found that most players were born in Q_1 (29.0%) and in Q_2 (29.5%) and, according to the author, the significance of RAE influence cannot be rejected (χ^2 = 12.9, $p < 0.05$). However, when calculating the Cohen ´s w value (w = 0.22), we have to state again only a small material significance (ES) of

RAE influence. It can be concluded from these findings that, in accordance with the results of some of the above mentioned studies suggesting decreasing, resp. no RAE influence in senior female age categories, as well as in accordance with the results of our research, only medium, resp. small RAE influence was proven in female professional tennis players.

In assessing RAE influence on positions in individual quarters of WTA rankings in 2014–2018 (Tab.2), it was found that of the female players placed in WTA rankings in 1–25 positions, the highest number is in the Q_1 quarter (36%); similar situation can also be seen for players in 26–50 positions (in Q_1 = 34.4%) and for players in 76–100 positions (in Q_1 = 39.2%), but not for players in 51–76 positions (in Q_1 only 24.8%). The influence of RAE on the position of the players in the ranking is small, with the exception of the players in 76–100 positions (medium RAE influence) materially insignificant.

Conclusion

The aim of this research was to determine the incidence of RAE influence in female professional tennis players (WTA Rankings, TOP 100) in 2014–2018. In assessing RAE influence in terms of material significance (ES), a medium influence of RAE was only proven in 2016 a 2017; the RAE influence was small in other years and during the whole monitored period. When investigating the influence of RAE on rankings in individual quarters of the year in the WTA Rankings (TOP 100) in the whole observed period, it was proven that RAE influence on the ranking of players is small, and, with the exception of players in 76–100 position (medium RAE influence), materially insignificant.

Even though some authors have suggested some ways how to eliminate the influence of RAE, none of them is currently universally applicable. It is therefore important to respect developmental patterns and the knowledge of RAE influence especially in junior categories, persistently attempting to carefully and rationally assess the future potential of athletes. Therefore, it is important for coaches, officials as well as parents to be familiar with the issue, to respect the laws of development of young athletes and to assist to eliminate RAE influence in sports selections.

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ANALYSIS OF MASARYK UNIVERSITY STUDENTS' INTEREST IN SPORTS COURSES IN MANDATORY PHYSICAL EDUCATION

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Radka Střeštíková, Zora Svobodová

Masaryk University, Faculty of Sports Studies, University Sport Center, Brno, Czech Republic

ABSTRACT

Purpose: The aim of our research was to analyze the interest of students of Masaryk University (MU) in sports courses in mandatory physical education. The partial goals was satisfaction with the offer of subjects and the obligation to attend physical education within university studies. The University Sport Center (USC) of the Faculty of Sports Studies provides mandatory physical education at MU. Students are required to have two credits in physical education (PE) within their bachelor's degree and long master's degree. They can choose both a semester lesson or in a form of block lessons that take place on Friday or weekend, as well as multi-day summer or winter training courses.
Methods: We created a survey for our research. The subject of the questions was to find out if the students were familiar with the offer of USC-organized sports courses and, if not, what is the cause of this ignorance or nescience. We also looked at their preferences for sports courses, what activities they would prefer on the course. We were also interested in student satisfaction with the offer of PE courses and with the obligation to attend these courses. The results were processed by descriptive statistics and data analysis.
Results: A total of 1608 students from all MU faculties answered our survey. The survey was conducted in the spring semester of 2019 in semester teaching, both in mandatory and in paid form. We found that 67% of students do not know the offer of summer and winter training courses. The biggest problem why they don't know the offer is the lack of interest in these activities. Among the activities that are interesting for them and would like to run them on summer courses are water sports, especially river rides, hiking, sightseeing, mountain hikes, cycling and rock climbing activities. Furthermore, we found that 95% of students are satisfied with the offer of PE courses. 91% of students see positively the obligation to attend PE at universities, 44% of them would like PE for 3 semesters or more.
Conclusion: Physical activity plays an important role in student life. For a young person who wants to be a university educated expert, movement, health, and vitality have an irreplaceable function. From the results of our investigation we can conclude that students are aware of the influence of active sports in their lives, agree with the organization of PE within their university studies and want to actively participate in physical education. Exceptions are sports courses, which they are not interested in, or have no idea that they exist. Based on the results, we will look for ways to promote both summer and winter courses, so that students can be informed about the offer (cooperation with MU faculties and rectorate) and then we will find ways to make the courses more attractive for students.

Keywords: Sports courses; mandatory physical education; students

Introduction

Regular physical activity brings many physical and social benefits and plays an extraordinary role in the prevention of various diseases. The International Charter for PE and Sport (UNESCO, 1978) declares the right of all people to have access to PE, sport and physical activity (PA), and this right must be guaranteed. It is necessary for the development of one's own physical potential, the development of physical literacy. It indicates the level of education in this area and is not a type of movement, but the quality of movement skills and abilities and includes attitudes to movement (Vašíčková, 2016).

Conversely, a sedentary lifestyle is closely linked to health pathologies and can thus trigger health problems both in childhood and adolescence (Roberts, 1991) and especially among university students (Irwin, 2007). At universities, students are faced with the problem of managing the transition to a different way of learning as quickly as possible, which results in a different way of life. Moreover, about 60% of them are temporary residents. Studying at university is the time when a young person completes the most important stage of his education, finds his lifestyle and completes his development (Valjent, 2010).

Some research confirms that the transition to college education is increasing the neglect of a healthy lifestyle and reducing physical movement (Bray & Born, 2004). This is due to changes in the life of a university student he needs to cope with – a family and school-regulated lifestyle, an increased number of study hours, increased stress due to pressure from study, and increased responsibility. However, scientific research into the health habits of college students has found low levels of physical activity and poor eating habits (Waldron & Dieser, 2010). The organizations and sports opportunities that universities offer to their students have a decisive influence on the quality of life of university students and should be adapted to their needs, both in terms of the features of the programs offered and their availability. These factors have been shown to support and enhance sport and physical practice (Reed & Phillips, 2005). It turns out that in this age group, physical literacy is more easily developed by offering a wide range of PA in order to take into account and use the potential and interest of all (Vašíčková, 2016).Our other researches show that if a student is satisfied with the offer of sports in his / her curriculum, he / she has a positive attitude towards compulsory physical education at university and to sports in general, so his / her quality of life is positively influenced (Svobodová, 2009).

In the Czech Republic, we can currently observe a decline in regular physical activity during adolescence (Frömel et al., 2007) and the period of study at the university can play an important role in shaping opinions and attitudes towards physical activities and sports. For a brief comparison of the system and content of teaching physical education and sports at universities in the Czech Republic, we selected our three largest universities - Charles University in Prague, UP Olomouc and MU Brno. Charles University in Prague - the faculties of this university approach PE teaching individually and differently. Students of some faculties are obliged to obtain a credit from physical education (from 4 credits to 1), at some faculties they must pass swimming tests, at least one training course or input examination. Overview of the organization of PE faculties is on the website (https://cuni.cz/UK). UP Olomouc offers its students the teaching of physical education and sports only as optional programs, the organization is provided by the Academic sport centre (https://ascup.upol.cz/).

Masaryk University (MU), as one of the universities, has a PE obligation in 2 semesters. The University Sports Centre (USC) of the Faculty of Sports Studies provides compulsory physical education at MU. Students are required to take two credits in physical education as part of their bachelor's and long master's studies. They can choose both semester teaching and a form of block teaching taking place on Friday or at the weekend, they also have a choice of multi-day summer or winter training courses. Currently, USC offers 80 compulsory courses and 75 paid PE courses. Unfortunately, the interest of students in winter and summer training courses is very low at the moment, and we decided to find out why this is the case. For comparison, in 2008, 24 summer training courses were announced, of which 19 courses were held, 636 students participated. In 2018, 5 summer training courses were announced, of which only 1 course was held and 27 students participated.

The aim of our research was to analyse the interest of students of MU in sports courses in mandatory physical education. The partial goals was satisfaction with the offer of subjects and the obligation to attend physical education within university studies.

Methods

The basis of the research was the created survey on sports courses and mandatory PE offers from the USC at MU. When creating the survey, we used the already published survey, which examined the physical activity of students at MU in 2005 and 2014 (Svobodová, 2009). For our needs, we have added questions related to teaching at USC, especially summer and winter training courses. The survey contains 12 questions, both closed and open. It concerns the basic data characterizing the monitored set of respondents, gender, age, faculty, we also distinguished students attending compulsory and paid PE. We created a survey based on the study of literature and adjusted it for the needs of research. The survey contains questions to find out the basic data characterizing the sample of respondents, gender, age, faculty, we also distinguished students attending mandatory and paid PE. The aim of the questions was to find out whether the students know the offer of sports courses organized by USC and if not, what are the causes of this ignorance or lack of information. We also tried to find out their preferences for sports courses, what activities they would prefer at the course. We were also interested in the satisfaction of students with the offer of PE subjects and the obligation to attend PE. And last but not least, whether they do sports in their free time and how often.

A total of 1608 students from all MU faculties answered our survey. The survey took place in the spring semester 2019 in semester teaching, both in compulsory and in paid form. The average age of respondents was 21 years. We distributed the surveys in paper form, mostly on compulsory PE in cooperation with the USC team of lecturers. All students were informed about the anonymity of the answers and about the possibility of not participating in the survey. All completed surveys are now stored in the principal investigator's office.

We evaluated the surveys with descriptive statistics.

Basic characteristics of the file:

Table 1 *Gender of participants*

	N	**%**
Men	559	35%
Women	1049	65%
Total	1608	100%

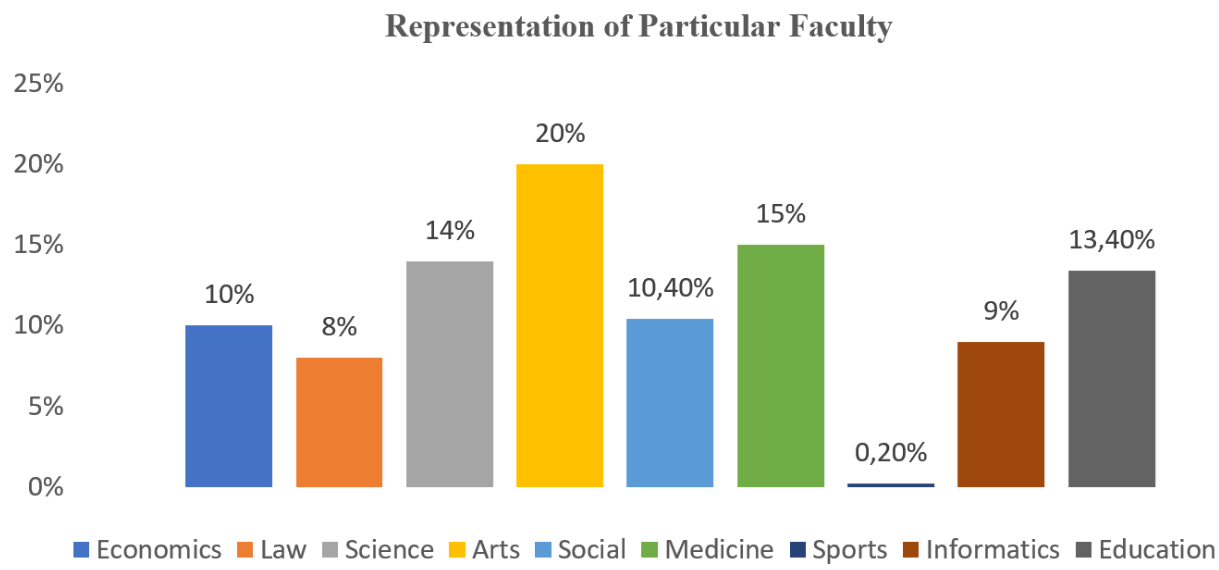

Figure 1 *Representation of individual faculties of MU*

Figure 1 shows the representation of individual faculties. Least students are from the Faculty of Sports Studies (FSpS) because USC offers teaching to all faculties except FSpS. They can only choose from payed PE. Other faculties are represented equally, only the Faculty of Arts has the largest representation. Students can register PE during the first 6 semesters of study, so the layout is random.

Table 2 *Participation in the form of Physical Education*

	N	%
Mandatory PE	1511	94%
Paid PE	97	6%
Total	1608	100%

Table 2 shows the stratification of students in mandatory and pay PE. 94% of the addressed students attend compulsory PE, which was the aim of the survey. We distributed the surveys in paper form mostly in compulsory PE for internal teachers. Paid courses were less chosen because they are intended for students who already have mandatory PE or cannot enroll in it (FSpS students).

Results

For us, the most important question we were dealing with was the knowledge of the courses, whether students know the offer of winter and summer training courses. Unfortunately, it was assumed that two thirds (67%) of the addressed students did not know the offer of courses.

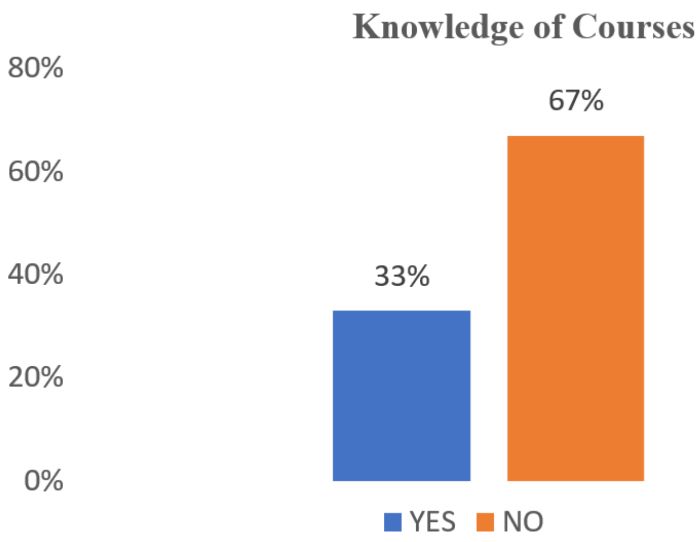

Figure 2 *Courses*

Part of the question was, if they know the offer, whether it suits them and if not, why they do not know the offer. Those who knew the offer usually answered that the offer suits them. There was a small percentage of those who wrote that the offer is satisfactory, but they prefer to choose semester lessons or that the dates of the courses do not suit them. Winter courses take place during the winter exam period and summer courses mostly in July or August.

Among the biggest problems why students do not know the offer is the lack of interest in these activities (40%), then that they have not heard about the offer, they do not know that the courses exist (16%), another addressed problem was time consumption of the course or lack of time (5%). In a low percentage, students reported that there is little information, no one told them, they prefer to ride alone, have other interests, or chooses semester teaching.

Another question we asked the students was the length of the courses. According to the answers, winter courses should last on average 7 days and summer courses on average 8 days.

Table 3 *Course selection factors*

Selection factors		**Followed categories**		**Percentage relative frequency relative to the number of respondents**
Absolute frequency		**Percentage share**		
1.	Price	976	22%	61%
2.	Course length	589	13%	37%
3.	Interesting place	698	16%	43%
4.	Sport activities	1187	26,5%	74%
5.	Social gathering event	361	8%	22%
6.	Learning new skills	393	9%	24%
7.	Other	29	0,5%	2%
8.	Not interested in courses	220	5%	14%
Total		4453	100%	277%

We were interested in what is the determining factor in the choice of courses. The following table 3 shows the responses. Students had a choice of 8 options, one of which was negative (lack of interest in the courses). They could choose more options.

The decisive factor for students in the choice of courses is sports activity (26,5%) in second place is then with (22%) the price and the next is an interesting place (16%). 0,5% of students stated a different reason, which was usually the date when the course was held. Only 5% of students reported lack of interest in the courses, which is in conflict with the answer to the question about the course knowledge and the reason why they do not know it.

Among the activities that are interesting for them and would like to attend them on summer courses are water sports, especially river rafting, hiking, cycling and rock climbing activities.

A supplementary question in the survey was whether students were satisfied with the offer of courses offered by USC in both mandatory and pay PE. From Table 4 we can see that 95% of respondents are satisfied with the offer, only 5% are not. Students had the opportunity to write under the question about what subject they would welcome. The answers were very diverse and some of them were inspiring for us.

Table 4 *Satisfaction with the offer of courses at USC*

	N	**%**
YES	1519	95%
NO	89	5%
Total	1608	100%

We chose the last question in the survey on the basis of previous research conducted at our department in 2005 and 2014. We asked students about the number of semesters of mandatory PE if they wanted this obligation at all and to what extent. Survey in paid subjects were chosen less because they are intended for students who have already completed the compulsory PE or cannot enroll in it (FSpS students, only 0.20%).

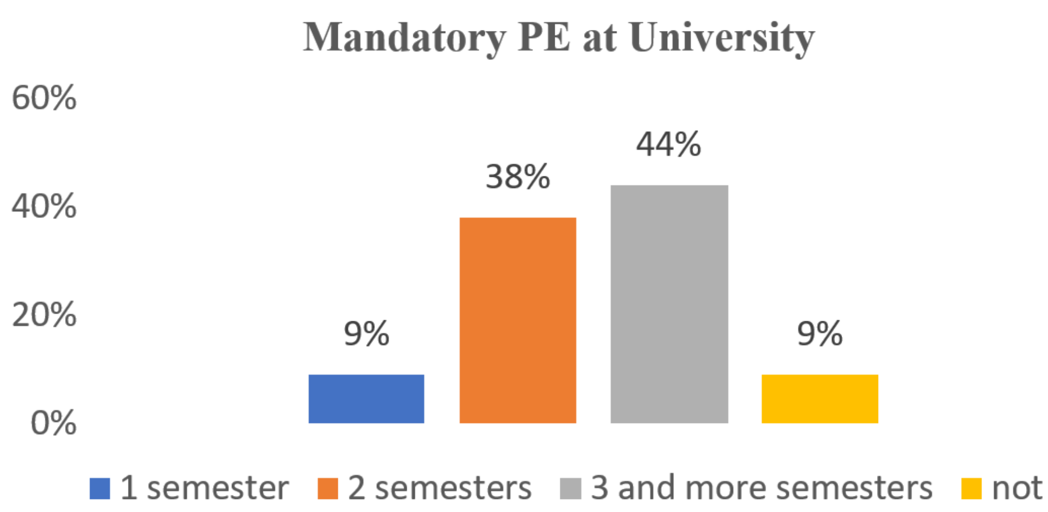

Figure 3 *Mandatory PE at University*

Figure 3 shows us students' interest in mandatory PE – 44% of students would like 3 or more semesters of mandatory PE, which is a very positive answer for us, 9% would abolish the obligation of PE in universities.

Discussion

The last important part of the survey was finding out whether the students agree or disagree with the mandatory PE at MU. We asked this question again like in 2005 and 2014 (Střeštíková & Svobodová, 2019). From the results that we compared in Table 5, we can see that the positive attitude of students towards mandatory physical education at MU is stable. Compared to previous researches, this year the number of students who agree to mandatory PE in two semesters has increased, and over the last 14 years the percentage of those who disagree with it has declined.

Table 5 *Comparison of interest in mandatory PE at MU*

	2005	**2014**	**2019**
1 semester	40(4%)	53 (4,3%)	142(9%)
2 semesters	245(23%)	393(31,6%)	605 (38%)
3 or more semesters	557(53%)	698(56,1%)	708 (44%)
Disagree	204(20%)	100 (8,0%)	152 (9%)
Total	**1046** (100%)	**1244** (100%)	**1608** (100%)

58% of students of the 2nd of the Faculty of Medicine of Charles University, 30% of the 3rd of the Faculty of Medicine of Charles University showed interest in compulsory PE, but to a greater extent - 60% think that the teaching of physical education should be compulsory. The results from the Faculty of Medicine of Charles University show that those who do not agree with TV are 10%, which corresponds to the findings of students at MU (Gajdošík, Baláž, 2012).

Conclusion

The aim of our contribution was to find out if students know the offer of winter and summer training courses and whether they are interested in them.

From the results we found out that 67% of students do not know about the offer of courses and the main reason is their lack of interest, as well as poor awareness. The answer to the question, what would be the decisive factor for them to go to the course is sports activity, price and interesting place. The reason why our offer is underutilized is due to a term that is unsuitable for them. So we will try to focus on the selection of activities they are interested in, make the offer more attractive and improve promotion, whether in the form of flyers, social networks, etc..

In terms of satisfaction with the offer of courses, most students are satisfied and able to choose from a wide range of courses. Currently USC offers 87 mandatory courses and 63 paid PE courses.

Students agree with the organization of PE within their university studies and want to actively participate in physical education. The proportion of those who disagree with mandatory physical education decreased by 11% between 2005 and 2019. Exceptions are sports courses, which they are not interested in, or have no idea that they exist. Based on the results, we will look for ways to promote both summer and winter courses, so that students can be informed about the offer (cooperation with MU faculties and rectorate) and then we will find ways to make the courses more attractive for students.

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OPINIONS OF TEACHERS ON TEACHING GYMNASTICS IN BANSKÁ BYSTRICA

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Juraj Kremnický

Department of physical education and sport, Faculty of Arts, Matej Bel University, Banská Bystrica, Slovakia

ABSTRACT

The aim of this article was to find out the views and attitudes of teachers of the fifth and sixth grades of elementary schools in Banská Bystrica on gymnastics. The research group consisted of total number of 25 physical and sport education teachers, 11 male and 14 females from eleven schools. We used our electronical questionnaire to find out the opinions of the teachers. We studied the opinions on teaching the gymnastics but also material equipment at elementary schools. In average we found out positive attitude of teachers toward gymnastics. The teachers consider the existing material equipment at elementary schools in Banská Bystrica to be sufficient.

Keywords: gymnastics; opinions; physical and sport education

Introduction

According to the ISCED 2 - the state education program (SEP), the subject of physical and sports education provides basic information about the biological, physical and social foundations of a healthy lifestyle. The pupils should develop skills and acquire knowledge, skills and habits that are part of a healthy lifestyle not only during school but also in adulthood. The educational standard has four basic parts: Health and its disorders, Healthy lifestyle, Physical fitness and physical performance, and Sport activities of the movement regime that take into account the movement and health-oriented concept of physical and sports education. The part Sports activities of the movement regime is divided into following basic thematic units: Theory of physical education and sports, General gymnastics, Athletics, Basics of gymnastic sports, Sport games, Swimming, Seasonal activities, Compulsory selective thematic unit and Testing. The authors of the state educational program recommend that the basic thematic unit of general gymnastics should be taught as a part of every physical and sports lesson in duration of 15% of the lesson time. We can see that gymnastic activities play an essential role in physical and sports education. According to Chrudimsky (2011) gymnastics should be for everyone and should follow the philosophy of 4F: Have Fun – to perform gymnastics to bring joy and pleasure. Gain Fitness – fitness development. Acquire good Fundamentals – developing basic movement literacy. Enjoy healthy Friendship – development of interpersonal relationships, trust, self - esteem.

In fact the teachers play an important role in shaping their pupils' opinions and attitudes. Perečínska & Jankura (2018) found in their research that the lack of inclusion or complete omission of gymnastic activities is the cause of negative attitudes of pupils. The decisive element in the implementation of gymnastic activities is the PE teacher whose expertise and interest in teaching the activity determine the quality and effectiveness of the teaching process and thus the attitude of the pupils. We agree with the opinion of Bartík (2009) that physical and sports education teachers should first see themselves as the ones who can influence and positively lead pupils to sport and sports activities. If an educator leads the teaching process in an interesting and attractive way for pupils, the pupils' interest in physical activity increases (Sližik, 2008, Gumbo, at al. 2017). Modern innovative technologies contribute to the attractiveness of the teaching process for example the inclusion of well-known sport or gymnastic games using non-traditional tools and equipment (Antala et al., 2014). According to Wan (2014) sports teaching must constantly introduce innovative teaching concept to combine theory with practice and continue to expand and deepen our P.E education. Using the innovation education concept in P.E teaching can deepen the reform of the physical education teaching and help us to better realize the goal of sports, achieving the goal of all-round development of body and mind for students.

We know from experience that the teacher has difficulty in guiding the teaching process in an interesting and attractive way while using an old gymnastics equipment and torn mats. In order to make the teaching process more attractive and especially safer, the city of Banská Bystrica bought an innovative and safe gymnastic set of equipment for all state elementary schools. On this basis, we are interested in the opinion of PE teachers on the inclusion of this innovative gymnastics set in the teaching process of physical education in Banská Bystrica elementary schools.

The aim and tasks of the article

The aim of the article is to find out and evaluate the opinions of teachers on the inclusion of innovative gymnastic equipment in the teaching process of pupils in the 5th and 6th grade at elementary schools in Banská Bystrica.

Methodology

The main method was an anonymous questionnaire. It was submitted electronically via a Google form and featured a set of closed and open questions. The teachers answered by either marking or writing the answer. The aim of the questionnaire was to find out the opinions of teachers on the inclusion of innovative equipment - gymnastics set in the teaching process of gymnastics. The gymnastic set includes:

- acrobatic carpet track 6 m
- mats – 4 pieces 2 × 1 m
- foam beam
- foam wedge
- foam vaulting box
- foam cylinder
- inflatabe mat 6 m – Airtreck + compressor
- small inflatabe mat

We addressed the teachers who teach the subject of physical and sports education, specifically 5th and 6th graders. The questionnaire contains questions that are categorically divided into these main units:

Attitude to the subject of physical and sports education:

- Relationship to sport.
- Relationship to gymnastics in physical and sports lessons.
- Difficulty in teaching gymnastics.
- The popularity of using individual types of equipment in sports gymnastics.
- Material conditions in schools in relation to gymnastics.
- Involvement in the school competition “Gymnastic all around competition”

We sent an electronic questionnaire to all 11 state elementary schools in Banská Bystrica. The answers were sent back by teachers from 10 elementary schools. The research group consisted of 25 teachers, including 11 men and 14 women. All teachers had the required university education and qualifications. In the results, we analysed the individual responses from the questionnaire using percentages separately for male and female teachers.

Table 1 *The group of PE male teachers in Banská Bystrica*

SCHOOL	SEX	AGE	YEARS OF EXPERIENCE	SPECIALIZATION
ZŠ Ďumbierska	male	23–30	1–5	Sports gymnastics
ZŠ Golianova	male	61–65	31 and more	Sports gymnastics
	male	36–40	11–15	Ice Hockey
ZŠ Jána Bakkossa	male	41–45	16–20	Atletics
ZŠ Radvanska	male	31–35	6–10	Football
ZŠ Sitnianska	male	51–55	26–30	Atletics
	male	23–30	1–5	Sports games
ZŠ Sl. sl. vysielača	male	46–50	21–25	Football
ZŠ Spojova	male	36–40	11–15	Conditioning preparation
	male	46–50	21–25	Atletics
ZŠ Trieda SNP	male	31–35	6–10	Football

Table 2 *The group of PE female teachers in Banská Bystrica*

SCHOOL	SEX	AGE	YEARS OF EXPERIENCE	SPECIALIZATION
ZŠ Ďumbierska	female	46–50	16–20	Sports gymnastics
ZŠ Golianova	female	41–45	6–10	Sports gymnastics
ZŠ Jána Bakkossa	female	36–40	6–10	Atletics
ZŠ J.G Tajovského	female	51–55	11–15	Basketball
ZŠ Pieninská	female	23–30	1–5	Volleyball
	female	31–35	6–10	Volleyball
ZŠ Radvanska	female	56–60	31– and more	Downhill skiing, football
ZŠ Sitniaska	female	31–35	6–10	Basketball
ZŠ Sl. sl. vysielača	female	31–35	1–5	Downhill skiing, swimming
	female	41–45	1–5	General
ZŠ Spojova	female	31–35	1–5	Volleyball
	female	41–45	16–20	Basketbal, tenis bedminton
ZŠ Trieda SNP	female	31–35	6–10	Atletics
	female	56–60	31– and more	Atletics

Results

The analysis of the individual questions from the questionnaire provided the answers below. The first five questions brought the basic information about each teacher, which we presented in the methodology. The following questions were aimed on the teaching process.

We have found that 64% of teachers at elementary schools teach boys and girls separately, while the remaining 36% teach boys and girls together. The majority of schools give grades for the subject of physical and sports education with the only exception of J. G Tajovsky elementary school. 93% of schools have two hours a week; only ZŠ Spojova has three hours of physical and sports education a week. In 64% of cases, the male teachers consider the number of lessons as insufficient, followed by 29% of teachers from elementary school J. Bakossa, elementary school of Pieninska and elementary school of SNP stated that the given number of hours is sufficient and one of the respondents was unable to assess the extent of teaching hours.

Female teachers rate the numbers of physical and sports education per week as insufficient in 73% of cases. On the other hand, two teachers (18%) from the Spojova and Sl. sl. vysielača claimed that 2 hours of physical and sports education per week was enough. One teacher from the elementary school Golianova was unable to assess the extent of the teaching hours. With these findings, we can state a clear dissatisfaction of most teachers with the current time dotation of physical and sports lessons.

All but one of the teachers share the opinion that gymnastics is a suitable basis for other sports. Only one teacher thinks gymnastics is not as necessary as athletics. All twenty-five teachers (100%) indicated that they would welcome a professional workshop considering how to use innovative gymnastic equipment. They would also welcome a methodological publication, which would recommend a series of gymnastic exercises and training together with a videos on DVD.

The following questions were to find opinions on the inclusion of innovative tools in the teaching process:

How many percent of time do you teach basics of gymnastic sports?

From the female teachers' answers, we found that 21% of the respondents devoted more than 20% to the thematic plan of gymnastics. Four teachers (29%) give 20% of total lessons to gymnastics lessons and two teachers (14%) marked 15%. Four teachers (29%) teach only 10% of given time the gymnastics and two teachers (14%) only 5% of the total lesson time. We found that (27%) of the male respondents plan to devote only 15% to gymnastics. Six teachers (57%) give 20% of total lessons to gymnastics during physical education lessons. There were also two teachers (18%) who dedicated to gymnastics 20% or more of the total lessons time.

Is teaching gymnastics your favorite activity?

35% of female teachers said they liked gymnastics lessons. On the contrary, 30% of teachers expressed a negative attitude and the remaining 35% did not see any difference between the teaching any other thematic units. Up to six male teachers (55%) gave a positive response and thus expressed a positive attitude. On the other hand, one teacher from the elementary school Golianová (9%) expressed a negative attitude to the teaching of gymnastics at the PE lessons. The remaining 36% of teachers do not distinguish any differences between teaching thematic units.

Is teaching gymnastics more challenging than the other thematic units?

36% of female teachers do not think that gymnastics is more demanding. The remaining 64% of teachers do not share this view and claim that gymnastics is one of the units that are difficult to teach. Up to seven out of eleven male teachers (64%) do not think that gymnastics is more demanding than other thematic units in physical and sports education. Three other teachers (27%) do not share this view and claim that gymnastics is a challenging thematic unit. The reasons were mainly related to safety and possible injury and reasons such as difficulties in demonstration, error correction, lack of interest and lack of general fitness of pupils.

After purchasing an innovative gymnastics set of equipment, do you teach the thematic unit basics of gymnastics sports more willingly or like a duty?

Most of the female teachers (57%) responded positively and they are happy to teach gymnastics. For other teachers (43%), gymnastics is taught because they have to. It is different with male teachers. Ten of the eleven male teachers (91%) said they were happy to teach gymnastics using the new equipment. One teacher (9%) teaches gymnastics still only as a duty. We are pleased that none of the asked teachers has said that he is reluctant to teach gymnastics or not willing to teach it.

To which gymnastic disciplines do you devote the most and least time?

The conclusion we have made according to the answers is that female teachers spend most of their time on floor exercise and less time on vault and rings. The lowest ranked apparatus in the process of teaching is horizontal bar. Male teachers, just like female teachers, devote most of the time to floor exercise, followed by vault. The least popular and least used apparatus in the physical education process the horizontal bar and rings. Both groups of teachers prefer to work on floor exercise. This fact is influenced certainly by the purchase of gymnastic equipment. They donate to floor exercises up to 55% of time given to the basics of gymnastic sports.

Which equipment do you use most often in teaching?

Female and male teachers both most often use following gymnastic equipment for teaching: mats, springboard, foam vaulting box, vaulting leather goat and acrobatic carpet track. They agreed that they most frequently used mats (100%), an acrobatic carpet track and a foam-vaulting box (91%), as well as a springboard (82%). The least used were foam beam (36%), rings (18%) and trampoline (9%).

Which gymnastics exercises do you prefer to teach?

According to female teachers, the most popular are acrobatic elements (51%) and vaults (38%), and among the least popular were the elements on the horizontal bar. According to the teachers, the most popular are coordination exercises and tuck vaults (46%) and less popular were hangs, hip circles and balance exercises.

If you do not fulfill the content of gymnastics in your classes as recommended by the State educational program, it is because:

According to 71% of female teachers, the safety reasons are the most problematic. Two teachers see that pupils are not interested in gymnastics (9%) and two teachers (9%) indicated insufficient material safety. The most common reasons given by male teachers were safety reasons (46%). Three teachers (27%) saw lack of interest in pupils and two teachers (18%) indicated insufficient material safety. One teacher marked his own disinterest as a reason why not to fulfill the content of gymnastics (9%).

Which gymnastic equipment that you do not have at your school do you need to improve the teaching process?

Most female teachers (57%) considers the equipment, which is available, as sufficient. The remaining 43% of teachers are missing small trampolines or springboard to improve their teaching. Majority of asked male teachers (64%) indicated that the equipment in their school was sufficient. Other teachers said they miss trampoline (16%), parallel bars and rings (9%).

Have you appreciated the activity of the city, which provided your school by new innovative equipment – gymnastic set?

More than half of the female teachers responded positively, claiming that secure equipment helped to increase safety during gymnastic exercises and 21% of respondents said they would open a gymnastic afterschool activity. The remaining 15% were positive about the city's initiative, but said they were unable to use the gymnastic equipment they received. All eleven male teachers (100%) stated that the new equipment helped the most in increasing the safety of the teaching process PE lessons.

Do you participate in a school competition organized by SAŠŠ – Gymnastic all-around competition?

Five (50%) of the questioned schools are actively involved in these school competitions, namely Ďumbierska, Golianova, J.G Tajovsky, Spojova and Sitnianska. The remaining 50% of schools do not participate in this activity. One of the female teachers said they were planning to join the gymnastic all-around competition next year. Sadly, the teachers of the remaining 4 elementary schools do not plan to participate in this only gymnastics event for elementary schools in Slovakia in the future. We agree with the recommendation of Antala et al. (2014) that if there is existence of great interest in the activity, the school could cooperate with sport federations and coaches to set up a sports club at the school. Students could attend it but also it could work for children living in the close area of the school.

Conclusion and discussion

The responses of teachers from Banská Bystrica elementary schools showed that 55% of female teachers and 35% of male teachers had a positive attitude towards teaching gymnastics. In contrast, 30% of female teachers and 1 male teacher (9%) expressed a negative attitude. The remaining 36% of female and 35% of male teachers have an indifferent attitude towards teaching gymnastics. More than half of the female teachers (57%) teach gymnastics with pleasure. For the rest (43%), gymnastics is taught because they have to. It is different with male teachers. Ten of the eleven teachers (91%) said they were happy to teach gymnastics. One teacher (9%) teaches gymnastics only because he has to. We are pleased that after purchasing an innovative gymnastics equipment, none of the teachers said they were reluctant to teach gymnastics or did not teach it at all. 24 out of 25 teachers think that gymnastics is one of the sports that builds a suitable basics and general fitness for other sports. Vaculíková, P. (2011) presents similar results, according to which the development of functional gymnastic preparation is a basic precondition for faster and more effective training of other physical activities. We agree with Kalistová et al. (2010) that gymnastic strengthening exercises should be included into scholastic physical and sports education because of their influence on the complex effect on the neuromuscular system.

According to the SEP, the recommended time for the thematic unit basics of gymnastics is 15%. The female teachers' answers show that 66% of respondents fulfil this time and 34% do not fulfil the recommended time. The male teachers all fulfil the recommended time. 36% of female teachers and 64% of male teachers think that teaching gymnastics is not more challenging than other thematic units are. 64% of female teachers and 36% of male teachers do not share this view, claiming that gymnastics is the unit that is difficult to teach. The reasons are mainly safety, possible injury and lack of general fitness of pupils. In order to reduce the risk of injury we recommend using safe innovative tools in the teaching. According to Kyselovičová (2009), various innovative tools and equipment are the factors that influence the physical education process, increase its efficiency, attractiveness and emotionality.

The analysis of the teachers' answers revealed that most of the time (55%) of teaching gymnastics is devoted to floor exercises, followed by vaulting and the least the rings and horizontal bar. They most often use mats, an acrobatic carpet track, and a foam-vaulting box, a foam beam and a springboard. The least used equipment were rings, horizontal bar and trampoline. We were surprised they do not use a 6-meter inflatable mat in all schools. In our opinion, it is the most attractive piece of equipment that is part of a purchased gymnastic set. The study of Bakx et al. (2015), investigated the pupils´

perceptions of teachers´ qualities. The interesting fact is that right after the personality of teacher the pupils consider teacher´s didactic skills as second most important. The similar study in Spain shows that *one group of teachers taught gymnastics but did not feel fully prepared to do so, which made them anxious and insecure, and the other group did not teach gymnastics at all because they lacked the necessary conditions and resources (Ramos, Molina, 2016).* Therefore, we suggest systematic training for teachers of physical and sports education in the form of workshops and methodological materials for the procedures and exercises of specific exercises on this gymnastic set. We agree with opinion of Devrilmez et al. (2018), who sees importance of ongoing monitoring of teacher knowledge in gymnastics. The authors investigated 240 Turkish teachers using questionnaire about their knowledge in field of basic teaching techniques in gymnastics. The questionnaire and the results can be used in initial teacher education and continuing professional development of the teachers.

The elementary schools in Banská Bystrica have currently sufficient material for teaching gymnastics according to 57% of female teachers and 64% of male teachers. All teachers welcomed the activity of the city of Banská Bystrica, which provided innovative and safe gymnastic equipment for all state elementary schools. The teachers said that new equipment helped mostly in increasing the safety of the teaching process at PE lessons. The foreign research shows the need of purchasing new safe equipment but that it is also necessary to build PE – related facilities. The teachers in Texas (USA) consider the new equipment and tools as a matter of course, while 68,6% (57 secondary school PE teachers (M(age) = 48.84 years; SD = 1.39) of participating teachers suggested to refurbish or expand PE-related facilities (Kretschmann, 2015). Devecioglu at al. (2012) states that the safety should be on the first place and it is influenced by several factors. One of the factors is paying attention to the management of sports equipment which should be safe and certified. According to Ningthoujam, Nongthombam (2017) the equipment is one of the backbones of PE classes. In PE classes, it should be age-appropriate and safe to use for the child.

Based on the answers of the teachers, we would like to recommend following suggestions for improving the teaching process of physical and sports education in Banská Bystrica:

1. Increase the number of physical education and sports lessons by demanding to use available lessons for the benefit of sport from school administration. For example, in Poland, they have 4 hours of physical and sports education per week Slovenia has increased the number of PE lessons from two to three per week. In France, there are five PE lessons per week and in Hungary, in the first four grades they are teaching physical and sports education every day!

2. Increase the interest of pupils not only in physical and sports lessons, but also in afterschool activities, extracurricular trainings and competitions. Motivate them with several gymnastic activities in competitive form, obstacle races and gymnastic games.

3. Explain to pupils the positive contribution of sport and especially gymnastics in their lives: impact on motor skills, development of imagination and its presentation, overcoming obstacles, correcting of body posture, general preparation and others.

4. Apart from the popularity of individual gymnastic disciplines – of pupils or teachers – it is important to teach all disciplines.

5. Participate in the school gymnastic competition Gymnastic all around, which has its progress to the Slovak Championship.

6. Use digital support for teaching. Video-record pupils through special software. Explain right in class what mistakes they make in their exercise demonstration.

7. Motivate the teachers for further education and use of safe, modern and attractive equipment.

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Contact Information:

Mgr. Juraj Kremnický, PhD., KTVŠ FF UMB Banská Bystrica

juraj.kremnicky@umb.sk

ACTIVE AGEING AND SARCOPENIA

VITICULTURE AS THE OPTIONAL PHYSICAL ACTIVITY FOR ELDERLY

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Tomáš Vespalec[1], Petr Scholz[2]

[1]*Masaryk University, Faculty of Sports Studies, Czech Republic*

[2]*College of Polytechnics Jihlava, Czech Republic*

ABSTRACT

Purpose: Adequate physical activity (PA) of elderly is currently an intensively discussed topic. In urban agglomerations, physical activity for this population group is often implemented as a variety of intervention programs. The question is whether some of the normal work activities in the countryside can provide sufficient amount of physical activity? And whether this activity is suitable for elderly? In our study we want to verify whether viticulture can be an interesting and suitable alternative of physical activity for elderly.
Methods: Our research is designed as a case study based on one-year observation. Subject of the observation was 65 years old man living in South Moravia region (CZE). Observation was realized from spring to fall 2017. Descriptive statistical methods were used for quantitative analysis and energy expenditure during work activities was set up according to the work of (Ainsworth et al., 1993) and (Novotný, 2003)
Results: During one year (March – October), the observed person made 36 visits to the vineyard. Mean of the visit duration was almost 3.5 hours and mean energy expenditure was 4663 kJ (1114 kcal) per visit. Within one year he has realized 20 different types of operations based of various abilities: endurance, strength-endurance, flexibility and balance. Some of the operations also needed fine motor skills.
Conclusions: Our study shows that viticulture could be an interesting activity for elderly. It brings a sufficient amount of PA, which is also quite diverse (from strength to fine motor skills). Moreover, the material results of this activity serve as a suitable motivational factor for regular implementation of vineyard care. However, the disadvantage of a given PA is its seasonal character (March – October) and the risk of overloading during long-term activity.

Keywords: Physical Activity; Hypokinesia; Elderly; Sedentary Lifestyle

Introduction

Sufficient physical activity is nowadays highlighted matter in an all-society independently on age group. Human movement insufficiency – hypokinesia is marked as the biggest problems in this field (Hendl & Dobrý, 2011). Trend of hypokinesia is sufficiently described on the local level (Frömel, Chmelík, Nykodým, & Et, 2007); (Máček & Máčková, 2013); (Matoulek, Svačina, & Lajka, 2014), (Bebcakova et al., 2015), (Zháněl, 2014) as well as on the all-European (Kahlmeier et al., 2015) or world levels (Hendl & Dobrý, 2011).

Primarily has hypokinesia and sedentary lifestyle negative consequences at medical level. Consequent health impacts resulting from insufficient physical activity have been medically diagnosed. Whether it is cardiovascular diseases (Ortega et al., 2011), metabolic disease and risk factors (Ekelund et al., 2007);(Martins, Morgan, Bloom, & Robertson, 2007) or orthopaedic diseases (Varo et al., 2003) including bone health (Sofková, Přidalová, Mitáš, & Pelclová, 2013), authors commonly agree about the negative impact of low or insufficient physical activity on health status. This phenomenon is referred in numerous studies as a sedentary lifestyle (Etemadi et al., 2012); (Tremblay, Colley, Saunders, Healy, & Owen, 2010); (Tudor-Locke, Craig, Thyfault, & Spence, 2013). In wider spectrum of factor is hypokinesia mentioned as negative impact at the economic level where it can reduced productivity, employability, costs of health care etc.

Our study focused on the age group of elderly (age 60 +). In this age group, we can find, in addition to natural physiological changes associated with ontogeny, a lot of other risk factors. In the Czech Republic, this age is usually connected with retirement (leaving a job), which is usually connected with a change in the exercise regimen of an individual. From described reason many preventive and interventional programmes for this age group are prepared to reduce risks and negative impact of hypokinesia. Unfortunately majority of this programmes is realized only as the additional physical activity and is organized especially in cities with greater population. Question (and also aim of our study) is whether some of the normal working activities in the countryside can provide sufficient amount of physical activity and substitute the organized interventional programmes? And whether this activity could be suitable for elderly?

Some of these aspects and positive impact of gardening has described (Ainsworth et al., 1993). They recommend gardening as the Czech phenomenon for elderly to meet the lifelong demands for a healthy life. Viticulture in our study could be described as specific variant of gardening. Viticulture represents activity that is connected with cultivation of vineyard and vine production. Viticulture is typical for South Moravia region. Vineyards take the area of 174.5 km^2, and in addition to large wine farms, there are numerous small private producers whose vineyards do not have more than 500 plants. These vineyards are characteristic of a manual work without using mechanisation.

Methods

The research is designed as case was study based on a one-year observation of the respondent, supplemented with his individual working activity records. The monitored person was a 65 years old man from the small village in Znojmo region (CZE). The man was selected based on the principle of availability and he was not informed about the objectives of the study. During 2017 his working activity was monitored at the vineyard with the area of 769 m^2, where he managed 420 grape vine plants.

Descriptive statistical methods were used for quantitative analysis and energy expenditure during work activities was set up according to the work of (Ainsworth et al., 1993) and (Novotný, 2003).

The estimate of energy expenditure of a working activity was carried out by two experts independently, and consequently confronted. In the context of the taxonomy of abilities according to Měkota (Měkota & Novosad, 2005), the activities were further divided to groups according to their character: endurance, strength-endurance, dexterity, flexibility and balance and involvement of fine motor skills. Subsequently the potential health risk was evaluated.

The list of activities is described in Table 1.

Table 1 *List of activities*

activity	MET	E expenditure [kJ/hod]	health risk	type of activity	Activity realization							
					March	April	May	June	July	August	September	October
cutting of branches	3.5	1125	2	2; 4	x							
transport of branches	4	1287	0	2; 3; 4	x			x	x			
removal of protectors	3.5	1125	0	4	x							
treatment after cutting	3	963	0	4; 5	x							
binding	3.5	1125	0	2; 5	x							
spraying the vineyard	4.5	1444.5	2	1; 3; 4		x	x	x	x	x		
lawn mooving	4	1287	0	1		x	x	x	x	x		
digging	4	1287	1	1; 4		x	x	x	x	x		
digging away	5.5	1768.5	1	1; 4			x					
breaking out of branches	3.5	1125	0	2; 3; 5			x	x	x	x		
weeding	7	2250	2	1; 4			x					
watering	4.5	1444.5	2	1; 4				x			x	
threading of branches	3.5	1125	0	4; 5				x				
hacking of branches	4.5	1444.5	2	1; 3; 4					x	x		
tearing off leafs	3	963	0	2; 3; 5					x	x	x	
guarding	3	963	0	2						x	x	
grape harvest - cutting	3.5	1125	2	2; 3; 4; 5							x	
manuring	4	1287	0	2; 3							x	
grass raking	4	1287	2	1; 4	x							
plowing	8	2574	2	1; 3; 4								x

Legend:

HEALTH RISK: 0 – minimum risk; 1 – high risk, imbalance; 2 – moderate, possible risk after log overload

TYPE OF ACTIVITY: 1 – strength-endurance; 2 – endurance; 3 – dexterity; 4 – flexibility and balance; 5 – fine motor skills

Results

All the results are generated regarding to basal metabolism of the respondent – 8,712 kJ (2,082 kcal). During the season 2017 the observed person has visited the vineyard 36 times in total. His visits were spread over the period of March – October. The month with highest number of visits was May (10 visits). In total, the senior worked for 121.5 hours in the vineyard and on average, he spent there almost three and half working hours per visit. On average, the respondent performed during one visit work with mean energy expenditure 4663 kJ (1114 kcal) per visit.

Duration of the visits was very different. The shortest visits wasn't longer than one hour and on the other side the longest time the respondent spent in the vineyard was 12 hours. May was the month with the highest number of visits. But the duration of the visits was shorter during this month and also average energy expenditure per visit was the lowest (2470 Kj/visit). In August the most energy demanding works were performed. An average energy expenditure of the senior was more than 5692 kJ/visit in August, which is more than twice in comparison with May.

Table 2 *Vineyard visits during 2016*

	No. of visits	Visit duration TOTAL [hours]	Visit duration MEAN [hours]	E expenditure TOTAL [kJ]	E expenditure [kJ/visit]
January					
February					
March	5	21	4.2	26862	5372.4
April	4	16.5	4.1	19245	4811.3
May	10	25	2.5	24705	2470.5
June	5	13.5	2.7	26590	5318.0
July	4	11	2.8	15791	3947.8
August	5	23	4.6	28462	5692.4
September	2	10	5.0	10968	5484.0
October	1	1.5	1.5	4356	4356
November					
December					

Within one year the senior has realized 20 different types of operations based of various abilities. Abilities with the highest representation were: dexterity (22), flexibility and balance (21), strength-endurance (19), endurance (18). Eleven of the visits during the season required also fine motor skills.

During the season we have also detect three periods with higher accumulation of work that could indicate potential overload and health risk. One was in the spring during cutting of the vineyard in March, second was connected with digging and digging away at the turn of April and May. The last physically demanding period was end of the August when digging and cutting operations were realized.

Discusion

Our study seeks to show that it is not absolutely necessary to only prepare specific interventional physical activities for elderly that has character of additional or artificially invented physical activity. When optimal natural working activity is utilized it could bring other positive aspect.

Primarily is no problem with motivation because activity as viticulture usually motivates with material outputs. It also often take longer time than usual interventional activities in the gym (lesson – 45 minutes, 1 hour). Other positive aspect is also variety of operations during the season and spectrum of skills and abilities that is used.

In the social level we can also mentioned that the activities associated with viticulture also represented the possibility of senior's socialisation in a social group which is culturally connected with the region.

On the other side this type of activity also has its limitation. The general problem is seasonality, because start of the season is in middle March and end at the turn of September and October. This causes a problem of searching another supplementary physical activity for the period of November – March. Other negative aspect is potential overloading during long lasting operations. Especially cutting and digging operations could bring health risk connected with imbalanced load and unilateral activity.

In global, when we compare observed results with the recommendations of WHO ("WHO | Global recommendations on physical activity for health," n.d.) on minimum PA we can mentioned that respondent meets the recommendation during almost all weeks from March till the end of August.

Conclusion

The study present research focused on physical activity of elderly and investigates whether viticulture can be used as optional activity with sufficient load and complexity of the movement. The respondent was 65 year old senior from South Moravian region (CZE). For the period March–October 2017 the senior visited the vineyard 36 times. During every visit he performed the mean working activity with energy expenditure 4663 Kj. By doing so he usually met the recommendations of WHO for the PA standards. Limitation factor for using viticulture as optimal PA for elderly could be accumulation of specific working activities that could leads to unilateral overloading of the body. Potential problem is also seasonality of viticulture.

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Contact Information:

Tomáš Vespalec
Kamenice 5, 625 00 Brno
Czech Rep.
Email: vespalec@fsps.muni.cz

Petr Scholz
College of Polytechnics Jihlava
Tolstého 16, 586 01 Jihlava
Czech Rep.
Email: petr.scholz@vspj.cz

ATTITUDE TOWARDS PHYSICAL ACTIVITIES IN A GROUP OF PREGNANT WOMEN

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Jana Juříková

Department of Kinesiology, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

ABSTRACT

Moderate and systematic physical activity during pregnancy is not only safe, but it also brings numerous health benefits, such as metabolic acceleration, lower risk of hypertension in pregnancy, prevention of swelling due to water retention within the body, reduction of premature birth, it also shortens and facilitates the childbirth and lower the risk of postpartum complications improves well-being and accelerates return to original physical condition after the child is born. Rather than regular exercises, however, it is a physical inactivity that brings risks. Some women are aware of this and they keep various physical activities during the pregnancy, on the other hand there exists a group of pregnant women who are afraid of doing exercises at all. This study attempts to define what are suitable activities during pregnancy, and find the reasons for pregnant women to perform and also not to perform physical activities. Survey was carried out in a group of pregnant women, the information concerning their attitude towards physical activities have been obtained by a questionnaire method. Questionnaires were anonymous and were submitted by 107 pregnant women. Results revealed that 63.6% of women spent their leisure time during pregnancy in an active way. Most of them reported that they are sufficiently informed; they mainly used the Internet to seek information. Pregnant women typically perform their pastime physical activity at home, alone (usually with DVD) or outdoor – walking alone or with a dog, which is even more beneficial, since the dog gives a brisk pace of the walk. Concerning the frequency of physical activity, most women stated the frequency of 2 – 3 times a week. Women, who do not perform any physical activity at all, usually refer to lack of time and energy, frequent nausea, back aches and other health problems. Some women feel like doing an activity, but to perform it, they would need a stimulus and/or more information on suitable activities for pregnant women. Some women also pointed to lack of information concerning proper physical activities during pregnancy, hence they are afraid that choosing the wrong type or intensity of exercise they might injure either themselves or their unborn child.

Keywords: pregnancy; information; physical activity; leisure time; healthy lifestyle

Introduction

Previous studies revealed that numerous pregnant women are afraid to perform physical exercises due to possible damages to their unborn child or even the risk of miscarriage. Contrary, it has been proved that physical inactivity is much riskier than regular exercises (Berk, 2010). These studies showed that systematic and moderate physical activity during pregnancy is not only safe, but it also brings numerous health benefits, such as metabolic acceleration, lower strain to cardiovascular system and risk of hypertension (Muktabhant et al., 2015; Magro-Malosso et al, 2017a), prevention of swelling due to water retention within the body, lower risk of varicose veins and deep vein thrombosis (Davies et al., 2003), it also reduces the risk of premature birth (Muktabhant et al., 2015; Magro-Malosso et al., 2017b; Vamos et al., 2015; Di Mascio et al., 2016), shortens and facilitates the childbirth, reduces pain perception (Haakstad et Bø, 2011; Vallim et al., 2011; Montoya Arizabaleta et al., 2010) and lowers the risk of postpartum complications (Vallim et al., 2011; Montoya Arizabaleta et al., 2010). It further improves well-being and self-esteem of a pregnant woman, lowers her tiredness, stress, anxiety and depression (Pivarnik et al., 2006) and accelerates her return to original physical condition after the child is born (Berk, 2010; Mazel et Murkoff, 2010).

Physical activity and its intensity prior to pregnancy plays a crucial role later when the woman gets pregnant. Any sport activity is of a significant influence to upcoming pregnancy. Women, who are used to perform a physical activity, are prone to remain active when they get pregnant. However, pregnant women who did not do any sport at all and were physically inactive so far, should start exercise only after consultation with a physician, the exercise should be of a very low intensity and ideally under the supervision of a professional trainer experienced in pregnant women training.

Methods

In 2014–2017 Masaryk University carried out a survey concerning eating habits and attitude to physical activities in a group of pregnant women who came to a medical examination within a project "TĚHOTENSKÁ OBUV" (Footwear for mothers-to-be). Information were obtained by the authors' questionnaire created by Kinesiology Department of the Faculty of Sport Studies, Masaryk University. The questionnaire was not standardized. The questionnaire contained 23 closed questions, some of them with the optional space for respondent's own answer. Questions were divided into 4 sections, focusing on general information (age, education, place of living, etc.), eating habits during pregnancy, physical activities during pregnancy and informational sources concerning nutrition and physical activities for pregnant women. The sections were chosen because of those sections reflected lifestyle in pregnancy well. In this paper will be elaborated just some answers to questions on physical activity during the pregnancy. The nutritional habits will be issued in another independent paper.

The respondents' group consists 107 women who filled in The Questionnaire of Nutrition and Physical Activities (38 in a paper form and 69 via e-mail), aged 22–44, average age was 31.0 (± 4.2) years. First, women gave general information of personal character: age, number of pregnancy, trimester, education, and whether they live in a town or village. Based on how the question in the questionnaires were answered was found which women practices physical activity during the gravidity and which women do not. According to this finding were all respondents split into two groups to make the comparison of their answers. The group of women who replied they practice free time physical activity during the gravidity was titled as „physically active". The second group of women who responded they do not practice free time physical activity within pregnancy (for health or other reasons) was titled as „physically inactive". In the paper below it will be mentioned as „active" and „inactive" only.

The computer programs used for evaluation of the questionnaires were Microsoft Excel for creation of the databases and StatK25 (Buňka et al., 2005) for statistical evaluation itself. The chí-quadrate test was chosen for statistical calculations and Kruskall-Wallis test for file level comparison.

Results And Discussion

Table 1 gives general parameters concerning age, education, place of respondents' living, the trimester of their ongoing pregnancy and the number of their pregnancies.

Table 1 *General parameters of the respondents' group*

Parameter	Pregnant women		Total
	active	non-active	
Number of respondents	68 (63.6%)	39 (36.4%)	107
Age			
< 30	20	18	38
30–39	46	19	65
40+	2	2	4
Average age	31,424 (± 3,968)	30,282 (± 4,362)	31,009 (± 4,152)
Education			
Apprenticed	3	2	5
Secondary school	7	9	16
Higher professional education	1	0	1
University	57	28	85
Place of living			
Town	55	27	82
Village	13	12	25
Pregnancy			
1st trimester	9	6	15
2nd trimester	33	15	48
3rd trimester	26	18	54
Number of children			
0 (1st pregnancy)	41	23	64
1 (2nd pregnancy)	24	12	36
2 (3rd pregnancy)	3	3	6
3 (4th pregnancy)	0	0	0
4 (5th pregnancy)	0	1	1

Source: Study of author

As obvious from the table, most women from both groups are between 30 and 39 years old, average age of the whole group is 31.009 (± 4.152). Youngest respondents were two 22-years old women, and two oldest respondents were of age 44. Concerning the education, university educated women are the majority, and most women live in a town. These factors probably pre-determine the group; women with a university degree are more willing to participate in a scientific research and also this kind of project is easily available for those living in a town.

The research was attended by pregnant women only; mostly it was their first pregnancy (64 women). Fewer women were pregnant for the second (36 women) or the third time (6 women). None pregnancy was the fourth, but one woman was pregnant for the fifth time.

Two groups of women divided on the base of physical leisure activities did not prove statistically significant differences at 5% probability level in any parameters given in the table above.

As mentioned before, women were divided into two groups – active and non-active, according to their answer whether they perform any physical activity during pregnancy. Most respondents (68 out of 107, which is 63.6%) perform a physical activity. This is rather positive finding in comparison with an American study which authors found merely 23% of physically active pregnant women (Evenson et Wen, 2010).

Women who stated that they do not perform any exercise were asked to provide the reason in following answer. The most frequent answers were as follows: lack of time and energy, sickness, back ache, medical reasons - not recommended by the doctor, tiredness and pain, swollen legs, too much work with the older child. Every woman found and stated a reason why not to perform a sport activity. Contrary, the study by Wojtyła with colleagues (2012) revealed that 11% of pregnant women reject their physical activities without any medical reason.

Indicator: the age of respondents

Fe = 2,0295

$F_{0,95}$ (1;105) = 3,9316

Q = 2,3335

$\chi^2_{\ 0,95}$ (1) = 3,8415

Indicator: number of children (how-manyeth pregnancy)

Fe = 0,8429

$F_{0,95}$ (1;105) = 3,9316

Q = 0,1006

$\chi^2_{\ 0,95}$ (1) = 3,8415

Indicator: the location of residence

Fe = 2,0259

$F_{0,95}$ (1;105) = 3,9316

Q = 1,0001

$\chi^2_{\ 0,95}$ (1) = 3,8415

Indicator: gestures (trimester of gravidity)

Fe = 0,1831

$F_{0,95}$ (1;105) = 3,9316

Q = 0,2263

$\chi^2_{\ 0,95}$ (1) = 3,8415

Indicator: reached education level

Fe = 0,0806

$F_{0,95}$ (1;105) = 3,9316

Q = 0,2263

$\chi^2_{\ 0,95}$ (1) = 3,8415

Further questions were addressed only to women who gave positive answer, i.e. those who perform a physical activity during pregnancy. This group consists of 68 respondents.Following question aimed to the place where women perform their activity. Respondents could choose from given options or they could write their own answer. Answers are processed in graph 1.

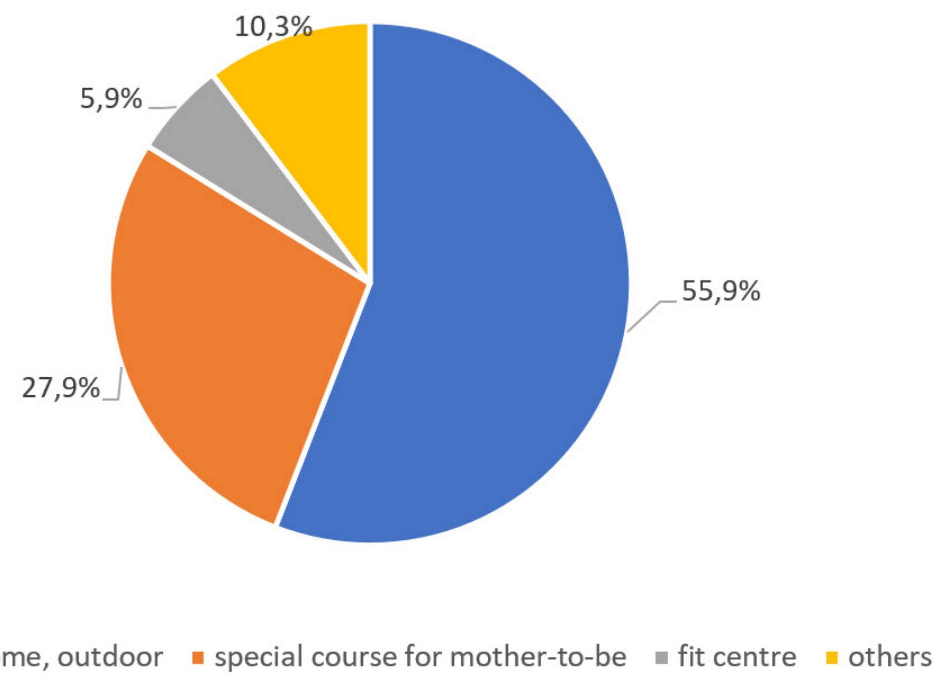

Figure 1 *Place where active pregnant women perform their physical activity*

Source: Study of author

We can see that most respondents (55.9%) perform their activity alone; they either stated that they do exercise at home (typically with DVD), or they go outdoor for walks, very often with dogs. In option Others, they provided answers as follows: 5km walk – daily, swimming in a pool, long walks, yoga, SM system (stabilization and mobilisation of the spine), exercises in a group but not specifically for pregnant. All of those physical activities might be recommended to pregnant women. There was no respondent who would state she practices in the time of pregnancy inappropriate physical activity (such as skiing, horse driving, racket sports, skating) or even restricted physical activity (such as diving, water skiing, parachute descent, ball games, exercising with tools, power sports, squash, canoeing, fight sports, climbing).

Next, respondents were asked about the frequency of exercises in physically active pregnant women – answers are shown in graph 2.

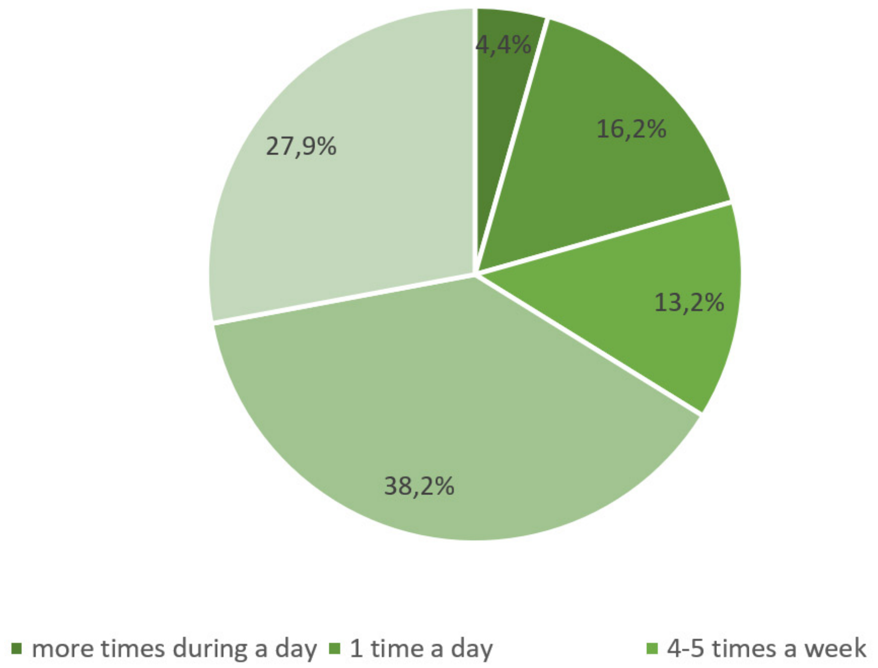

Figure 2 *Frequency of exercises in physically active pregnant women*

Source: Study of author

The majority of respondents (38.2%) stated, that they do some physical activity 2–3 times per a week – that is not enough. The best choice is to do some physical activity on daily base as responded 16.2% respondents. Some instructions for pregnant women recommend minimally 30 mins of a physical activity daily, with gradually increasing intensity from medium to higher, unless a doctor said otherwise (ACOG, 2002). Medium intensity is understood as a brisk walk. Results given in the graph show that most respondents (38.2%) perform their physical activity 2–3 times per week. Merely 16.2% of respondents perform the activity on a daily basis. Accordingly, foreign studies revealed great differences between recommendations and real performances (Evenson et al., 2002; Petersen et al., 2005). Pregnant women often have less physical activity than recommended (Haakstad et al., 2007) and in the course of pregnancy they tend to decrease it even more (Rousham et al., 2006; Weir et al., 2010). Other literary sources recommend at least 150 mins of medium intensity weekly, or to keep the activity which had been performed before pregnancy and slowly adjust its intensity as recommended (PAGAC, 2008; Wolfe et Davies, 2003; Sanda et al., 2017).

Next question aimed at the fact, whether pregnant women consider their physical activity beneficial for the pregnancy. Answers are given in graph 3.

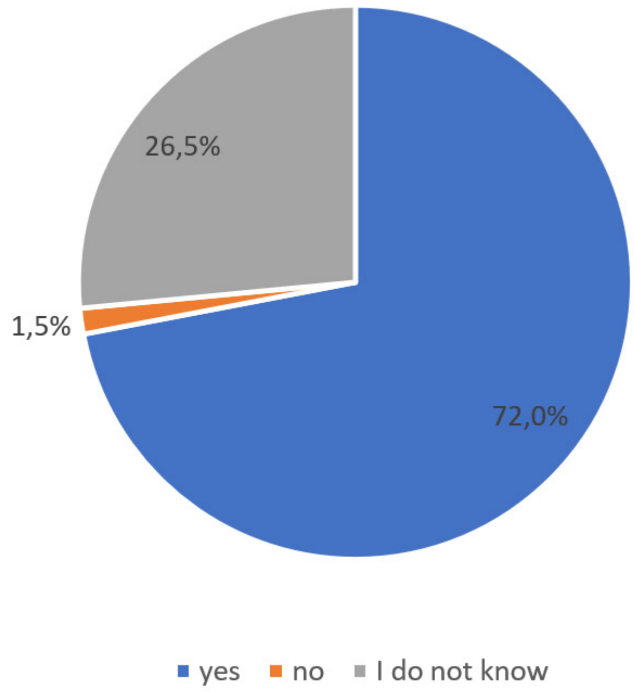

Figure 3 *Answer to the question whether pregnant women consider their physical activity beneficial for the pregnancy*

Source: Study of author

Graph shows that most pregnant women (72.0%) believe that their physical activity helps them to get over pregnancy much better. Merely 1 woman (1.5% of respondents) does not share this point of view. Numerous studies from abroad confirm that physical activity is of a significant influence to relevant growth of body weight, physical condition and facing the labour pain (Ferrari et al., 2013; Merkx et al., 2017). Evenson and Bradley (2010) found out that confidence in benefits of physical activity during pregnancy differs according to race, ethnicity, education and also the fact whether the pregnant woman performs the regular activity or not.

Conclusion

The present survey revealed that majority of pregnant women performs a physical leisure activity (answer given by 63.6% or respondents). They mostly choose exercising at home (usually with DVD) or walking, which is in accordance with recommendations. Most women (38.2%) do the activity 2–3 times per week, merely 16.2% of respondents are physically active every day. Finding that almost all women (with 1 exception) believe in benefits of physical activity for pregnancy, is very encouraging one.

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DETERMINANTS OF CHANGES IN PHYSICAL ACTIVITY LEVELS IN LATE ADOLESCENCE; PROSPECTIVE ANALYSIS IN URBAN COMMUNITIES

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Natasa Zenic [1], Admir Terzic [2], Ivan Kvesic [3]

[1]*University of Split, Faculty of Kinesiology, Split, Croatia*

[2]*University of Tuzla, Faculty of Physical Education and Sport, Tuzla, Bosnia and Herzegovina*

[3]*University of Mostar, Faculty of Science and Education, Mostar, Bosnia and Herzegovina*

ABSTRACT

Purpose: Physical activity levels (PA-levels) significantly decline during adolescence, and sport participation during childhood and adolescence is frequently emphasized as protective factors of PA-decline. However, there is a lack of studies which specifically examined sport-related factors and its influence on changes in PA (PA-changes) in adolescence. This study aimed to prospectively observe sport factors as: (i) correlates of PA-levels and (ii) predictors of PA-changes in the period between 16 and 18 years of age among urban adolescents from Bosnia and Herzegovina.

Methods: The sample of participants comprised 324 adolescents (44% females) who were prospectively observed over two testing waves: (i) baseline, when participants were 16 years old; and (ii) follow-up, 20 months later (18 years of age). The variables were collected by previously validated questionnaires including questions on predictors (sociodemographic variables and various sport factors [current/former/ever participation in individual and team sports, experience in sports, competitive result achieved]), and criteria (PA level obtained at study baseline and follow up, measured by Physical Activity Questionnaire for Adolescents [PAQ-A], and difference between PA-levels at baseline and follow-up). The t-test was used to compare PA-levels. The associations between variables were evidenced by: (i) Spearman's rank order correlations (between predictors and PA-levels), and (ii) logistic regression analysis (between predictors, and PA-changes observed as binomial criterion [PA-incline vs. PA-decline] – excluding those participants who reported active sport participation at study baseline).

Results: The PA-level significantly declined over the study course (t-test: 6.60, $p < 0.01$). Sport-related predictors were significantly associated with PA at baseline (Spearman's R: 0.33–0.45, $p < 0.01$), and PA at follow-up (Spearman's R: 0.32-0.45, $p < 0.01$). Meanwhile, there was no significant correlation between studied predictors and differences in PA-levels between baseline and follow-up. Also, logistic regression did not reveal any significant influence of predictors obtained at study baseline and PA-changes observed as binomial criterion (PA-incline vs PA-decline).

Conclusion: While studied sport-related predictors significantly influence the PA-levels in the age of 16 and 18, with the higher level of PA among those adolescents who are actively involved in sports, sport-participation do not predict changes in PA-levels over the observed period of life. Knowing the influence of PA on overall health status, future studies should provide additional details on possible predictors of PA-changes in adolescence.

Keywords: physical activity; adolescents; sport participation; changes; logistic regression

Introduction

Physical activity (PA) is an important determinant of overall health status and consequently it is a widely recognized public health concern (Haskell, Blair, & Hill, 2009; Kohl 3rd et al., 2012). Most of the lifelong patterns related to health behavior are established during childhood and adolescence, and promotion of PA should begin at an early age (Best, Ball, Zarnowiecki, Stanley, & Dollman, 2017). One of the approaches which showed promising results is identification of the factors which may be potentially related to PA-levels in different age groups. In general, the idea is to evidence factors which may be negatively related to PA (in order to control it as "risk factors"), as well as to find factors that may be positively related to PA (in order to proclaim it) (Miljanovic Damjanovic, Obradovic Salcin, Zenic, Foretic, & Liposek, 2019).

Sport-factors are frequently observed as being related to PA levels of children and adolescents (Van, Paw, Twisk, & Van, 2007). Naturally, sport participation is in most cases "physically demanding", and consequently the overall PA-levels of children involved in sport is logically higher than PA of those children who are not engaged in sport activities. Collectively, studies regularly confirmed strong positive correlation between sport participation and PA-levels in children and adolescents, emphasizing the importance of sport participation in reaching appropriate levels of PA in youth. The importance of such investigations is accentuated by the simple fact that PA-levels significantly decrease during late adolescence, and therefore knowledge on factors which reduces such negative trends is additionally important (Kohl 3rd et al., 2012). However, while there is no doubt does the sport participation positively influence PA levels in children and adolescents, the association between sport-participation and PA-changes which occur later (i.e. when children are not actively involved in sport) are not known. The most probable reason for the lack of such knowledge is the fact that answering actually requires prospective analyses, which are more complex and challenging than cross-sectional studies. Theoretically, even cross-sectional findings on "higher PA in athletic children" could be questioned with regard to its causality. In short, while there is a logical possibility that "sport increases PA", there is still a chance that the cause-effect relationship should be observed in "opposite direction" (i.e. those children who naturally tend toward high levels of PA are more inclined toward sport participation).

This study aimed to prospectively observe the influence of sport factors on (i) PA-levels, and (ii) changes in PA-levels, in older adolescents from urban communities. We hypothesized that sport participation in earlier adolescence (i) will have positive impact on PA and (ii) will prevent PA-decline in late adolescence.

Methods

The participants were adolescents from urban communities from three cantons in Bosnia and Herzegovina (B&H; Tuzla-, Western Herzegovina-, and Herzegovina-Neretva Canton). Participants were attending their 3rd year of high-school (approximately 16 years of age) at study baseline, and the follow-up testing was commenced at the end of their 4th year of high school (approximately 18 years of age), approximately 20 months after baseline testing (2nd wave). Since previous studies identified clear influence of community (urban/rural) on changes in PA levels (Miljanovic Damjanovic et al., 2019), in this study we were specifically focused on urban children.

In the first phase of the sampling procedure we stratified all the high schools in selected cantons into two groups according to their size. Second, we randomly selected one-third of the 3rd-year classes from two defined groups. Then, the investigators residing in B&H (please see authors of the paper) visited schools and distributed the consent forms, which were duly signed by one of the parents/responsible adults. The baseline testing was performed in the following week. The testing was anonymous, but we asked participants to use self-defined confidential code to pair the responses at two testing waves. They were instructed about the study aims, that testing was absolutely anonymous, and that they could leave the questionnaire unanswered. After testing, participants placed the questionnaire form in the closed box. The procedure and study fulfilled ethical guidelines and was approved by ethical board of University of Split, Faculty of Kinesiology (Split, Croatia).

The variables included participants' sociodemographic characteristics (gender, age [in years]), sport factors, and PA levels. The PA levels were tested by the Physical Activity Questionnaire for Adolescents (PAQ-A). In short, PAQ-A was repeatedly found to be a reliable and valid questionnaire in samples similar to one observed herein (Pojskic & Eslami, 2018; Samaržija & Mišigoj-Duraković, 2013). The questionnaire consists of nine items asking participants to provide seven-day self-report recall, with a final theoretical score ranging from 0 (minimum) to 5 (maximum PA level). The first 8 items include questions on various types of PA (i.e., PE activity during sports, physical education, sports, active transportation). Generally, the PAQ-A provides a composite PA score derived from eight items (the 9th item does not contribute to the overall score). On the basis of this instrument we observed three variables: (i) PA-level at study baseline, (ii) PA-level at follow-up, and (iii) PA-changes (obtained as the difference between baseline and follow-up PA levels). Consequently, we were able to identify two categories of adolescents: (i) those whose PA levels declined and (ii) those whose PA levels inclined during the study period, which was later used as the criterion variables in logistic regression calculation. Sport factors were tested at baseline, and included questions asking students about their sport participation: (i) involvement in competitive team sports and (ii) involvement in competitive individual sports (both reported as never involved, quit or currently involved), (iii) highest competitive sport-achievement/result (never involved/competed, locally, nationally/internationally), (iv) duration of sport involvement (never participated, <1 year, 2–5 years, > 5 years) (Zenic et al., 2019)

Descriptive statistics included means and standard deviations (for numerical variables); and percentages and frequencies (for ordinal and nominal variables). Student's t-test was used to compare PA-levels. The associations between variables were evidenced by: (i) Spearman's rank order correlations (to identify correlations between sport-factors and PA-levels), and (ii) logistic regression analysis (to evidence influence of studied variables and on PA-changes observed as binomial criterion [PA-incline vs. PA-decline]; for those adolescents who did not report active sport participation at study baseline), with Odds ratios (ORs) with 95% confidence intervals (95% CIs) reported. A p-value of 95% was applied, and the statistical package Statistica ver. 13.0 (Statsoft, Tulsa, OK) was used for all calculations.

Results

Table 1 *Descriptive statistics (F – frequencies, % – percentage) for sport factors obtained at baseline*

	Total		Males		Females	
	F	%	F	%	F	%
Participation in individual sport						
Yes, still participating	70	21.60	56	32.56	14	9.21
Quit	120	37.04	62	36.05	58	38.16
No, never	134	41.36	54	31.40	80	52.63
Participation in team sport						
Yes, still participating	66	20.37	50	29.07	16	10.53
Quit	164	50.62	92	53.49	72	47.37
No, never	94	29.01	30	17.44	64	42.11
Experience in sport						
Never participated	66	20.37	22	12.79	44	28.95
< 1 year	60	18.52	22	12.79	38	25.00
2–5 years	108	33.33	62	36.05	46	30.26
> 5 years	90	27.78	66	38.37	24	15.79

	Total		Males		Females	
	F	%	F	%	F	%
Competitive achievement						
Never competed/participated	150	46.29	70	40.70	80	52.63
Local	138	42.59	86	50.00	52	34.21
National/International	36	11.11	16	9.30	20	13.16

When observed at baseline, 20% of participants were never involved in sports, with males being more involved in sports than females (13% and 29% non-involved for males and females, respectively). These figures were logically followed with higher sport competitive achievement and longer sport involvement among males (Table 1).

The PA-level significantly declined over the course of the study in total sample (t-test: 6.60, $p < 0.01$) among females (t-test: 3.51, $p < 0.01$), and males (t-test: 5.04, $p < 0.01$). Further, PA-level in males was significantly higher than in females (t-test: 8.73 and 6.71, $p < 0.01$ at baseline and follow-up, respectively) (Figure 1).

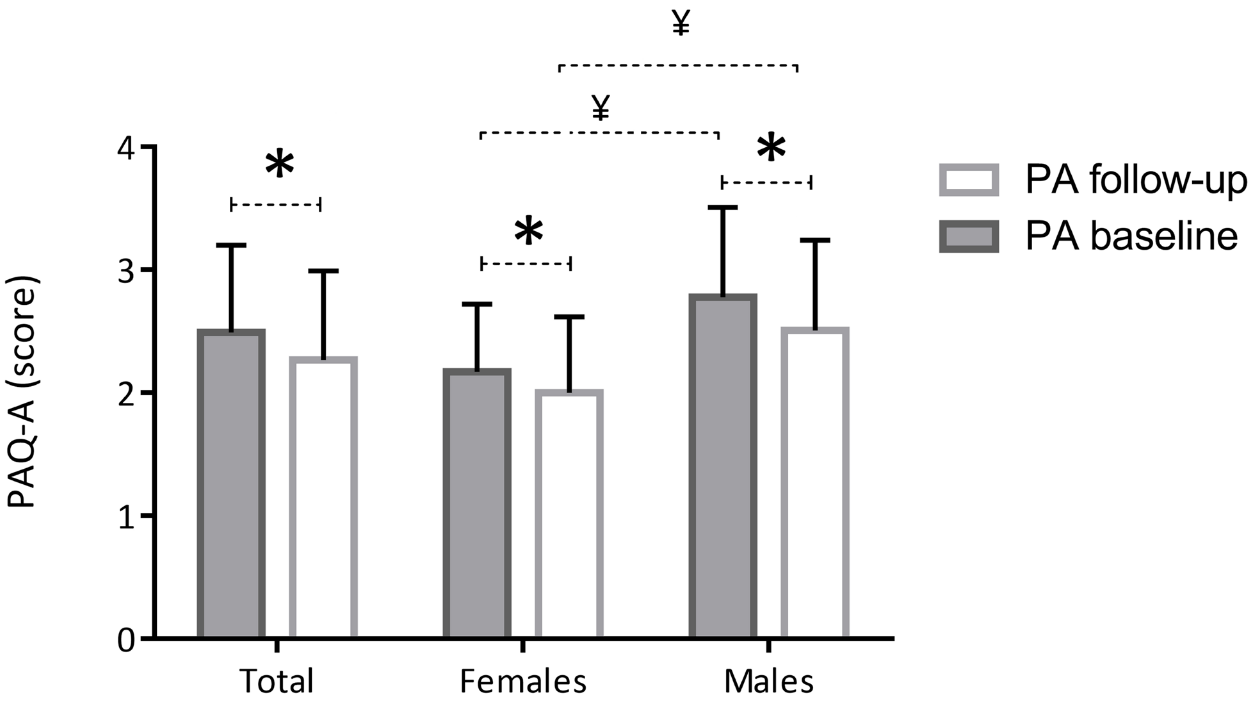

Figure 1 *Descriptive statistics (Means + Standard Deviations) for the physical activity as obtained by Physical Activity Questionnaire for Adolescents (PAQ-A) with t-test differences between groups (* indicates significance of p < 0.05) and within groups (¥ indicates significance of p < 0.05)*

Table 2 *Spearman's rank order correlation between sport factors and physical activity levels (PAQ-A) obtained at study baseline follow-up and physical activity changes over the course of the study course (differences)*

		PAQ-A (baseline)	PAQ-A (follow-up)	PAQ-A (differences)
Participation in individual sport	Total	0.39*	0.30*	0.02
	Males	0.29*	0.19*	0.05
	Females	0.31*	0.32*	0.07
Participation in team sport	Total	0.45*	0.41*	0.03
	Males	0.43*	0.41*	0.00
	Females	0.33*	0.32*	0.01
Experience in sport	Total	0.41*	0.38*	0.00
	Males	0.44*	0.37*	0.05
	Females	0.18*	0.33*	-0.10
Competitive achievement	Total	0.31*	0.45*	0.00
	Males	0.45*	0.39*	0.08
	Females	0.11	0.32*	-0.12

Sport-related factors were positively associated with PA at baseline (Spearman's R: 0.33–0.45, $p < 0.01$), and PA at follow-up (Spearman's R: 0.32–0.45, $p < 0.01$). Meanwhile, there was no significant correlation between studied predictors and differences in PA-levels between baseline and follow-up (Table 2).

The logistic regression calculated in order to identify possible association between sport factors at study baseline and changes of PA observed as binomial criterion (PA-incline vs PA-decline) did not reveal any significant influence of predictors on criterion (Figure 2)

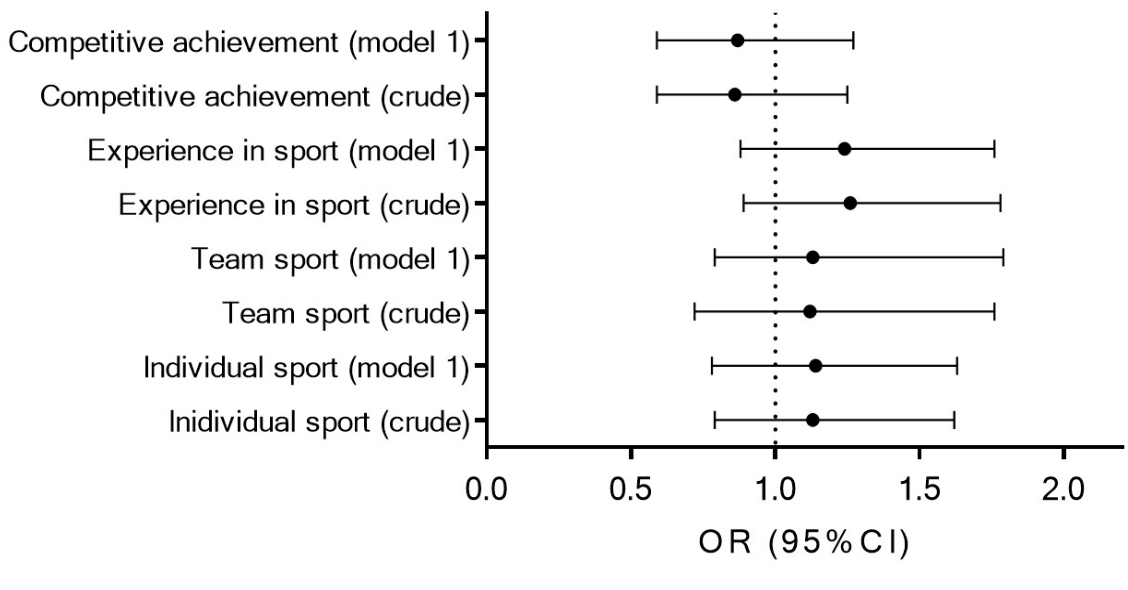

Figure 2 *Results of logistic regression calculated for binomial criterion PA incline vs. PA decline over the course of the study (model 1 – model adjusted for gender as covariate; crude – nonadjusted regression model) for those participants who did not report active sport participation at study baseline*

Discussion

It is globally confirmed that sport participation plays important role in PA in childhood and adolescence (Sallis, Prochaska, & Taylor, 2000). However, recent studies confirmed that sport participation actually increases the PS levels not only throughout sport participation “per-se”, but children who are actively involved in sport are more likely to have higher levels of everyday PA than their non-athletic peers (Telford et al., 2016). The mechanism of such influence was logically explained throughout differences in fitness status between sport participants and non-exercising children. In brief, those children who were engaged in sport were more likely to have better fitness allowing them to be generally physically active (Telford et al., 2016). Although we did not observe the PA levels in details, our findings are generally supportive to such considerations, because of the evident positive correlation between different sport factors and PA in studied adolescents, irrespective of gender.

With regard to eventual differential influence of various studied sport factors on PA level, we did not evidence that some of the studied factors are more or less correlated with PA levels. However, it seems that correlation between sport factors and PA level in increases in females, while decreases in males during the course of the study (note that for females correlation coefficients are numerically higher in follow-up). For a moment we can therefore hypothesize that sport participation in females induce certain positive tendency toward physical activity, which is evidenced even after they quit organized (competitive) sports. On the other hand, such tendencies are not evidenced from males. Most probably, the differences in the original motives for sports participation between genders could explain such findings. In brief, while girls prefer fitness and sociability as motives for sport participation, boys are more oriented toward “competitive motives” (i.e. “I want to be a sport star”, “To be popular”, “Enjoyment in competition”) (Soares, Antunnes, & van den Tillaar, 2013). As a result, with the end of “competitive sport engagement” girls are more likely to participate in other types of physical activities (i.e. fitness exercising, outdoor activities) than boys.

Our results did not confirm that sport participation in adolescence is a factor which influence changes in PA activity between 16 and 18 years of age. This is particularly important finding, since this period of life is known to be characterized by significant decrease in PA level, while sport participation is frequently observed as “preventive” against such decrease (Dumith, Gigante, Domingues, & Kohl III, 2011). Since in this analysis we included only participants who did not report active sport participation at study baseline, it is clear that results actually do not confirm the hypothesis about “protective effect” of sport participation in adolescence against decrease in PA level. From the authors’ perspective, as former athletes and active sport pedagogues, the most probable explanation of such findings could be found in “orientation to success”, which is dominant approach in youth sport in the country. In other words, sport programs in adolescence are mostly oriented toward competitive achievement, and therefore children are not properly educated about positive outcomes of sport participation which will be important later in life (i.e. health related fitness, positive social consequences).

Conclusion

While sport factors were correlated with PA levels at study baseline and follow-up indicating higher PA level in adolescents involved in competitive sports, sport factors were not identified as being significant predictors of changes in PA levels between the age of 16 and 18 years. Therefore, we may support only the first of our study hypotheses (i.e. on positive association between sport participation and PA-levels in adolescents). The most probable explanation for lack of influence of sport participation on PA-changes in late adolescence may be found in lack of “health-education approach” in adolescent sport participation. Knowing the importance of PA and globally confirmed decrease of PA-levels in late adolescence, future studies are needed in order to identify the correlates of PA-changes in this period of life.

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THE IMPACT OF DIFFERENT TYPES OF PHYSICAL ACTIVITY ON WALKING AS A VITAL EVERYDAY MOVEMENT IN OLDER ADULTS

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Lenka Svobodová, Martin Sebera, Kateřina Strašilová, Tomáš Hlinský, Marie Crhová, Andrea Martincová, Petr Vajda, Nikola Stračárová

Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

ABSTRACT

Introduction: Due to an international trend of the aging population, we see increased attention paid to studies dealing with the factors that have a positive or negative impact on successful aging. As we know, a higher level of physical activity and thus increased physical fitness significantly affect the quality of aging. One of the major problems in the elderly is the risks of falls. This age group is at high risk of injuries caused by falls. Analyses of aspects related to the falls revealed the significance of lower muscular tension, previous experience with falling, the bad stereotype of the walk, impaired balanced abilities, and so on.
Purpose: In this study, we focused on the impact of different types of physical activity on walking as a vital everyday movement.
Methods: Fortyfour older adults (M_{age} 69,09 years, SD 4,25; 22 male and 22 female) were randomly assigned to four groups, three training groups, and one control group; resistance training group, proprioceptive training group, endurance training group. The group consisted of seniors without a history of malignant disease during their life and without regular physical activity. All groups were tested on timed 10-meter walk test (10MWT), the 3-m backward walk (3MBW), and the 6-minute walk test (6MWD) at baseline, after 12 weeks and after 14 weeks (2 weeks after finishing intervention program). The 10MWT is used to assess walking speed over a short distance. The 3MBW is a test-close related fall risk. The 6MWD is a sub-maximal exercise test used to assess aerobic capacity and endurance. The distance covered over a time of 6 minutes is used as the outcome by which to compare changes in performance capacity. *Results:* We revealed differences between the types of exercises and the sustainability of the acquired skills. Results indicated significant improvements in gait speed in all exercise groups. Subsequent measurements after a 14-day off indicated a slight deterioration trend in all groups. The resistance group showed the best results in the walk-back test. This group was the only one to maintain its standard also after 14-days off. All groups, including control, showed an improvement in aerobic capacity and endurance (measured by 6MWD). We found out differences between groups only after 14-day off.
Conclusion: Our study confirmed the usefulness of performing targeted physical activity in older adults. Resistance and proprioceptive training has shown an important role in the prevention of falls.

Keywords: resistance training; proprioceptive (balance) training; endurance training; prevention of falls; older adults; gait

Introduction

Due to an international trend of the aging population, we see increased attention paid to studies dealing with the factors that have a positive or negative impact on successful aging.

Being physically active makes it easier to perform activities of daily living, including eating, bathing, toileting, dressing, getting into or out of a bed or chair, and moving around the house or neighborhood. Physically active older adults are less likely to experience falls, and if they do fall, they are less likely to be seriously injured (U.S. Department of Health and Human Services, 2018).

And falls are one of the main risk factors in the life of older adults. This age group is at high risk of injuries caused by falls. Analyses of aspects related to the falls revealed the significance of lower muscular tension, previous experience with falling, the bad stereotype of the walk, impaired balanced abilities, and so on.

In this context, we selected three types of physical activity and investigated their impact on the level of walking. Walking was conceived as a daily basic physical activity and its score as an estimate of the risk prediction of falls, confirmed by numerous studies. For our purposes, we have selected three types of training based on the study of scientific articles on this topic, resistance training, proprioceptive training, and endurance training.

Regular resistance training (RT) and increased amount of muscle mass can induce many health benefits and increase life quality (Barbalho et al., 2018), decrease the risk and fear of falls, reduce mortality (Dankel, Loenneke, & Loprinzi, 2016) and enhance the opportunities to practice regular sport activities in everyday life (Adams, Swank, Barnard, Berning, & Sevene-Adams, 2000). According to study by Fragala (2019) „a properly designed resistance training program for older adults should include an individualized, periodized approach working toward 2–3 sets of 1–2 multijoint exercises per major muscle group, achieving intensities of 70–85% of 1 repetition maximum (1RM), 2–3 times per week, including power exercises performed at higher velocities in concentric movements with moderate intensities (i.e., 40–60% of 1RM)“. For good designing of effective resistance training, we use 1-RM. The 1-RM test is considered as an efficient and reliable method of determining maximum strength (Barbalho et al., 2018). It has been many times validated (Schroeder et al., 2007), and it is regarded as safe if all recommendations are followed (Shaw, McCully, & Posner, 1995)

Postural stability, gait, and balance decrease with age (Baloh, RW, Ying, SH, and Jacobson, KM. 2003). Although various factors are associated with falls, gait, and balance deficits have been identified as some of the most important intrinsic fall risk factors in older adults (Shumway-Cook, A, Brauer, S, and Woollacott, M., 2000). Many authors have described that dynamic balance improvement is associated with a decrease in risk of falls and fear of falling and improvement in quality of life (Matsumura, BA and Ambrose, AF., 2006). That is why many authors carried out studies that verify proprioceptive training in older adults (Sérgio Garcia, 2015; TatsuyaHirase, 2015; Yanan Zhao, 2017; Martínez-Amat, 2013*).* Older adult's postural stability is considered important to perform common activities of daily living, such as walking, turning, and so forth. And because of the elevated number of facts and perceptions involved in the maintenance of postural stability, it is challenging to improve postural stability with the appropriate training. Many studies include unstable surfaces in proprioception training. This type of training stimulates the proprioceptive system producing motor responses and stabilizing the joints from the three levels of neural protection (McArdle, WD, Katch, FI, and Katch, VL., 2000). Different tools, such as Swiss ball and BOSU, have been used to create instability (Sherrington, C, Lord, SR, and Finch, CF., 2004).

Endurance training can include many types of physical activity. Nordic walking is one form of exercise that has gained a lot of interest among middle-aged and older adults. Previous studies concerned higher heart rate and oxygen consumption and energy cost than walking without poles (Terttu Parkatti, Jarmo Perttunen, and Phyllis Wacker, 2012; Schiffer et al., 2006; Hansen & Smith 2009; Saunders, Hipp, Wenos, & Deaton, 2008).

This outcome is the first partial area of the project “Predictive Role of Molecular Biomarkers for Determination of Physical Fitness, Early Parameters of Cardiovascular Risk and Aging in the Czech Senior Population and Determining the Impact of Intervention Programs on Selected Parameters”.

Purpose

In this study, we focused on the impact of different types of physical activity on walking as a vital everyday movement and one of the main predictors risk of falls.

Methods

- Sample

Fortyfour older adults (M_{age} 69,09 years, SD 4,25; 22 male and 22 female) were randomly assigned to four groups, three training groups, and one control group; resistance training group, proprioceptive training group, endurance training group. The group consisted of seniors without a history of malignant disease during their life and without regular physical activity. The group was homogeneous in age. Nobody from participants dropped out.

- Intervention program

The subjects included in the experimental group participated in a 12-week intervention training program, performed two days per week (60 minutes), with a total of 24 sessions.

Resistance training

Training consisted of 3 sets per exercise per muscle group, 8–12 repetitions, intensity 70–80% of 1RM, exercise selection 8–10 different exercises, modality free-weight or machine-based exercises. Each session included a 10-min. warm-up, ended with a 5-min. cooldown period. Students specialists carefully supervised each exercise at each spot.

Proprioceptive training

Intervention programs consisted of specific proprioceptive exercises that were conducted in static and dynamic positions with the bosu and gym ball as unstable training tools that were designed to program proprioceptive training. Training was progressively structured in 2 or 3 phases. The exercise sessions were carefully supervised by a fitness specialist and program, and finishing with a 10-min. cooldown period of stretching and relaxation exercises (Antonio Marti´nez-amat, 2013)

Endurance training

Before the intervention, a certified Nordic walking trainer taught the Nordic walking technique to the participants following the guidelines. The intervention included standard Nordic walking exercise in the surrounding forest. Each session ended with a 5-min cooldown period of slow walking and stretching. During the training, participants were instructed to walk as fast as it was comfortable. Training intensity was based on the subjective perception of exertion.

Control group

Participants of the control group were asked not to change their activity levels and medication during the 12-week intervention period.

- Measurement

All groups were tested on timed 10-meter walk test (10MWT), the 3-m backward walk (3MBW), and the 6-minute walk test (6MWD) at baseline, after 12 weeks and after 14 weeks (2 weeks after finishing intervention program without training). The 10MWT is used to assess walking speed over a short distance. The 3MBW is a test-close related fall risk. The 6MWD is a sub-maximal exercise test used to assess aerobic capacity and endurance. The distance covered over a time of 6 minutes is used as the outcome by which to compare changes in performance capacity.

- Data analysis

After no rejecting hypothesis of normality, we chose parametric statistical methods. Differences among groups we calculate with use of one-way analysis of variance (ANOVA). Post hoc test, we chose Scheffe´s test. For the calculating size of effect, we used eta-square. We used SW Statistica 13.3 by TIBCO.

Results

- Baseline

First, we test if there is a difference among groups in baseline. Using one way ANOVA, we found out there are no statistically significant differences.

The graphs below present the results of the selected tests.

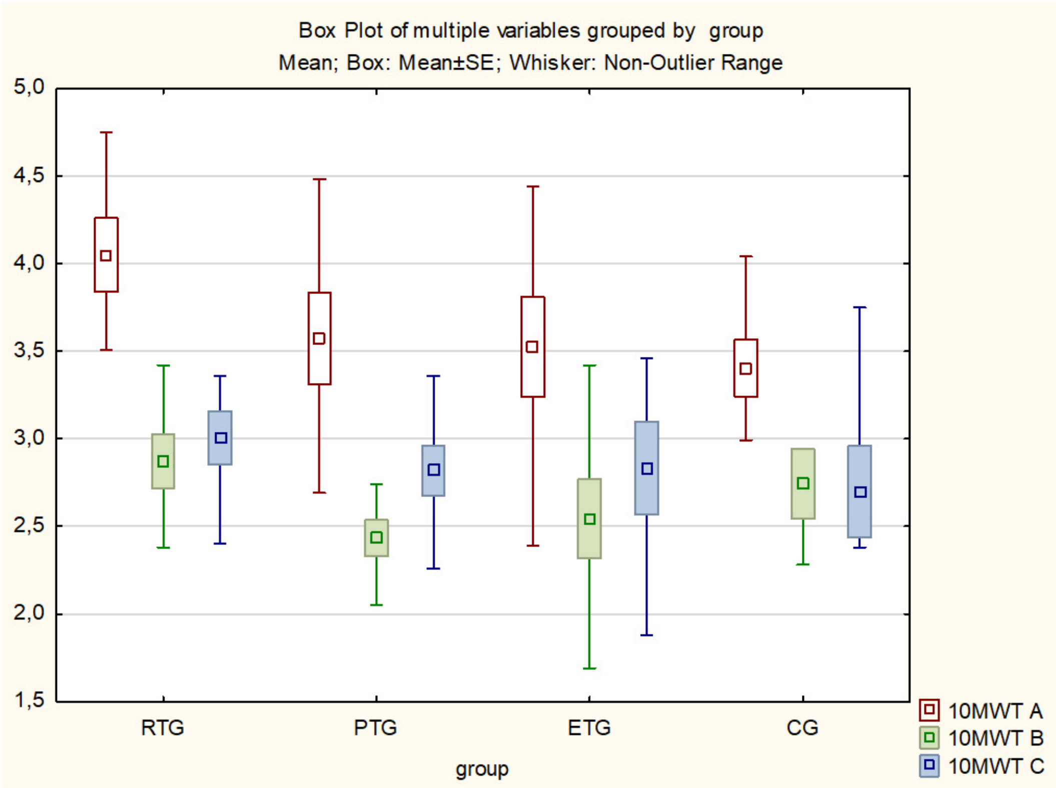

Figure 1 *The 10-meter walk test (10MWT)*

All training groups followed the same trend. Measurement results immediately after the end of the intervention program showed a statistically significant improvement. Measurements after 14 days without training showed a slight deterioration, and this effect is not statistically significant. The control group showed an improvement in the endpoint. The statistical significance of the effect was not confirmed.

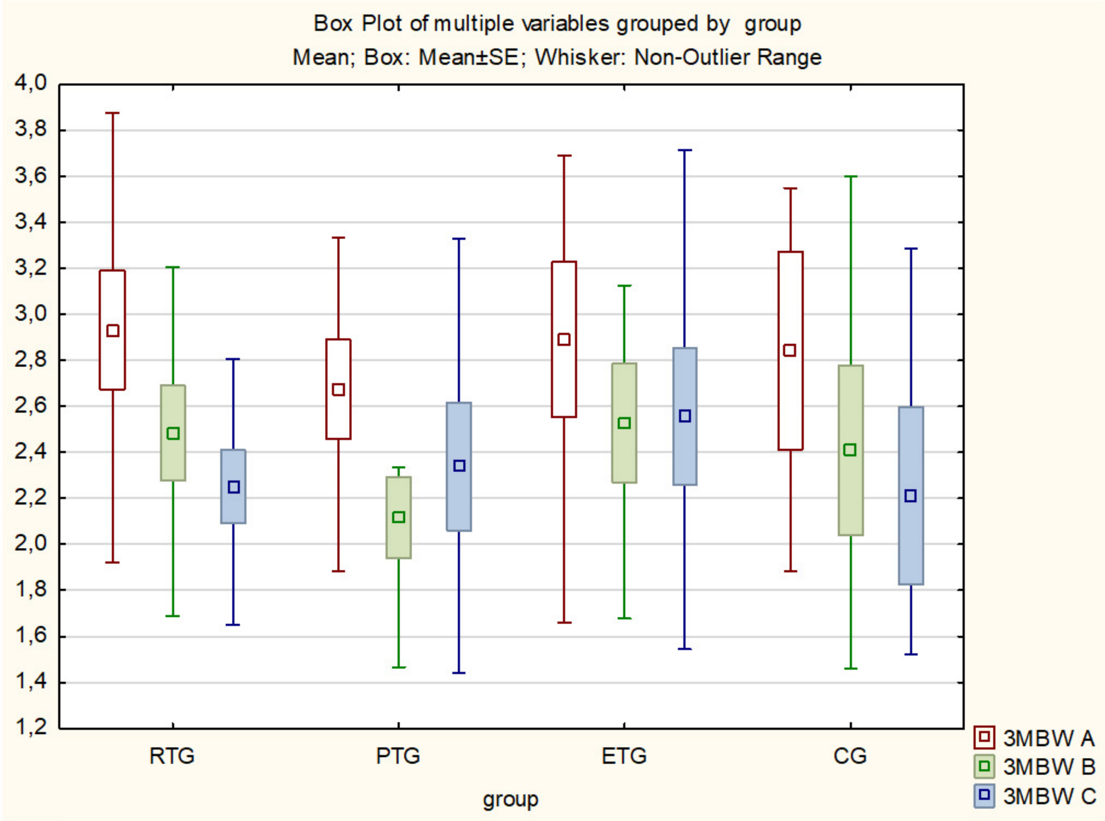

Figure 2 *The 3-m backward walk (3MBW)*

We revealed differences among groups in this test. The resistance training group (RTG) showed the best results in the 3-m backward walk (3MBW). This group was only one to maintain its standard also after 14 days off. Evidence-based on statistical significance. The proprioceptive training group (PTG) also showed statistically significant improvement, but only immediately after finishing the intervention program. Other groups improved, but there were no statistically significant changes.

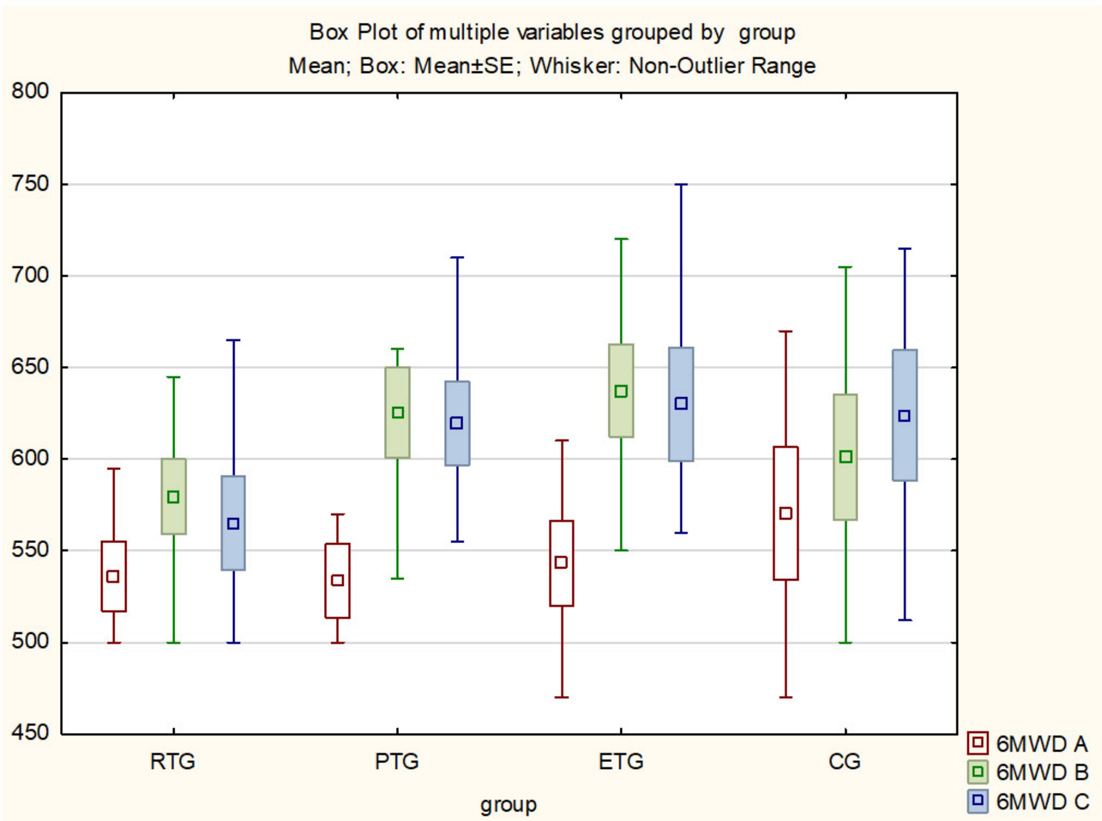

Figure 3 *The 6-minute walk test (6MWD)*

All observed groups showed a statistically significant improvement between the first and second measurements. Repeated measurements after 14 days showed no significant changes.

Discussion and Conclusion

For good designing of effective exercise programs that can help older adults maintain or improve their mobility are important to the understanding of the physical attributes needed for mobility tasks in later years. And also, the ability to assess physical attributes so that that client weaknesses can be detected and then targeted for individualized programming.

We investigated the influence of the particular type of training on various walking tests. We consider walking to be a basic motor skill related to self-sufficiency in senior age. We chose three tests, a short walk test for speed, a walk test for 6 minutes, and a short backward walk. The 10-meter walk test (10MWT) assess functional mobility, gait, and vestibular (Shirley, 2019). Each of our type of training has a positive effect on gait speed.

Several measures of fall risk have been previously developed and include forward walking, turning, and stepping motions. However, recent research has demonstrated that backward walking is more sensitive at identifying age-related changes in mobility and balance compared with forward walking (Carter et al., 2017).

The 6-minute walk test (6MWT) is a submaximal test to assess load tolerance. The test evaluates the distance traveled by the respondent in 6 minutes at the highest speed. A six-minute walk test is commonly used to measure functional performance. Standard estimates from 6MWD to METs and VO_{2max} can also show an indicator of cardiorespiratory fitness. VO_{2max} is generally regarded as the best indicator of cardiorespiratory fitness. (STENSVOLD et al., 2017). According to the American Heart Association (AHA), a low VO_{2max} – meaning a higher fitness age – is associated with increased risk of cardiovascular disease and all-cause mortality. People who have lower cardiorespiratory fitness also have a higher risk of developing certain cancers, including lung, breast, and gastrointestinal cancers. VO_{2max} can predict the risk of early death even better than some traditional risk factors like being overweight, high cholesterol, or smoking. So, you could say fitness age might be a better predictor of longevity than chronological age (Ross et al., 2016)

We can confirm the general statement that an active lifestyle can lead to improve or maintain several parts of functional mobility that revealed 10MWT and 6MWT. Training is already required for more demanding movement tasks. How it confirms the 3MBW test and how they verify studies on conducted training seniors (Barbalho et al., 2018; Dankel, Loenneke, & Loprinzi, 2016; Adams, Swank, Barnard, Berning, & Sevene-Adams, 2000; Fragala, 2019).

Acknowledgments:

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STRENGTH AND CONDITIONING TRAINING

PHYSICAL FITNESS OF ARMY FORCES OF THE CZECH REPUBLIC

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Martin Bugala

Masaryk University, Faculty of Sports Studies, Brno, Czech Republic

ABSTRACT

Introduction: The activities of security forces and armed forces depend on two parameters: psychological level and physical fitness. These two components are the main parts of the selection procedure. Physical fitness is a topic to be discussed, especially in regard to security forces or armed forces (Bonneau, Brown 1995; Sörensen *et al*. 2000). Physical preparation fundamentally affects the performance of a policeman or a soldier and it is associated with stress management and service interventions or combat tasks (Gershon *et al*. 2008; Darryl 2000). This research is focused on physical fitness of the army forces. Further this research is important not only because it should result in expanding the portfolio and knowledge enriching study fields, such as the Special education of Security Bodies (SESB) and Applied Sport Education of Security Bodies (ASEBS) at the Faculty of Sports Studies of Masaryk University, but it also aspires to be of great contribution for security forces or armed forces themselves (Bugala, Reguli, Čihounková 2015; Reguli, Bugala, Vít 2016).
*Aim***:** The aim of the study is to find out the physical fitness level of the Army forces of the Czech Republic.
Methodology: Research design as descriptive and quantitative. The data of the physical fitness test was collected from the individual Army forces of the Czech Republic in the last 4 years (2015, 2016, 2017, and 2018). The quantitative data were analysed on the basis of the statistical methods. After executing the basic statistical and normality tests, we focused on ANOVA. The total number of respondents was in 776. The ratio between genders was 698:78.
*Results***:** After comparing physical fitness tests with Sit UP, Press Up, Pull Up, Stay in Pull Up, Cooper Test, and Swimming 300m over the past four years, there was no significant change in physical fitness. All disciplines had almost the same value except for the exercise with the name Stay in Pull Up. This exercise is for women. Fifteen women were tested in 2015, twenty-five women were tested in 2016, twenty-eight women were tested in 2017 and only ten women were tested in 2018. The small number of women, who tested is caused by the fact, that women are not as common in Army as men.
Conclusion: We can say that the emphasis on the physical performance in Security and Army forces is still up to date. We did not notice any significant differences between the years 2015, 2016, 2017 and 2018 tested. Thanks to this finding, we can state that there is a continuous maintenance of physical fitness in the Czech Republic's army.

Keywords: Army forces; physical fitness; physical fitness tests; security forces performance

Introduction

The activities of security forces and armed forces depend on two parameters: psychological level and physical fitness. These two components are the main parts of the selection procedure. Physical fitness is a topic to discussed, especially in regard to security forces or armed forces (Bonneau, Brown 1995; Sörensen et al. 2000). Physical preparation fundamentally affects the performance of a policeman or a soldier and it is associated with stress management and service interventions or combat tasks (Gershon et al. 2008; Darryl 2000). Thanks to good physical preparation members of the army forces they are able to manage stress situations not only during model situations, but in real war. According to Yerkes-Dodson law optimal task performance occurs at an intermediate level of arousal. Therefore, it is necessary to monitor physical readiness so as to avoid the reduction of combat abilities in the event of an excessive burden (Vít, Kohoutková, Bugala, & Sebera, 2014).

This research is focused on physical fitness of the army forces. Further this research is important not only because it should result in expanding the portfolio and knowledge enriching study fields, such as the Special education of Security Bodies (SESB) and Applied Sport Education of Security Bodies (ASEBS) at the Faculty of Sports Studies of Masaryk University, but it also aspires to be of great contribution for security forces or armed forces themselves (Bugala, Reguli, Čihounková 2015; Reguli, Bugala, Vít 2016).

Aim: The aim of the study is to find out the physical fitness level of the Army forces of the Czech Republic.

Methodology

The work is conceived as descriptive and quantitative. For data collection we used the internal physical fitness testing of the Army forces of the Czech Republic in the last 4 years (2015, 2016, 2017, and 2018). Physical fitness tests consist of: Sit Up, Press Up, Pull Up, Stay in Pull Up, Cooper test and Swimming 300 m. All tests were carried out according to the internal methodology of the Army of the Czech Republic (Czech Army, 2019). The data were generated into the Microsoft Office Excel spreadsheet. Afterwards the data were transferred into the STATISTICA software where they were analysed. Then, as the very first step, we used descriptive statistics in order to detect extreme values and describe the research sample. We chose statistical significance α 0.05. Then, when testing the normality with $p \leq \alpha$, we did not confirm the normality of the data. Therefore, based on these results, we reject the hypothesis of the normality for all the questions. These facts have shown that it is necessary to use nonparametric tests in further statistical analyses. After executing the basic statistical and normality tests, we focused on ANOVA. We have rejected hypotheses about data normality, and therefore we have chosen the nonparametric Kruskal-Wallisova test for the independent variables. We have chosen the independent variables because we calculated with the fluctuations, which was about 15%.

Research sample: The research sample was 777 respondents it total and it is to be found further specified in Table 1. The average age was 40 years. The ratio between genders was 698:78, as you can see in Table 2. We focused on members of Army of the Czech Republic.

Table 1 *Basic characteristics of the research sample*

	Study sample N	Average	Median	Minimum	Maximum	Standard deviation
Age	776	40,32	40	22	60	6,320

Table 2 *Gender ratio*

Gender	Frequency	Cumulative frequency	Percentage	Cumulative frequency in percentage value
Male	698	698	89,948	89,948
Female	78	776	10,051	100,000
MD	0	776	0,000	100,000

Results

We conducted and compared individual physical tests: Sit UP, Press Up, Pull Up, Stay in Pull Up, Cooper Test, and Swimming 300m for years 2015, 2016, 2017 and 2018. Using boxplot we illustrate the evolution of discipline over the years. An overview of the average results over four years is shown in Table 3.

Table 3 *Overview of the average results for four years*

Variable	Descriptive Statistics of the disciplines			
	Valid N	Mean	Median	Std.Dev.
Sit-Up	1122	41,829	41,000	7,5747
Press Up	895	26,619	27,000	5,5997
Pull Ub	1709	11,229	12,000	2,5504
Stay in Pull Up (s)	78	0,368	0,355	0,1762
Cooper test (m)	2604	2602,302	2600,000	327,5088
Swimming 300 m (min)	460	5,840	6,080	0,8265

For comparative discipline we chose non-parametric Kruskal-Wallis test for independent variables. Single results for years tested are presented in boxplot number 1, 2, 3, 4, 5, and 6. There are we can see values and their comparison. On the boxplot number 4 called Stay in Pull UP, at the first there are view the main differences. This discipline is determined for women. It is a replacement for Pull Up. But these differences are not significant because 15 women were tested in 2015, 25 women were tested in 2016, 28 women were tested in 2017, 28 women were tested in 2017 and only 10 women were tested in 2018. For this reason, there have been statistic changes, as you can see on Boxplot number. 4. The small number of women, who tested is caused by the fact, that women are not as common in Army as men.

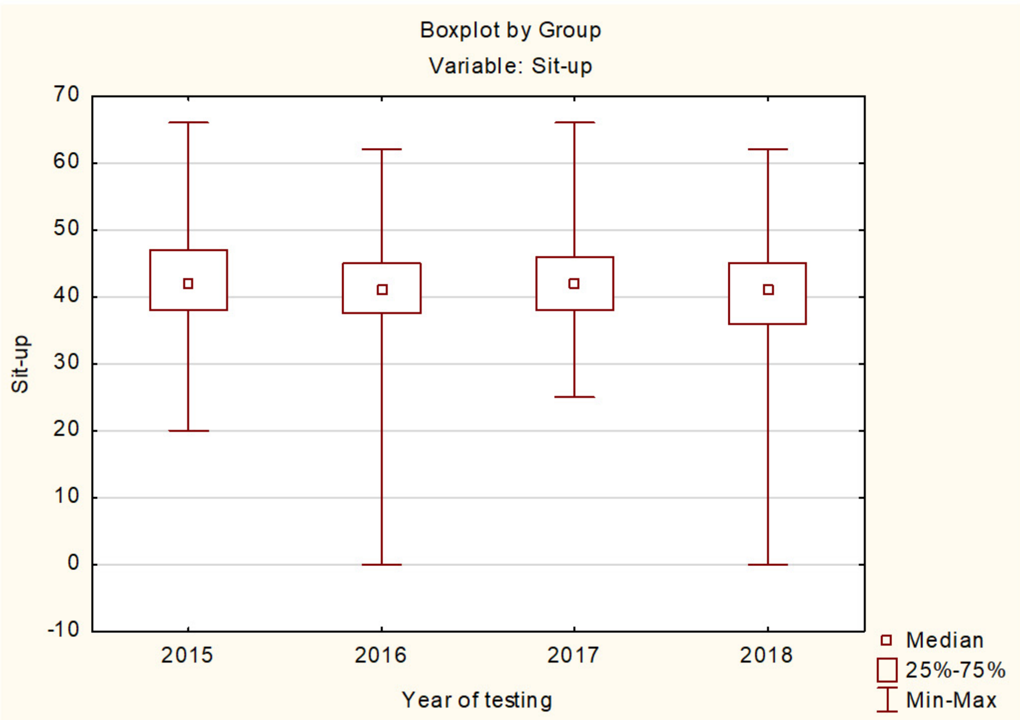

Figure 1 *Boxplot 1 Sit-up*

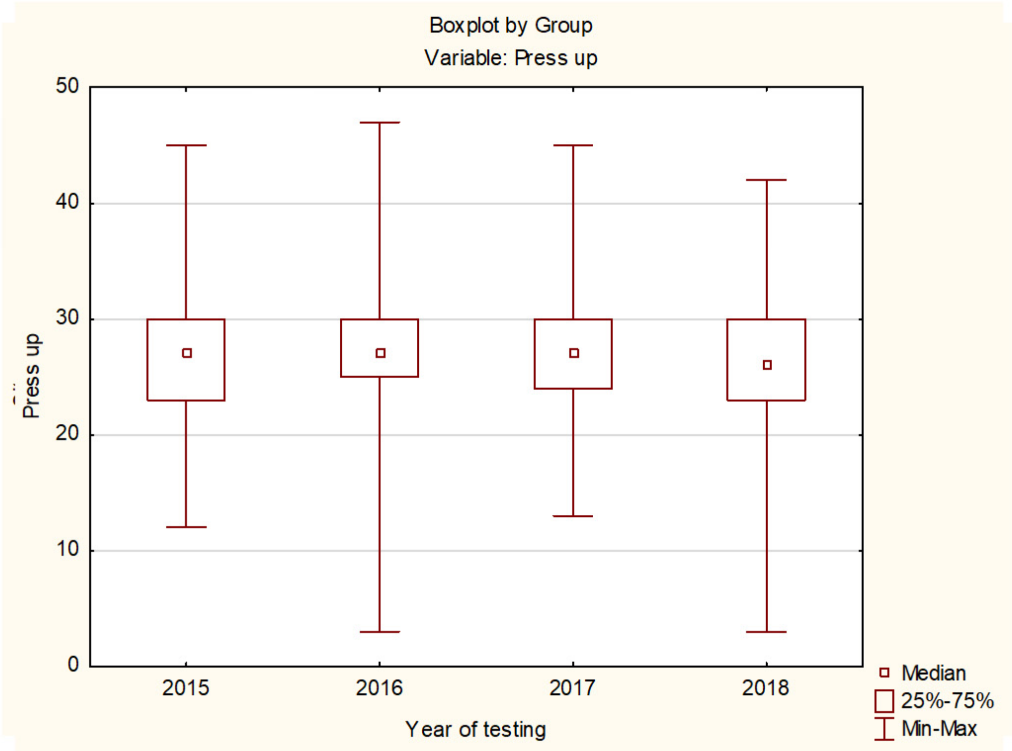

Figure 2 *Boxplot 2 Press Up*

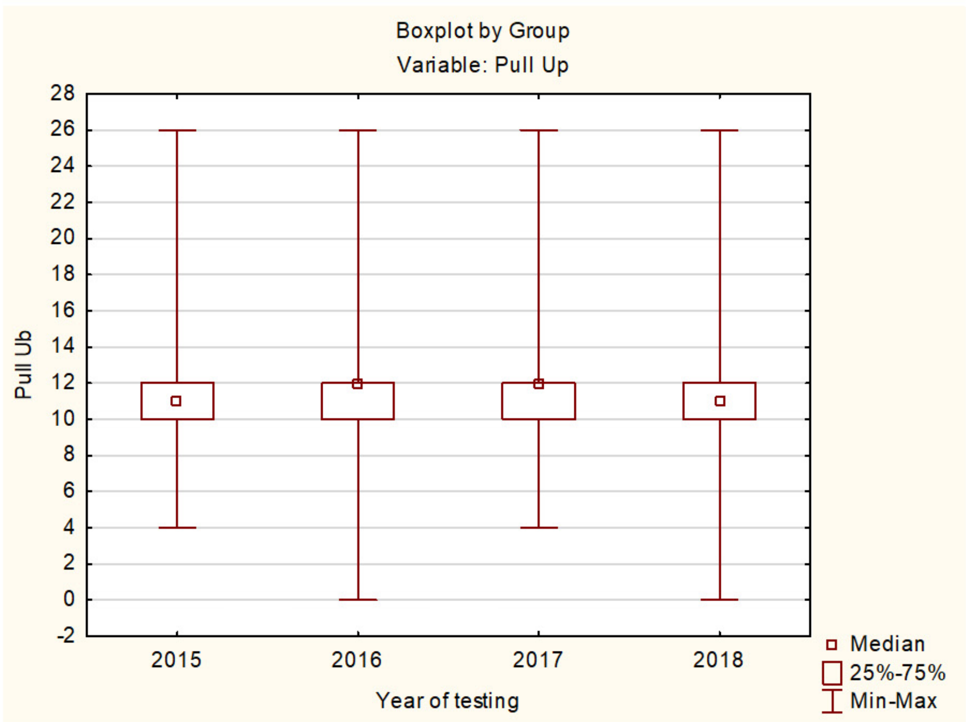

Figure 3 *Boxplot 3 Pull Up*

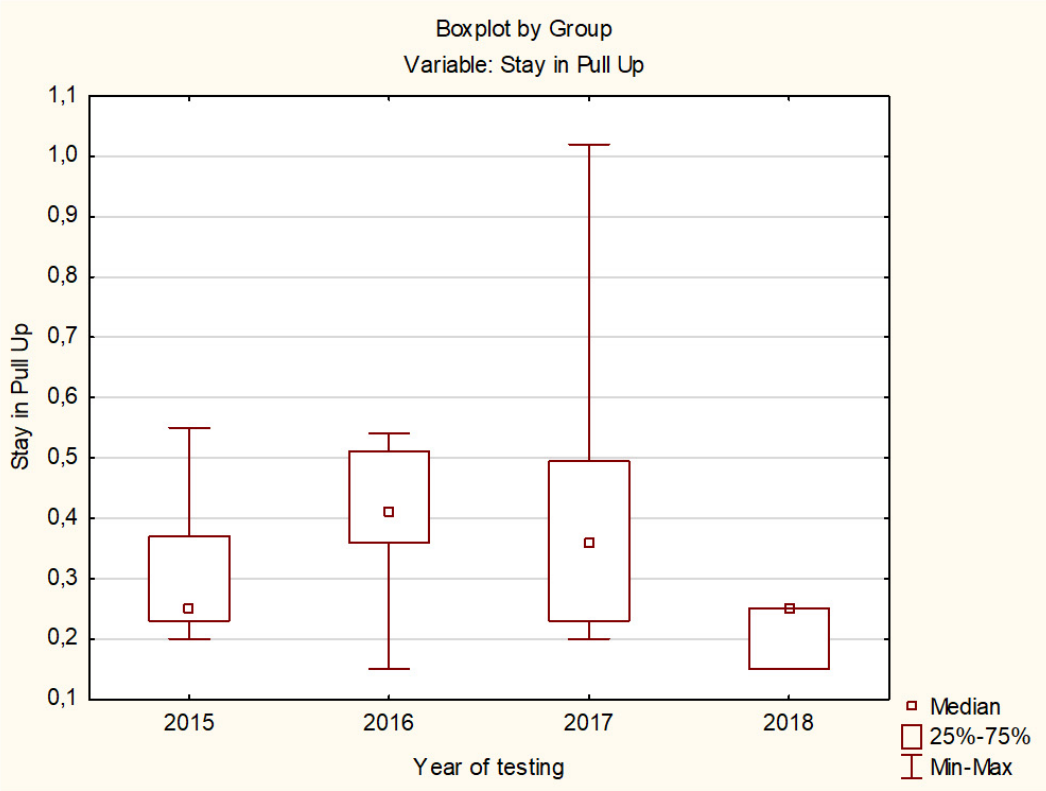

Figure 4 *Boxplot 4 Stay in Pull Up*

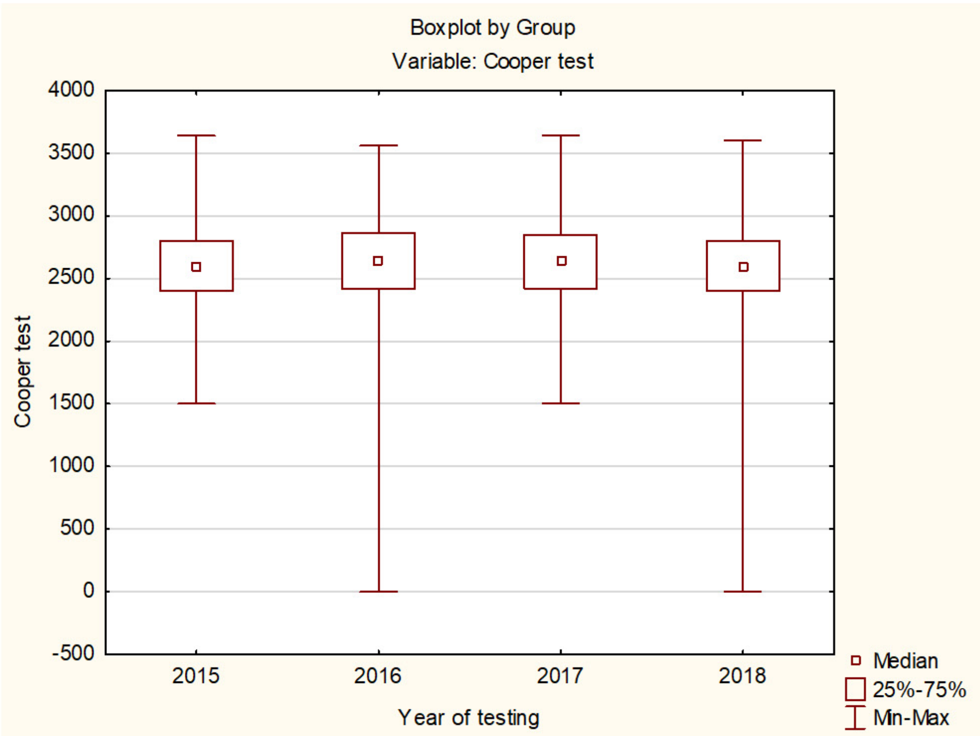

Figure 5 *Boxplot 5 Cooper test*

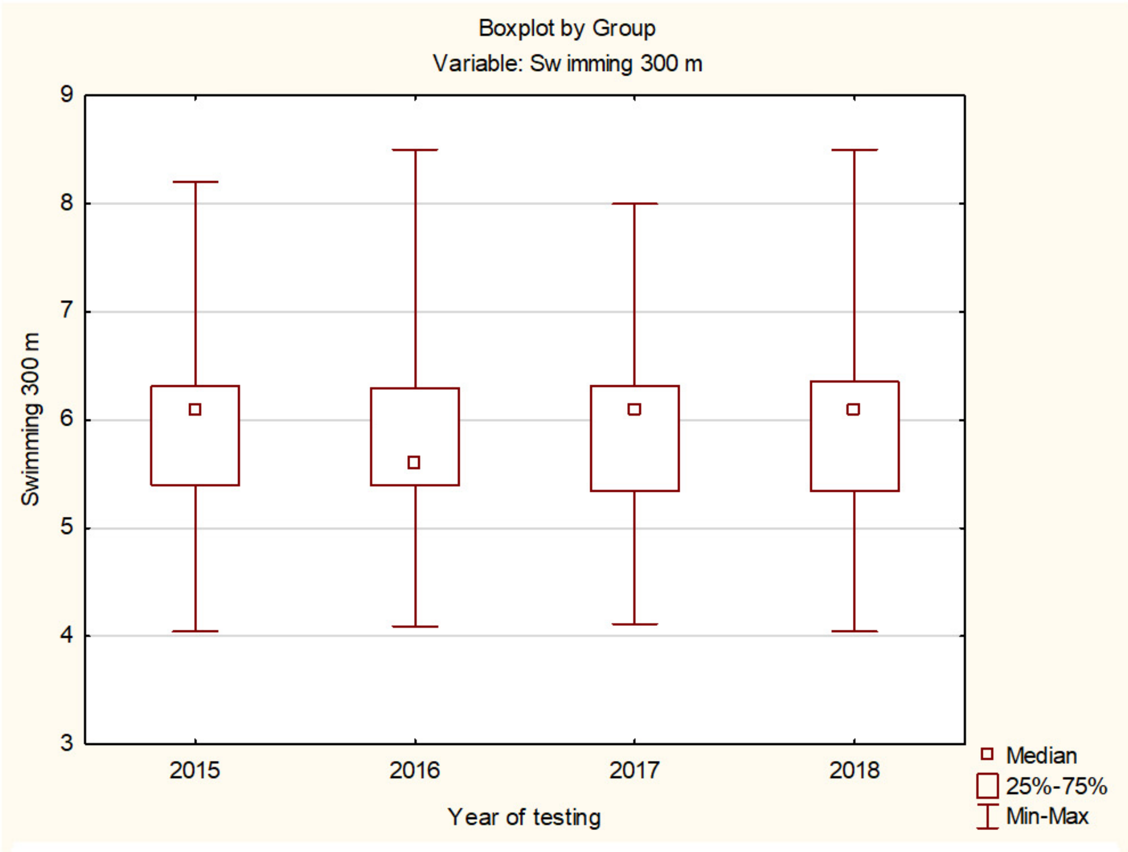

Figure 6 *Boxplot 6 Swimming 300 m*

Discussion

We can say that the emphasis on the physical performance in Security and Army forces is still up to date. The results are also confirmed by the fact that soldiers deal with physical activity and martial arts in their leisure time (Cihounkova & Kordik, 2015). We did not notice any significant differences between the years 2015, 2016, 2017 and 2018 tested. Thanks to this finding, we can state that there is a continuous maintenance of physical fitness in the Army of the Czech Republic. These results are positive, but it is necessary to constantly solve this problem and analyse it scientifically. As a result, any changes can be described and explained. The scientific approach is crucial and all findings should be based on scientific results and evidence (Reguli, 2018).

Conclusion

Physical fitness is very important for performance in the army profession. Being physically capable allows you to better manage stressful situations and perform tactical and combat tasks. The research presents results that clearly show that the soldiers maintain their physical level. This army approach is right. Physical fitness should still be a priority for the Army of the Czech Republic.

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EFFICIENCY OF JUMPING PREPARATION IN YOUNGER PUPILS IN ATHLETICS

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Ivan Čillík, Miriam Karperová

Department of Physical Education and Sport, Faculty of Arts Matej Bel University Banská Bystrica, Slovakia

ABSTRACT

The aim was to find out, compare and evaluate the efficiency of take-off preparation for selected indicators of motor performance in athletes in the category of younger pupils. The monitored group consisted of 5 girls (average age 12.4 ± 0.22 year) and 4 boys (average age 12.9 ± 0.12 year) regularly participating in the training process three times a week. During 8 weeks in the racing period, take-off preparation was applied in the training process, consisting of two different batteries of take-off drills. The take-off preparation took place two to three times a week, taking into account the participation of athletes in the race. We performed the following tests to determine the efficiency of the take-off preparation to change the level of motor performance in selected indicators: 50m run, 20m cursory run, standing long jump, vertical jump with countermovement without arm swing and repeated vertical take-off drills without arm swing in 10s. We found that in the output measurement, the athletes of monitored group achieved an improvement in motor performance in tests for explosive power of lower limbs and the maximum running speed tests.

Keywords: maximum running speed; take-off preparation; sport preparation; explosive power of lower limbs

Introduction

The basic task in training children according to Katzenbogner (2004) is to create fitness basics, to teach children simple but high quality motor skills and abilities, to create a space for new social links, meaningfully use their free time and thus shape their personality. Čillík (2004), Kučera et al. (2011) draw attention to the need for adequate training with regard to physical development and the level of adaptation skills. This is especially true in the age of 10–15 years, due to the turbulent changes in physical development, when children in athletics are in the stage of basic sports training. Change from childhood to adulthood – is typical for the age between 10 and 15 years. It is a period when the body undergoes significant changes, both biological and psychological, develops in the field of social relations and motor skills. This development is uneven, affects mainly motor skills and mental development, so it is necessary to take into account the specificity in the training of athletic disciplines (Čillík a kol., 2013). According to Hawkins (2010), by the end of the 10–15 years age period, children have increased aerobic capacity and their anaerobic capacity, along with the acceptance of the training stress that is placed on them, is generally becoming greater. Although their tolerance of negative effects during lactic acid accumulation is already at a better level, physical immaturity of bones, tendons, muscles and changes in body structure affect training methods in puberty. The training should provide general physical development achieved through general and versatile exercises that are relevant to the discipline. Sport-specific exercises in this phase of training create 15–25% of the training volume. Exercise volume increases more than intensity, increasing intensity must be carefully controlled.

Vanderka (2014) refutes myths about strengthening children and youth that talk about developing strength and negative influence on body growth and injuries. The development of strength abilities also affects the nervous, circulatory and respiratory systems, and this affects the development of the passive musculoskeletal system. Based on current knowledge in a complex understanding of the problem, strengthening seems to be very beneficial also in childhood. However, the assumption is a professional guidance in the application of fitness exercises. Exact scientific observations, together with the practical experience of youth trainers, show that even in children, muscle strength is manifested by improved performance across a range of speed-strength motor tests (e.g. vertical jump, acceleration and maximum speed).

Each manifestation of explosive power consists of two components: the velocity, which has sensitive periods in the ontogenesis of an individual under 12–13 years; we try to perform each exercise as quickly as possible, the number of repetitions in the series is low, or there is only one repetition - this achieves stimulation of this component, the problem at this age is to achieve an adequate concentration for one-time maximum acceleration; strength, which we improve through the development of muscles - this component is recommended to apply thoughtfully, especially due to the ontogenesis of the body. Sedláček et al. (2003) states that reflective explosiveness can be effectively developed from 9–10 years up to 18–20 years. In the period of 13–14 years, the most suitable conditions for the development of the speed component, e.g. the ability to reflect in the shortest possible time. For the age category 12–13 years, the most suitable take-off drills of horizontal and vertical character are performed without an additional load.

In relation to the setting up a training program, it is important to prevent an increase in the intensity of the training load by appropriate volume increasing (Corbin, Pangrazi, 2003). Shimon (2011) adds that the development of speed skills and agility has a firm and irreplaceable role in the early stages of a long-term sports training. Kučera et al. (2011) consider speed abilities in children as a basis and primarize them along with agility over all other abilities, but they add that we must not emphasize special development of speed through special exercises in any case, but develop speed through general training. In our study, we focused on athletes at a younger school age and investigated the impact of a motion program with a focus on the take-off drills on selected speed and speed-strength abilities.

Methods

Athletes regularly attending athletic training participated in the research. Monitored group consisted of ten athletes aged 11–13 (table 1). The group of girls consisted of five athletes (average age 12.4 ± 0.22 year) and the group of boys consisted of 4 athletes (average age 12.9 ± 0.12 year). There were six athletes who were also the students of secondary sports school.

Table 1 *Individual indicators of athletes of monitored groups*

<table>
<tr><th rowspan="2">Athlete</th><th rowspan="2">Age</th><th rowspan="2">Sport age</th><th rowspan="2">Decimal age (input)</th><th colspan="2">Performance</th><th colspan="2">Performance</th></tr>
<tr><th>60 m (input)</th><th>60 m (output)</th><th>60 m hurdles (input)</th><th>60 m hurdles (output)</th></tr>
<tr><td>SE</td><td>12</td><td>1.5</td><td>12.49</td><td>9.92</td><td>10.40</td><td>X</td><td>X</td></tr>
<tr><td>FA</td><td>12</td><td>3.5</td><td>12.66</td><td>10.18</td><td>9.61</td><td>12.15</td><td>11.32</td></tr>
<tr><td>ŠI</td><td>11</td><td>3.5</td><td>11.91</td><td>9.52</td><td>9.95</td><td>X</td><td>X</td></tr>
<tr><td>PA</td><td>13</td><td>4.0</td><td>13.23</td><td>9.22</td><td>9.43</td><td>X</td><td>11.47</td></tr>
<tr><td>MO</td><td>11</td><td>1.5</td><td>11.60</td><td>9.71</td><td>9.72</td><td>X</td><td>X</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>PE</td><td>11</td><td>3.0</td><td>12.98</td><td>8.96</td><td>8.85</td><td colspan="2">X</td></tr>
<tr><td>HR</td><td>13</td><td>3.0</td><td>13.26</td><td>8.00</td><td>7.77</td><td colspan="2">X</td></tr>
<tr><td>KA</td><td>12</td><td>3.0</td><td>12.62</td><td>9.58</td><td>9.59</td><td colspan="2">12.56</td></tr>
<tr><td>VA</td><td>12</td><td>4.0</td><td>12.98</td><td>9.36</td><td>9.13</td><td colspan="2">X</td></tr>
</table>

The research period, during which we applied the assembled battery of take-off drills, lasted for 8 weeks. The athletes received 2 to 3 training sessions a week, taking into account the eventual start at the race in that week. In the monitored season, athletes had to complete 23 training units lasting for 60–75 minutes. These training units always contained one of the batteries of take-off drills, except for the main part of the training. The length and volume of take-off drills were compiled in accordance with Sedláček et al. (2003), who recommends a minimum of 3 to 4 weeks, with the number of training units 2 to 3 per week in order to achieve adaptation changes to increase explosive power.

Sports training during the race season of the monitored group was focused primarily on the development of speed and speed-strength movement abilities. In the category of younger pupils, the trainings included more special preparation for individual disciplines. Except for the take-off drills included in each training unit, the athletes underwent training in high jump, long jump, hurdles and cricket throw. Input and output measurements were performed at the athletic stadium with an artificial surface and the weather conditions were consistent. Input temperature 20°, wind support in the range from +0.7 to +1.1 m.s^{-1}, output temperature 21°, wind support range from +0.6 to +1.0 m.s^{-1}.

At the beginning of the research, before the initial measurements, we asked the parents of the athletes forming the experimental group for their cooperation and consent. Before implementing the research, we performed measurements of somatic parameters – body height, body weight, the length of legs and BMI index. The length of lower limbs – athletes stood barefoot in a standing position on the mat and we measured the direction from the mat to the highest point on the large plume of femur (trochanterion) using a tailor's meter (Fančovičová, 2011).

To find out the level of motor performance of speed and speed-strength abilities, we have chosen these tests implemented in the following order:

1. repeated vertical jumps in 10 s, hands on hips – ankle drills (test of eccentric-concentric contraction), only ankle joints involved in the take-off (SSC);
2. vertical jump with countermovement without using arm swing, hands on hips (test of eccentric-concentric contraction), ankle, knee and hip joints involved in the take-off;
3. standing long jump (test for explosive power of lower limbs);
4. 50m run from half standing start (test of running speed);
5. 20m cursory run (test of maximum running speed).

The selection of tests was based on the intention to determine the effectiveness of the program on the level of speed abilities and the level of reflective explosiveness. In speed abilities, we found maximum running speed (20 m cursory run) as a decisive assumption of performance for sprinting and jumping disciplines. Running for 50m is a comprehensive test of running speed. Long jump is a comprehensive test of the reflective explosiveness of lower limbs. The test of eccentric-concentric contraction repeated jumps shows the ability to quickly stretch and shorten in a minimal time interval (plyometry – SSC), using only ankle joints. The test vertical jump with countermovement expresses the ability of muscular eccentric-concentric contraction over a longer period of time and involving a greater number of motor units.

The rest interval between each test was sufficiently long. Nevertheless, the testing lasted for 100 minutes including warm-up and stretching, which can be quite tedious if we want athletes to perform their best. However, the experimental group consisted of athletes who were fit enough to handle the test load. We used photocells to measure speed abilities. We used a timekeeper – Witty (Microgate), designed for sport and training, to record the results of speed abilities. We also used OptoJump Next to measure speed- power abilities. Next is a device designed to measure and objectify the main properties of jump, as the flight and the contact time with a pad (Biasi, 2013). Experimental programme included two sets of take-off drills (tables 2, 3).

Table 2 *Take off drills – set I*

	Exercise description	Number of repetitions
1.	Ankle drills	10
2.	High knee skip	10
3.	Power skipping (right, left)	10
4.	Power skipping (double jumps) (right, right, left, left)	12
5.	Power skipping (right, left) running method	10
6.	Take-offs over 20 cm hurdles (5 hurdles), take-off from right leg, landing on left leg (1 step between hurdles)	5 + 5
	Number of repetitions together:	**62**

Table 3 *Take-off drills – set II*

	Exercise description	Number of repetitions
1.	Cone hops (6 small cones) – front position (front-front-back-front-front-back...)	16
2.	Cone hops (6 small cones) – lateral position (front-front-back-front-front-back ....)	32
3.	Power skipping (Right, left)	6
4.	Box jumps (40 cm) – without jumping off the box, just stepping off the box	6
5.	Frog jumps	5
	Number of repetitions together:	**65**

Planned volume load in the monitored programme of take-off drills was 127 in the first week. During the experimental period it was 3547 repetitions in 23 training units. All monitored athletes completed at least 80 = planned training load (table 4).

Table 4 *Completed training load of athletes during the monitored period*

Training indicators	SE	FA	ŠI	PA	MO	PE	HR	KA	VA
1. Days of loading (number)	21	19	19	19	22	23	20	21	21
2. Load units (number)	21	19	19	19	22	23	20	21	21
3. Duration of the load (hour)	24.0	22.25	21.75	22.0	25.25	26.5	23.0	24.25	24.25
4. Number of competitions (number)	1	3	2	2	1	3	2	1	3
5. Gymnastics (hour)	0	0	0	0	0	0	0	0	0
6. Games (hour)	1.83	1.83	1.83	1.33	1.83	1.83	1.83	1.83	1.83
7. Swimming (hour)	0	0	0	0	0	0	0	0	0
8. Hiking, skiing, skating (hour)	0	0	0	0	0	0	0	0	0
9. Coordination exercises (hour)	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
10. Speed exercises (hour)	2.95	2.61	2.45	2.45	3.45	3.45	1.95	1.95	3.45
11. Endurance exercises (hour)	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
12. Take-off drills (number)	**3175**	**2850**	**2856**	**2794**	**3361**	**3547**	**2989**	**3237**	**3175**
13.Strengthening exercises (hour)	0.83	35	0.83	0.83	1.08	1.08	0.33	0.83	0.58
14. Training of running techniques (hour)	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
15. Training of hurdle run technique (hour)	2.06	2.06	1.28	2.06	2.06	2.06	2.06	1.53	2.06
16. Training of jumps technique (hour)	2.28	2.28	2.28	2.28	2.28	3.03	2.28	3.03	2.28
17. Training of shots and throws (hour)	0.56	0.36	0.56	0.56	0.56	0.56	0.56	0.56	0.56
18. Warm up, stretching, cool down with running at an easy pace (hour)	7.0	6.33	6.33	6.33	7.33	7.66	6.66	7.0	7.0

The non-parametric Wilcoxon test for 2 dependent selections was used to determine the significance of the differences between the input and output measurements in the monitored parameters. In the terms of practical significance, the coefficient effect size “r” (Corder - Foreman, 2009) was used and interpreted as follows: r = 0.10 - low effect, r = 0.30 - medium effect, r = 0.50 – large effect (Cohen, 1988). The probability of error type I. was set to α = 0.05 in all analyzes. The statistical analysis was performed using the computer programs IBM®.

Results

Despite a short intervention period (8 weeks), we recorded changes in the monitored group of children in monitored somatic parameters. Body height increased on average by 2cm, body weight increased over 1kg for girls and 0.3kg for boys, and the length of lower limbs increased on average by more than 1cm (tables 5, 6). We recorded a slight decrease only in BMI.

Table 5 *Values of somatic parameters at the beginning and at the end of monitored period – girls*

INPUT					OUTPUT		
	Body height (cm)	**Body weight (kg)**	**Length of lower limbs (cm)**	**BMI (i)**	**Body height (cm)**	**Body weight (kg)**	**Length of lower limbs (cm)**
1	156.0	37.5	86.0	15.41	159.0	38.0	88.0
2	160.0	40.6	88.0	15.86	162.0	41.5	89.5
3	160.5	47.9	82.0	18.63	163.0	48.5	84.0
4	166.0	53.2	86.0	19.31	167.0	53.5	87.0
5	158.0	44.7	88.0	18.03	160.0	47.9	89.5
Mean	160.1	44.78	86.0	17.45	162.2	45.88	87.6

Table 6 *Values of somatic parameters at the beginning and at the end of monitored period – boys*

INPUT					OUTPUT		
	Body height (cm)	**Body weight (kg)**	**Length of lower limbs (cm)**	**BMI (i)**	**Body height (cm)**	**Body weight (kg)**	**Length of lower limbs (cm)**
1	157.0	47.2	85.0	19.07	160.0	48. 0	87.0
2	160.5	47.4	85.0	18.25	162.0	47.0	86.0
3	149.5	36.0	80.0	16.11	151.0	36.5	81.0
4	160.0	48.5	84.0	18.75	161.0	49.0	85.0
Mean	156.75	44.8	83.5	18.0 5	158.5	45.1	84.0

Table 7 *Values of speed and speed-strength indicators in the group of girls*

	INPUT	**OUTPUT**	**Wilcoxon test**	**Effect size**
	X	X		
VV [cm]	26.52 ± 1.92	27.38 ± 2.47	Z = -0.674, p > 0.05	r = 0.38 medium
OP [cm]	25.25 ± 1.18	27.16 ± 0.48	Z = -1.483, p > 0.05	r = 0.83 large
SLJ [cm]	187.2 ± 17.68	191.8 ± 16.77	Z = -1.461, p > 0.05	r = 0.82 large
50 m [s]	7.90 ± 0.21	7.83 ± 0.21	Z = -2.023, p < 0.05	r = 1.14 large
20 m [s]	2.97 ± 0.07	2.93 ± 0.08	Z = -2.032, p < 0.05	r = 1.14 large

Notes: VV – vertical jump with countermovement, OP – repeated jumps, SLJ – standing long jump; 50 m run; 20 m cursory run.

In the vertical jump test with countermovement without using arm swing, 4 athletes showed an improvement (by 0.1cm to 2.8cm) and one athlete reached worse results (2.5cm). The difference between input and output testing is not statistically significant (table 7). Practical significance is at the level of medium effect and the average percentage improvement is 3.4%. 4 athletes improved and 1 worsened also in the repeated jumps test. With the small number of members of the group (n = 5), the difference between input and output testing is not statistically significant but practical significance is at the level of large effect (table 7). Percentage improvement on average by 4.2% is the most significant of all tests in the group of girls. Three competitors improved in the standing long jump, one athlete worsened and one achieved the same performance in the input and output measurements. The difference between input and output testing is not statistically significant, but practical significance is at the level of large effect with an improvement on average by 4.6cm (table 7). The average percentage improvement was 2.5%.

In the tests of speed abilities 50 m run and 20 m cursory run, we recorded an improvement of all athletes in both tests. The differences between the input and output tests are statistically significant and practical significance is at the level of large effect (table 7). In the 50m run, the improvements are on average by 0.07s (0.9%) and at 20 m cursory run on average by 0.04s (1.0%).

Table 8 *Values of speed and speed-strength indicators in the group of boys*

	INPUT	**OUTPUT**	Wilcoxon test	**Effect size**
	X	X		
VV [cm]	30.9 ± 9.13	32.02 ± 9.05	Z = -1.841, p > 0.05	r = 1.09 large
OP [cm]	27.68 ± 5.05	28.08 ± 3.83	Z = -1.826, p > 0.05	r = 1.09 large
SLJ [cm]	194.75 ± 15.19	202 ± 14.07	Z = -1.826, p > 0.05	r = 1.09 large
50 m [s]	7.64 ± 0.77	7.54 ± 0.75	Z = -1.826, p > 0.05	r = 1.09 large
20 m [s]	2.87 ± 0.26	2.82 ± 0.31	Z = -1.841, p > 0.05	r = 1.09 large

Notes: VV – vertical jump with countermovement, OP – repeated jumps, SLJ – standing long jump; 50 m run; 20 m cursory run.

We recorded an improvement in the output measurement of each athlete in all the tests. The improvements in the individual tests are not statistically significant but the practical significance is at the level of large effect (table 8). In the vertical jump test with countermovement without using arm swing, we noted an improvement by 0.4–2.3cm, which is an improvement on average by 3.9%. In repeated jumps, the improvement was 0.3–3.2cm, on average by 4.6%. In the standing long jump, everyone improved by 5–10cm, on average by 3.9%.

In the tests of speed abilities, athletes improved by 0.1s (1.2%) at 50m running and by 0.05s (1.1%) at 20m cursory run.

Discussion

When developing the program for the development of reflective explosiveness, we used our own knowledge and experience with training in mentioned category. Despite the fact that there is a lot of knowledge about the training of children in the category of younger pupils, trainers do not follow the basic principles of training due to the effort to improve performance quickly.

The increase in somatic indicators (length parameters and body weight) by 1.2–2.5% during the 8-week monitored period confirms that monitored children are in the period of growth sprint. Monitored athletes are a select group that achieved more favourable somatic indicators than the Slovak population of children - higher body height and weight and lower BMI.

The monitored groups consisted of athletes aged 11–13, who have been continuously engaged in sports training in athletics for 3–4 years (only in two cases 1.5 years). The implemented block was adequate due to the level of physical development and level of training and comprehensively focused on the development of the take-off abilities. In both groups, the reflective explosiveness (standing long jump), the eccentric-concentric contraction of the plyometric character (repeated vertical jumps) and the eccentric-concentric contraction of the lower limbs were improved over a longer period of time and with a greater number of motor units (vertical jump with countermovement).

The female athletes achieved on average in the output measurement performance 191.8cm in the standing long jump. Brown (2001) states the standard for the selection of talent at the age of 11–13 years performance 187.33cm. The performance of monitored female athletes is better than it is stated in the curriculum for sports classes with a focus on athletics (Čillík, 2003) for 12–13 years old, where the performance standard in the standing long jump is 170.5cm. The female athletes of the monitored group show higher performance in both cases. The male athletes achieved on average in the output measurement performance 202cm in the standing long jump. Brown (2001) states an average performance 194.33cm for 11–13 years old boys and the curriculum for sports classes (Čillík, 2003) states the performance standard 178.5cm for 12–13 years old boys. The male athletes of the monitored group also achieved higher performance in both cases.

Even in the test 50 m run the monitored group of girls and boys achieved better performances than the performance standards states for sports classes. In 50 m run, female athletes achieved an average performance in output measurement 7.83 s. The performance standard is 8.8s for 12–13 years old girls. Male athletes achieved an average performance in output measurement 7.54s in the test 50m run. The performance standard in the curriculum is 8.55s for 12–13 years old boys.

Conclusion

We confirmed that in just 8 weeks, at a frequency of two to three training units per week, there may be significant changes in performance in the tests: vertical jump without countermovement, repeated jumps for 10s, standing long jump, 50m run and 20m cursory run. The results indicate that the program of take-off drills, which the athletes underwent at least 79%, had a positive effect on performance increase in the explosive power of lower limbs and in running speed.

Except for the program of take-off drills that athletes underwent, it is necessary to take into account the overall training load, which positively influenced the development of speed and speed-strength abilities. This means that other training means significantly contributed to the increase in performance in selected tests, which the athletes underwent.

Due to the small number of members of the groups and different ongoing physical development, we cannot generalize our results to the whole population and wide age range.

Reflective explosiveness plays an important role in athletics as well as in many other sports. Its development is linked to the consequent increase in the level of performance at maximum running speed.The age category of younger pupils is the best time to start developing it. The development of the speed component of the take-off should predominate its strength component.

The inclusion of take-off drills in sports training for younger pupils has been confirmed as the right way to develop the reflective explosiveness and speed abilities. As a part of the training process, we recommend applying different combinations of the take-off drills, whether in the form of repetitions of the take-off in a series or in the form of competition games or obstacle courses, all with consideration of age and preparedness level of the athletes.

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ISOKINETIC EQUIPMENT IN THE STRENGTH TRAINING OF ARMWRESTLERS

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Gabriel Harčarik

Faculty of Manufacturing Technologies of the Technical University of Kosice with the seat in Prešov, Slovakia

ABSTRACT

The author introduces the main reasons for aiming his research at the development of isokinetic, diagnostic and training equipment which should have its basic exploitation in armwrestling. In the results he discusses what parts the equipment is composed of. He brings the information about what data from the IsoForce system can be obtained and what can be set up on the Tend Force Gauge microcomputer. Later he describes three modes of exercise in detail, their foundation in training process or in diagnosics. The author explains inevitable portable adjustable construction which allows the implementation of all needed movements for armwrestling and that it has to meet other different requirements. In the results he describes all the advantages that TENDO IsoForce brings. He also informs about the tests that can be done within the diagnostics of strength abilities in armwrestling with the help of this equipment. In the end the author states that he sees the big potential in TENDO IsoForce for armwrestling purposes and informs about his plans for future as to the improvement of the equipment.

Keywords: IsoForce; isokinetic dynamometers; testing; strength abilities; armwrestling

Introduction

Since ancient times a man armwrestling match (in various modifications) has been very attractive for viewers. The best test of strength of armwrestling is match itself, but it only chooses a winner. The muscle strength is considered to be one of the determinants of sports performance in armwrestling.To be more specific it is rather a speed strength sport. Based on the result we don´t know the strength parameters that the winner generated against his rival. We are able to measure the time of the match and say whether the rival was beaten by explosive force after the start, or the match was balanced, long and the winner is a sportsman with better strength endurance. We still don´t know what force was developed within the ceratin technique. To do so we would need to find (create) suitable diagnostic equipment and tests. Harcarik (2008) states that until now oldfashioned terrain tests for strenght measurment has been used in armwrestling (pull ups, bench press, biceps stroke with EZ dumbell against wall, rolling thunder® grip, ...). These tests do not correspond to the biomechanics of motion in armwrestling. Cvecka and Schickhofer (2011) say that modern approach in assessment of strength abilities reperesents the equipment exploitation that enable ongoing recording of the forces apllied in dynamical conditions within constant speed in so-called isokinetic mode. The advantage of these equipments is the ability of measuring of acting force and associated parameters in full movement range during concentric, with some equipments also excentric, phase of movement. In the certain test, there is no trace of increased efforts in acceleration of movement like in standard dynamic tests. Increased effort results in increased strength. With constants speed it results into increased performance (Hamar, 2007).

Based on the desribed problems we started searching for the equipment which would be suitable for our needs. During the market research we were analyzing many isokinetic equipments such as Keiser, Excentrix, 1080 Quantum. They would be suitable for our diagnostics, but they are expensive and not portable. We also come acros to TENDO AbEx for torso strenghtening and abdominal muscle measuring. It uses isokinetic equipments with hydraulic resistance system. Its 6 speed system is different from previous equipments and it measures only concentric movement phase, which is sufficient for armwrestling purposes.

Methods

We underwent TENDO AbEx testing to find out whether measured data were correct and whether they have informative value. Different treatments followed the testing and we also atest its potential in testing of armwrestlers. The result is creating of brand new universal isokinetic equipment TENDO IsoForce (Figure 1) created by Mgr. Gabriel Harcarik, PhD. In cooperation with TENDO which started to be used in armwrestling. TENDO IsoForce je high quality isokinetic hydraulic resistance system with six different levels of speed. This equipment is equipped with strength measurement TENDO Force Gauge (Figure 2) with LCD display which gives immediate feedback about the developed force. We can see the use of this equipment in training process but in present we attest its potential in diagnostics of strength abilities of armwrestlers. For testing we need three implements.

1. Measurment system TENDO IsoFORCE (sensor unit)+Force Gauge (mikropočítač)
2. Portable adjustable construction
3. Armwrestling competition table (ten je standardized by rules)

Figure 1 *Tendo IsoForce*

Figure 2 *Tendo Force Gauge*

What data do we obtain with the help of TENDO IsoForce + ForceGauge?

- The system measures an average force and peak force in the point of pulling the arm;
- By entering body weight, it is possible to calculate relative force for 1 kg of body weight (Relative Average Force to BW);
- The system measures time of force;
- The system counts the number of repetitions;
- The system counts percentage of the strength compared to the best repetition (percent value of the bestrepetition);
- Possibilty of setting the time interval of force measurement;
- Possibility of setting a unit of measurement (kg, lb, N);
- Possibility of setting the amount of force for the beginning and end of force measurement.

This kind of feedback enables not only to find out the force of skeletal muscles and follow the progress for set training program, but it also is an important motivational factor in training itself which leads to effectiveness. Effective strength training means the rise of sports performance with faster recovery. But in majority of sports it is only a part of the sport preparation.

The advantage fo hydraulic isokinetic piston is possibilty od setting speed for concentric phase of movement and the possibility to test right and left limb separately and together, which enables implementation of various exercises and tests. In diagnostics and training it is possible to choose from three modes of exercises.

1. *Isokinetic exercise without excentric muscle contraction.* It means that exercise resistance is concluded only in concentric muscle contraction. The advantage of this type of exercise is that after exercise there is no muscle pain which is caused by excentric muscle contraction. Excentric training is very difficult, but it is an integral part of every training on the table with stronger sparring partner. It prolongs the time of regeneration, worsens the arm pain and increases the risk of injury. Excentric method for strength ability development is therefor not

used in armwrestling training for it is an offensive sport. To win we armwrestle the rival. This demands mainly isometric-isotonic muscle mode or the alternation during the match.

2. *Isokinetic exercise joined to additional excentric muscle contraction.* We achieve this by additional burden od rubber expander at the end of the IsoForce arm. The measured results, mainly with rubber expander, are not usable for repeated testing and comparing the results because they are distorted by expander features. These are changed by abrasion and it is difficult to measre these changes. It doesn´t matter in training but it hasten the implementation of individual repetitions. The main reason for adding the rubber expander is that the hydraulic piston is very strong and the arm too light to get it back to its starting position. To solve this, it is possible to add some weight at the end of the arm. The 5-kilogram weight proved itself in practice and we count with it in diagnostics. This weight distorts the measurment, but it is a constant weight which is not changed during the whole motion path in comparison to expander features. The expander increases the resistance with longer path.

3. *Isometric exercise:* we achieve this by simple disabled arm. In isokinetic exercise it is suitable to choose measuring of average strength (even though force value is measured in armwrestling). For isometric exercise it is reccomended to measure the maximal force. Ideally, the meter displays the actual data about the developed isometric force. Mazurenko (2016) made isometric measurements of peak force with the help of other equipment and then he determined preservance in force in a way that a sportsman had to maintain 70–80% of this rate for as long as possible. We can set the time of measuring static force on TENDO Force Gauge. After the set time of measuring (e. g. 20 seconds), the equipment ends the measuring and displays the measured value (for armwrestling it is a very important entry as to the tactics). In isometric dynamometers we are able to create different positions and tests which comes from individual particularities of the individual and are crucial for a sportsman in match. In the case of weak endurance strength he can add an isometric time training. The problem is that this kind of training is refused to be done regularly by armwrestlers. According to Harcarik (2016), but also to Mazurenko (2016) static dynamometer was not proved itself because the sportsmen were locatin the pain in elbow, wrist during and after testing and the did not want to undergo the diagnostics again.

Portable adjustable construction (Figure 3) had to be designed as a between part that allows force transfer from TENDO IsoForce with the help of a cable on the hand of an armwrestler. The construction meets the following criteria:

- It has to be light, solid, portable, demountable in a way that the fit into the boot of the car together with TENDO IsoForce (for diagnostic purposes),
- It has to be able to be fixed to armwrestling table easily and firmly to front and from the side,
- Calibration pulley has to be of a standardized height 110 cm and has to move to sides,
- It also has another pulley and this one has to be height adjustable and able to move to sides,
- It can be used as a loading roller for discs which enables to connect speed sensor and a movement path as for example fitrodyne, tendo, myotest, ...

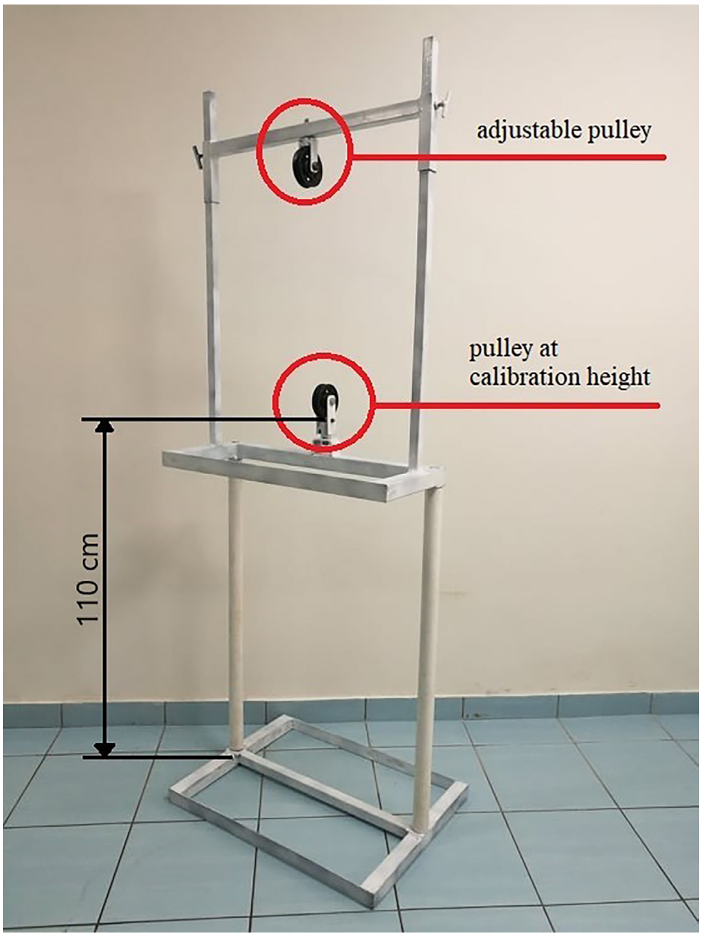

Figure 3 *Freestanding construction*

Construction ofthis type together with TENDO IsoForce enables to appy various working positions and modes in training or in diagnostics. One equipment supplies functions of more equipments. Based on our several months lasting testing, attesting and training on this isokinetic equipment we are able to see its big potential in the use either in training, but mostly in diagnostics of armwrestlers. The advantage of the whole diagnostic/training aquipment is that sportsmen are enabled to perform the same biomechanics of movement as it is used in an actual armwrestling match. It is a complex technology and not only an isolated movement in one joint. On the other hand, it is possible to use this equipment for either testing or training.

Results

Advantages of isokinetic hydraulic equipment in practis

1. *Possibility of diagnostics of strength abilities in isometric and isotonic muscle mode.* The equipment is suitable for standardized testing of armwrestling techniques, that means complex movements which are performed naturally, without restrictions. This is a big asset in comparison to old fashioned „terrain“ tests that measured strength abilities isolated and not directly. Our isokinetic equipment together with the adjustable pulley and competition table allow us testing directly the strength which is developed by amwrestler in certain technique. Thanks to that we are able to compare the results among sportsmen in specific techniques or exercises and quantify the difference in strength among rivals. Based on the discussions with coaches we agreed that for armwrestling more appropriate would be the measurement of peak force. Also with the help of this equipment we are able to perform also isolated tests or exercises as needed. In the future it will be inevitable to exactly describe them and standardize them.

2. *Control of the process of convalescence after an injury.* In case that a sportsman comes back after his injury, it enables to uncover efectively possible muscle disbalances. If he was already tested on this equipment or he trained on it we are able to say exactly what performance decline an injury caused, what the difference is in certain exercises/tests, how fast the return to previous form is and how to be at the same or higher level as his rival (if we know his parametres).

3. *Training availability.* The equipment is available also for club training. His price is a little bit higher than the price of common roller trainer, but significantly lower than the price of other isokinetic equipments.

4. *Motivation and competitiveness.* Thanks to immediate feedback a sportsmand and a coach are informed about achieved results. Overcoming own results can be motivating, but also those that training partner achieved in the same exercise. This was confirmed also on the national meetings or during the trainings in the club where the sportsmen naturally long for overcoming their rivals not only in matches, but also in measured values in certain exercises or tests. We can see the big difference in comparison to common training where dumbells, pulleys or special trainers.

5. *Multifunctionality.* It is possible to use this equipment for wide range of exercises from isolated ones (e. g. flexion in the lactate) to more articulated (whole technique, e. g. „top“). It enables performance of pull exercises and after the modification also pressure exercises.

6. *Variety in the training process.* In training the exercises on this equipment can be a part of traditional exercises within general and specialized preparation. Sportsmen like the training on the isokinetic equipment because it allows them to train the same exercises as are the exercises on pulley. At the same time it gives them feedback about achieved force at different speed levels. Also if needed we can use isokinetic or isometric mode.

7. *The ability to set the speed of movement.* It is an advantage and a disadvantage at the same time. Neither a coach nor a sportsman can quantify speed/resistance that is recalled on the equipment. In practice, they are used to kilograms and therefore they ask how much one kilogram is per one speed level on the equipment. They need to understand that it is not about weight but defined movement speed they work at. We can set the speed from 1 to 6. The 1 is the highest speed and the 6 is the lowest! The 6 is sufficient even for the strongest sportsmen, but weaker sportsman can use it too. This speed is used also in the diagnostics of force abilities in armwrestling. In practice training on lower speeds (4–6) prove itself in strength development if a sportsmen does his best. The next advantage of this isokinetic equipment is the training of the starts. In present, these are performed only with rubber expanders or by sparing partners. In both cases we miss the feedback about the developed strength. In speed training we used the speeds 1–3, where the 3 was better option for sportsmen than the 1, which was described as too „easy/light“. If we can observe that the performance of a sportsman does not increase but it even decreases, we can search for the mistake in training or in diet or tiredness. It is necessary to make a change to achieve the required result. We can also compere the level of force in at different speed levels before various competitions or within individual mesocycle.

8. *Safety.* So far, no injuries or negative response were recorded during the screening, testings or trainings. It is a very important factor for a sportsman and his performance growth. Armwrestling is a very difficult sport and there are many minor injuries mainly in the area of elbow or wrist.

Diagnosis of strength abilities in armwrestling with the help of TENDO IsoForce

The first big testing in armwrestling with TENDO IsoForce took place on 16/03/2019 in Presov on the national meeting of wide cadre before the Europe Championship. We attest the usage of these tests.

Imitation of the technique „top“ (Figure 4).

It was the most responsible and the most exact out of all the tests. We attest it on the 3 other meetings. We caught flies and now we can start to standardize it.

Figure 4a *Testing of imitation of technique „top“ a) starting position*

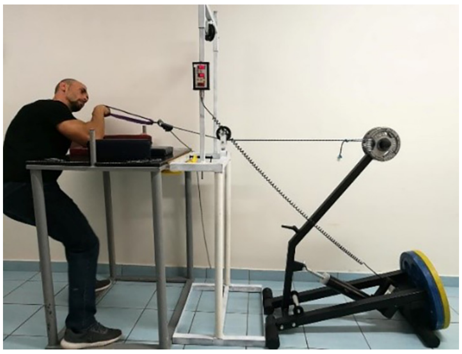

Figure 4b *Testing of imitation of technique „top“ b) final position*

- *Wrist flexion with winding attachment* was not the right one because we did not know how to remove undesirable movements that affected the result. We replaced it by more suitable and more exact test where we use special excentric holder in different sizes according to the length of the middle finger of the dominant hand.
- *Test with eccentric handle for the finger and wrist force in the isometric mode* (Figure 5) passed the retest and attest on the training and meetings. We can start with standardization process.

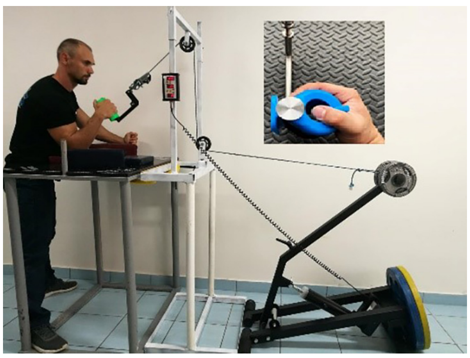

Figure 5 *Test with eccentric handle for the finger and wrist force in the isometric mode*

- *Test of imitation of technique bottom sideways (pulley from above)* did not prove itself in the form we designed and it has to be further modificated until it meets the requirements.

- *Test lateral pronation with belt (pulley in plane with hand)* did not prove itself in the form we designed and it has to be further modificated until it meets the requirements.

Conclusion

We can see a big potential in the use of IsoForce in sport practice and we dare to say that it can be a revolution in armwrestling in either diagnostics or training process. It is a high quality isokinetic hydraulic restistant, multifunctional and affordable equipment with 6 different speed levels. This equipment is equipped with force measurement (Tendo Force Gauge) with LCD display which gives the immediate feedback about developed strength. IsoForce is not capable of measuring excentric force, but this is not needed. For armwrestling performance isometric force and the size of concentric contraction are crucial.

In the next research we will focus on the attesting of other tests that are redeemable for armwrestling followed by their standardization. In the future we aim to design the equipment that will enable diagnostics and training of force abilities for as many sports as possible so it can be used in fitness and for commercial purposes. At the same time it should be universal, portable and affordable. The manufacturer works on computer software which should be able to make a graph we we can see increased strength in time and all the data should be saved in computer as it can be seen in other diagnostics equipment. The next task will be attesting the relationship between the achieved results in tests and in match.

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TRAINING SYSTEM HAST FOR THE DEVELOPMENT OF STRENGTH ABILITIES IN ARMWRESTLING

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Gabriel Harčarik

Faculty of Manufacturing Technologies of the Technical University of Košice with the seat in Prešov, Slovakia

ABSTRACT

In the opening the author describes the current situation in an armwrestling training. Based on the experiences and the study of literature he states that in practice there is almost no systematic guided training with a sparingpartner at a table. He perceives this as a problem. In the results he presents his own program HAST where he describes the individual training parametres. They are important for a quality training program with a sparingpartner at the armwrestling table. He points out the mistakes often made at the armwrestling training and he proposes suitable solutions within the scientifically based informations used in strength training. In the discussion he describes in detail the key parts of HAST and the experiences from the realization of this program with his trainees. In the end he states that the similar program should be a part of the preparation of armwrestlers and at the same time he adds that the scientific attesting is needed.

Keywords: specialized training; RPE; exercises with a sparingpartner; parametres of training

Introduction

In the strength training with dumbells, on pulleys or on trainers, determination of training load is simple and explored. In an armwrestling training with sparing partner it is a lot more difficult. The main problem is the absence of programing, periodization and a registry of trainings with sparingpartners at a table. Based on our foundations, 99% of the trainings take place at the table with sparingpartners disorganized, in the form of wrestling where only technical mistakes are corrected. Training load is not set even though there is a supposition of performance increase. Therefore it is very difficult to evaluate the effectivity of this kind of training and later adjust and lead the training process. Usanov and Chugina (2010) have written the most comprehensive book on armwrestling in Russia, but the whole monograph does not show what training on a table with a sparring partner should look like. Similarly Tivora, Rachmanov (2001), Kondraškin, Larin (2005) and Babaje (2005) focuse only on strength training using dumbbells, pulleys or special machines during training. They show the classic number of series 1–5, repeats 3–10 and the intensity 50%–100%, which they derive from the maximum weight in the exercise. They recommend performing both static and dynamic exercises. Jarombek (2003) indicated the structure of training unit at the table within the technical preparation but it wasn´t aimed at the development of strength abilities. Harcarik (2011) in his dissertation thesis proved that strength abilities are able to develop thanks to the table training while this program in the experimental fold significantly affected strength abilities, the sportsmen achieved important changes in the evaluation of the result in the armwrestling match. They recorded more victories in comparison to control fold. Esentially there is no methodology or training system concerning stregth training at the table with sparingpartner. Therefore we decided to develop the training system HAST (Harcarik Armwrestling Sparing Training), which is specially developed for armwrestling needs. It tries to define as many training parameters for effective development of strength abbilities as possible. When studying of foreign literature (there is a lack o fit and it is difficult to obtain it) we didn´t come across to any similar and integrated training system which would be devoted to this problem. The program HAST is about needs and specifics of this sport, it was improved to today´s appearance.

Methods

Based on the results, which have been achieved in our dissertation thesis with the “Table Program”, we have decided to further develop this program. We have seen its potential as this is an unexplored area of the training process in which there is a large number of variables that can have a major impact on the development of strength skills in armwrestling. So far, no one has paid attention to them, even though training with a sparring partner is very important in our opinion, as the match itself takes place between two opponents and not between an athlete and a barbell or machine. When creating HAST, we focused on training parameters that we can influence and which, based on our long-term observations, proved to be important for the development of strength skills in armwrestling. Based on previous experience with “table” training, we were able to determine how much armwrestlers can handle. In determining the breaks between the series, we started from research dealing with the issue. We see the problem of rest pause in the fact that armwrestling is a unilateral sport and the rest and training time is doubled as we need to train the right and left hand. Another indicator related to the development of strength abilities and adaptation to strength training is the pace and thus the time under tension. In our opinion, this data is very important and we are able to monitor and modify it according to the goal. However, literature on armwrestling does not give concrete examples and therefore we were looking for inspiration in other sources. Determining intensity / exertion is a decisive parameter for developing strength abilities. That was one of the biggest problems. In the literature, the intensity was determined only when practicing with the equipment, but we needed to evaluate it when training with the sparring partner. After a long search and subsequent verification in practice, we have proven to use the scale for perception of exertion. We have included all these training parameters in our HAST program and set them up for armwrestling training with a sparring partner.

Results

In armwrestling the strength training (with dumbells, pulleys and on the specialized trainers) is followed by standard rules of strengthening and methodology is taken from other sports sectors. Here we can see some mistakes, but this will not be our concern. Training load, rest, training intensity, exertion are training parametres, which determine quality of the training process. We are going to define these parametres for HAST program.

Training volume defines the amount of work we made in a training. Often, it is set by number of series, repetitions or total overweight (can be defined with the table training). The most common the total number of repetition in an exercise or training is used. We used Prilepin’s Table (Table 1.), which is a result of long lasting experiences of russian coaches for weightlifting. Weightlifting together with armwrestling are the speed-power sports. Based on this chart we can choose the optimal number of repetitions, series or intensity in % of 1RM – cannot be set in the table training.

Table 1 *Prilepin’s Table*

Intensity	Reps Per Set	Optimal Total Reps	Total Rep Range
< 70 % of 1RM	3-6 reps per set	24 total reps	18-30 total reps
70-79 % of 1RM	3-6 reps per set	18 total reps	12-24 total reps
80-89 % of 1RM	2-4 reps per set	15 total reps	10-20 total reps
90 > % of 1RM	1-2 reps per set	7 total reps	4-10 total reps

We know that for development of strength the best method is the method of maximal exertion where the weights from 85% of 1RM are used - that means 2–4 repetitions. In the case that we start with the strength preparation, we start at 3 repetitions. The optimal number of the total repetition is 15 so that means 5 series. So, with the weight (resistance) on 85% level we make 5 series of 3 repetitions to achieve an ideal training impulse for strength growth. The total range says that we can make 3–4 series of 3 repetitions or even 6–7 series of 3 repetitions. Practice is very important here together with coach´s experiences and it´t up to him what training load he sets. Performance of a sportsman is also one of the key elements along with his health, the etape of sport preparation or the period he is currently in. When starting, it is sufficient to use the optimal number of repetitions, because we don´t knowto set exactly 85% of 1RM for maximal strength development. Therefore we searched how to set the intensity of the training.

Intensity is indicated by weight of a dumbell in strengthening. This entry can be defined absolutely in kilograms or relatively, that means by percentage of maximum. One maximal repetition (1RM – repetition maximum) is 100% of lifted weight. It represents the heaviest weight you are able to lift in given exercise only once. In other sports this can be speed, height, pace, etc. In the case of the table training with sparingpartner it is not possible to define it as it is defined with dumbell. Therefore we focused on the concept of intensivity or effort.

Exertion and perceiving it is influenced by fyziological, psychological and other factors. By other factors we mean signals from working muscles and joints, blood lactate, heart rate, ventilation, oxygen consumption, hormonal secretion, pain caused by exercise, etc. (Watt et al., 1993, Mocková, 2000). The studies proved that for majority of these mediators there is a certain threshold which equals to anaerobic threshold (ANT). Psychological factors participate by 33% on perceiving the exertion mainly at lower and medium intensity. At high intensity there are more fyziological stimulus. The other factors that affect perceiving the volume are: environment, sex, age, physical training, smoking and medications. Borg´s researches in 1993 showed the relationship between perceived effort, heart rate, lactate, % VO_{2max} and the rhythm of breathing of a sportsman. Borg´s scale ranges from 6 to 20 (Slezakova, 2009). In sport, the exertion is a subjective evaluation of how difficult an individual series appears to you. For example: If we lift 100 kg dumbell 6 times or 8 times, then the intensity in both cases equals to 100 kg, but the exertion is higher for 8 repetitions. When searching for criteria for evaluation of factor of perceiving the effort we come across to RPE scale (Rated Perceived Exertion). In HAST RPE scale (Table 2.) from 1–10 proved itself where 1 is the easiest and 10 feels the hardest. We orientate according to our feeling of how many repetitions we would be able to make or how many are left in reservoir until the complete breakdown.

Table 2 *RPE manual for armwrestling*

10	Maximal effort. Could not have done another rep
9.5	MIGHT have been able to do 1 more rep
9	Could do 1 more rep for sure
8.5	Could definitely do 1 more rep, maybe 2
8	Could do 2 more reps for sure
7.5	Could definitely do 2 more reps, maybe 3
7	Could do 3 more reps for sure
5-6	Warm up weights
1-4	These are irrelevant

RPE scale is more exact for armwrestling training with sparinpartner. We even prefer it in strength training with dumbells to using percentage of weight. Though, sportsmen have to understand it correctly when determining the exertion or how many repetition they would make in a set. RPE is used with so called autoregulating trainings where the number of sets is modified during the training. A sportsman should perfectly perceive the signals of his body and note them down to his training diary.

The research shows that RPE is effective way of how sportsmen can dose the intensity of training. We have to say that there are certain differences when applying this scale in training of experienced sportsmen and unexperienced ones. Helms er. Al (2017) found out the strong relationship between the real 1RM and RPE in squat, bench press and dead lift while the average RPE in 1RM are nearly the same. He states that RPE is a valid scale of training exertion and that it can be used invarious exercises and intensities. Mash (2019) claims that RPE cannot be effectively used by triathlon beginners and there can be certain differences in understanding of what is really 1RM and 10RPE. Without enough experiences from trainings, it can be difficult to estimate the maximal intensity. Meghan et al (2004) did the research about the reliability of perceived exertion scale (RPE) and quantification of exercise intensity with high (H) intensity, medium (M) intensity and low (L) intensity. RPE was measured after each of the sets finished and 30 minutes after exercising. RPE was higher when exercising H than it was with M and L ($p < 0,05$). Performing a lower number of repetition with higher intensity was considered to be harder than performing a higher number of repetition with lower intensity. They say that RPE is more reliable scale for quantification of various intensities of training.

Even though the percentage of training exertion is an effective way of perioidization of strength programs, it does not take into account the stressful factors of everyday life. For example: Training with higher intensity for a long time which might lead into burnout syndrome or overtraining but it is programmed in a way that a sportsman can train for a few weeks with high intensity. By using RPE we can avoid overloading, injuries and it seem to be an effective way to listen to body signals and for establishing a deload week. There is a table (Table 3.) of conversion of RPE rate to percentage for individual number of repetitions which can ease the relationship between the RPE exertion and the intensity of training. It is a very important chart for HAST.

Table 3 *Relationship with percentage 1RM, repetitions and PRE Helms et. al (2017)*

	Repetitions performed							
RPE	1	2	3	4	5	6	7	8
10	100[a]%	95.0%	91.0%	87.0%	85.0%	83.0%	81.0%	79.0%
9.5	97.0%	93.0%	89.0%	86.0%	84.0%	82.0%	80.0%	77.5%
9	95.0%	91.0%	87.0%	85.0%	83.0%	81.0%	79.0%	76.0%
8.5	93.0%	89.0%	86.0%	84.0%	82.0%	80.0%	77.5%	74.5%
8	91[a]%	87.0%	85.0%	83.0%	81.0%	79.0%	76.0%	73.0%
7.5	89.0%	86.0%	84.0%	82.0%	80.0%	77.5%	74.5%	71.5%
7	87.0%	85.0%	83.0%	81.0%	79.0%	76.0%	73.0%	70[a]%

In HAST we understand that it is important to distinguish 3 main functions of training when creating them (development, maintaining, recovery) and individual parametres which are important when creating and planning training days from the regeneration and training volume point of view. Armwrestlers make a mistake here and they have very intense trainings too often. They train every day or every other day (48 hours) and they don´t have a time for volume and intensity regeneration they set. This is followed by overloading, tiredness, lower performance, arm pain, microtrauma or injuries. For better training volume setting we use (Table 4.).

Table 4 *Parametres needed for training creation Horniak (2015)*

Type of training	Volume/Intensity	Regeneration time	Training RPE
Development	Extreme	> 72 hr.	10
	High	48–72 hr.	9
	Significant	24–48 hr.	8
Maintaining	Medium	12–48 hr.	7
Recovery	Low	< 12 hr.	< 6

Pace can affect the training exertion so it affects also RPE. The standard writing of pace is e. g. 4012 (4 seconds excentric phase, 0 seconds endurance in down position, 1 second pull up in concentric phase, 2 seconds is isometric stamina in starting position). In armwrestling all the exercises are performed at the table from starting position and we move to concentric phase (attack/victory). For HAST needs we use the opaque writing of pace as not to confuse sportsmen. For better understanding here is an example: We start the movement by concentric phase where we try to to wrestle the rivalto the winning position. Then in the winning position there should be a 1–3-second break according to needs and abilities of a sportsman to push or hold the rival in this position. Return to starting position should be slow and lasting from 2 to 4 seconds. Now, there should be a short break that can be entirely without muscle effort or only with a short break 1–2 seconds and then there is another repetition. The writing is: 122P concentric phase 1 second (maximal exertion) 2 second stop in down position, 2 seconds excentric phase (maximal deceleration) P (pause for breathing up to 3 seconds without muscle exeration, but I do not allow the grip. In HAST we very often use static stamina at different levels of a match according to the needs of a sportsman but mostly it is in the starting position (0009) or in the winning position (0900) (if not stated differently). The problem is if the static stamina lasts longer than 10 seconds and the other number would distort the description of a pace. This is why the static position is divided by two slashes, e. g. 0/20/00.

In HAST we place importance on movement Dynamics (the speed of muscle contraction) and that´s why we have to develope it systematically by suitable training methods. In preparation period and with the beginners we start with the medium movement speed with ahigher nmber of repetition. A performance racer lowers the number of repetition in competition period with movement accelaration (contraction) at the same time. If we need to produce certain speed in competition, the training exercises should be at the same speed. Sirucka (2009) states that the intended speed of exercise performance is one of the most important factors for strength growth. It is important to have a maximal speed in the concentric phase of movement. This way we maximalize muscle tension and at the same time we achieve a unique nerve adaptation. Van Cutsem, Duchateau, Hainaut, (1998) state that maximal increase of the intended movement speed leads to a higher production of the strength, higher occurance of doubled activations and lowering of activating threshold of motorical units. Aagaard, Simonsen, Anderson, et al. (2002), Gabriel, Basford, J (2001) a Maffiuletti, Martin, (2001) found out the similar conclusions and that it is like that in both dynamical and isometrical contractions cases. The fact that this adaptation applies also for isometric contraction is another proof that the real movement speed is not so important as the intended movement speed because within the isometric contraction the length of the muscle stays the same. Decreasing of activating threshold can be an asset for strength production. If MVT are activated sooner during the contraction, which should occur in the contraction with maximal intended acceleration, they have more time for incresing the strength (Sirucka, 2009).

Table 5 *relationship between training goals and training parameters*

Training Objective	% 1RM	Reps per set	Sets per exercise	Rest interval	TUT	Predominate fuel souce
Maximal Strength	80/85–100%	1 to 5	4 to 7	2–6 minutes	5–10 sec	ATP/PC
High Power Output	70–100% %	1 to 5	3 to 5	2–6 minutes	4–8 sec	ATP/PC
Contractile Hypertrophy	75–85%	8 to 15	4 to 8	60–90 sec	20–60 sec	ATP/PC and Lactate
Cyloptasmic Hypertrophy	60–75% to	8 to 15	4 to 8	60–90 sec	20–60 sec	Lactate
Muscle Endurance	< 60%	15+	2 to 4	30-60 sec	80 sec	Lactate and/or oxygen

Time under tension (TUT) relates to pace. Poór (2015) states that even though we have an established number of repetitions in each set, we still can work with the pace of repetitions. The total time of a set can be different and leads to completely different results. If we perform for example 8 quick repetitions and each of them lasts 0,5 sec., the resultant TUT is 4. We run out of the actual supplies of ATP-CP when recruiting hight threshold motor units. Even though there was this unit recruitment they are not totally exhausted. In armwrestling there is often performed the training with a sparing partner, where in a set, there are 8 repetitions and each of them last 5 sec. (resultant TUT is 40 seconds). This rate recalls the hight degree of anaerobic glycolysis. As a result of a big exhaustion of motor units the training effect lies in increase of energetical supplies and it leads to muscle hypertrophy. That is not always wanted in armwrestling because the muscle mass increase doesn´t mean the increase of the maximal strength. We have to choose the number of repetitions so that the resultant TUT leads to desired goal. In HAST we take into account that editing the number of repetitions and TUT is necessary if the training leads from volume to intensity. By lowering the number of repetitions you lower TUT (at the same movement pace). The similar effect can be achieved if you accelerate the pace and the number of repetitions stay the same. It is up to a coach and a sportsman to establish such a pace and a number of repetitions that will corrspond the goal they want to achieve. In armwrestling training with sparingpartner this important parameter is not used at all. We consider this as a bigh mistake (Table 5). In our HAST program, using TUT proved itself, even though the sportsmen are not happy about it as it is very difficult(mainly if a sparingpartner checks the time with stopwatch). We recommned to change the pace of one repetition from 3 to 5 seconds and to perform 4–5 repetitions in one set in a way that TUT is around 20 seconds. The lower number of repetitions is more appropriate to maintain the right technique at hight intensity.

The rest between the sets is the last parameter of the training which we focus in HAST on and we thanks to it we know how to influence the total strength increase and a performance. The reality in an armwrestling trainin with sparingpartner is that the rest time is not monitored and the start of the match or set is only according to the feeling. Many times sportsmen succumb the challenge of the rival (sparingpartner) and they compete tired which worsens their performance but also increase the level of injury risk. Petr and Stastny (2013) state that to reach the full concentration and maximal free exeration every other set will be performed in conditions of full recovery of energetical supplies. The authors claim that the bier resistance is used in a set, the more time the body needs to recover. Schoenfeld er al. (2016) say that the group of trained young men who rest 3 minutes trained 13% more training volume to the other group who rest for 1 minute. The authors bring the evidence that longer rests support the bigger increase of muscle strength and hypertrophy with young trained men. Willardson (2006) states that more sets are better than one set for a maximal strength development. Though, whether we achieve the maximal strength growth can depend on the abilities to maintain the repetitions in following sets. The key factor which determines the ability to maintain the repetitions in a set is a length of the rest interval between the sets which is established according to the aim of the training. For maximal strength growth where we perform the set fully (RPE 9–10) in the range of 4–8 repetitions, we need approximately 3 minute for full recovery. It has to be said though, that the length of the rest interval doesn´t secure wanted effect if there are no other component (intensity and volume) established accordingly.

Discussion

What need to be said about HAST? The first time we dealt with the table training with sparingpartner was in dissertation thesis. Harcarik (2011) found out that for armwrestlers who had worse left arm competition results, the specialized table training program is suitable for them. Right-handed sportsmen have a tendency to underestimate the training of their left arm. In this program they keep the same training volume for both arms which lead into improvement their performance of their left arm. As the table training is complicated, the sensitive and individual approach is inevitable. More sportsmen were complaining about its difficulties even when performing 3 sets per training. We recommend to start at two sets of 6–8 repetitions while the resistance intensity of the sparingpartner should by regulated by words so that the trainee had 2 repetition supply in each set (that equals the current rate of RPE 8, but this scale wasn´t part of the original table program). In other training the sportsmen could increase the number of repetitions up to 12 repetitions. This number was a limit as an arm pumped and this prolonged the rest time between the sets. In current program HAST (Table 6) we do not recommend to perform more than 6 repetitions. Working with pace and TUT seem to be a better option. During the realization of the experiment we found out that it is not suitable to perform more than5 sets per exercise. Sportsmen were describing significant fatigue of their arm on the second, sometimes even on the third day. Within the HAST program, ideally, we start with 2 sets and we try not to make more than 5 sets. When we talk about the number of repetitions, we start at 6 and make no more than 12 repetition per exercise. Te training was performed two times a week, on Monday and Friday, with a sparingpartner. On Wednesday we had a training devoted to general strength with the exercise such as bench press, pull ups, dead lifts and triceps extension with a rope.

- Sparingpartner is a very important part of HAST. We need to realize that sparingpartner too during the training performs some muscle work, therefore ideally there are 3 sportsmen on the training. The first on is a performer and he follows the program. The second one is a sparingpartner and he make active resistance for a performer. The third one rests and checks the time.
- The intensity of sparingpartner resistance must be regulated by performer in each set by word so that the resistance is not too big or too small. The resistance should be in a way that RPE is adhered, with required TUT, pace and with optimal technique of exercise.
- Sparingpartner who make a resistance can do so:
  - By one arm – if he is strong enough, he doesn´t prepare for a competition, is not injured or it is a coach who corrects the technique
  - By two arms (Figure 2) – if a training partner is as strong or wekaer, has a different program, could be tired before the competition or is injured, trainer who wants to make as big resistnace as possible.
- A sparingpartner who rests controls the pace, TUT, number of repetitions and a break time. It is suitable to use stopwatch (Figure 1) on the table so that everyone can see it.
- Sportsmen should write down fullfillment of the plan but mainly all the detail which influenced them durin the training. For example: I had the arm pain, so I lower the exerate to RPE 6 and did only 3 repetitions at a lower pace 2222. TUT was 24, or I felt very well and went to RPE 10 with maintaining the other parameters, but in the last set I pumped my forearm. A coach should set the next training according to the notes.
- The disadvantage of HAST is that we cannot measure (quantify) the progress right on the training as it is with dumbell training. We can check the effectivity only by motor tests or to apply it to achieved results at competition or to individual rival.

- It is a problem when a sportsman saves or lie about what exerate he made and he doesn´t achieve desired training stimulus. Nor coach or a sparingpartner can estimate the exerate (even thought the RPE is set). That can be caused by many other factors sucha s: motivation, tiredness, unsuitable warm-up, injury, stress, psychic state, daily activities, sleep ....
- We don´t know to estimate the deree of tiredness so the injury risks rises. This can be a problem with highly motivated sportsmen who pushed their pain level. They also have a high aspiration level before competition.
- Not suitable sparingpartner can also be a problem. He might not be well informed about the training, he is not experienced enough, he changes his techniques during the exercise, he doesn´t respect the needs of a perfomer, he makes too big resistance so a performer cann fulfill established program.

Table 6 An example of training unit HAST

Exercise	**Sets per exercise**	**Reps per set**	**Tempo**	**RPE**	**TUT**	**Rest Interval**
„Hook“	4	3	122P	9,5	15 sec	3 minutes
pronation wrist	4	4	1121	9	20 sec	3 minutes
Side Pressure	3	6	2121	8	35 sec	2 minutes
Isometrci hammer curl	4	0	000/10	9	10	2 min

Note: The left arm aches in elbow. I decreased the Hook exercise and a side pressure RPE to 5

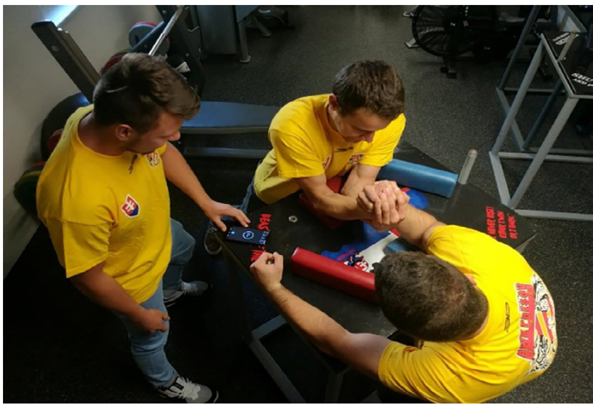

Figure 1 *Technique “Hook“*

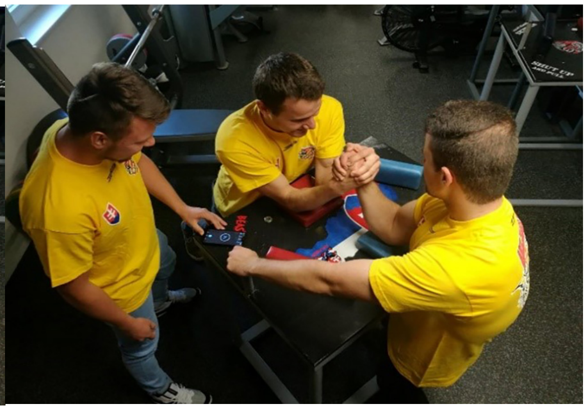

Figure 2 *Isometric Hammer Curl*

Conclusion

Until now many coaches thought that strength abilities have to be developed only with the use of dumbells, pulleys and other strengthening tools. Harcarik (2011) confirmed that the strength abilities can be developed by the table training with a sparingpartner in armwrestling. HAST is a systematic methodology of training which takes into account many parametres when creating a training plans. This program has not been used in armwrestling so far and it is a big asset for this sport. So far only the members of AWK Presov club make use o fit and some of the members of Slovak representation. We have to scientifically (statistically) attest the effectivity of HAST. But in practice it seems to be very effective for strenght abilities development of armwrestlers.

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THE EFFECT OF KINESIO TAPING ON THE RESULT IN THE STANDING LONG JUMP

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Aleš Kaplan[1], Iva Hnátová[2], Miloš Peca[3]

[1]*Faculty of Physical Education and Sport, Charles University, Czech Republic*

[2]*MOTUS Kinesiology Taping instructor*

[3]*HC Kometa Brno Fitness Coach; Faculty of Physical Education and Sport, Charles University, Czech Republic*

ABSTRACT

This paper draws attention to a short-term experiment that aims to elucidate the effect of kinesio taping of the musculus triceps surae on performance in the standing long jump. We therefore dealt with an area that has not yet been sufficiently explored. For this reason, our aim was to determine and evaluate the effect of the application of kinesio taping on muscle strength in the standing long jump and to make a comparison with the results without the use of kinesio taping. The musculus triceps surae was selected for testing. Thus, we assume that the application of facilitation kinesio taping to the musculus triceps surae will influence the probands' performance in the standing long jump. The experiment was performed with a group of n=20 young probands, athletes aged 16.25 (± 0.76), without prior injury. In this context, we realise that we cannot generalise the results to cover the entire population, especially to injured individuals or after an accident.

Keywords: fitness preparation; kinesio taping; standing long jump; testing

Introduction

The effects of kinesio taping have long been the subject of research by various scientific teams. In order to determine the effect of kinesio taping on the result in a standing long jump motor test, it was necessary to study the theoretical background related to our research topic. For the sake of clarity, the theoretical background section presents selected studies that are related to the issues we deal with. To begin with, we would like to say that the most commonly mentioned effects of kinesio taping are increased muscle strength, improved blood and lymph flow, alleviated pain, increased joint movement, faster scar healing, reduced tone in hypertonic muscles and possibly the correction of poor posture, as stated in Kase et al. (2003) and Lee et al. (2012).

The effects of kinesio taping on a selected physical activity can be divided into four categories in scientific literature. In the first category, we would like to draw attention to effects on muscle strength, where Huang et al. (2011) tested whether kinesio taping and traditional taping applied to the musculus triceps surae had an effect on jump height. They simultaneously monitored the EMG of selected muscles. The results of the studies showed that kinesio taping applied to the calf muscle had an effect on the activity of the musculus gastrocnemius pars medialis, which was increased by kinesio taping, but had no effect on jump height. On the other hand, traditional taping did not influence the involvement of the muscles, decreasing jump height slightly. Another interesting testing was conducted by Mostert-Wentzel et al. (2012), who studied whether kinesio taping had an effect on the explosive muscular strength of the musculus gluteus maximus in the vertical jump. The monitored set consisted of 60 young healthy athletes who were divided into two groups. A “Y” kinesio tape, recommended by the Kinesio Taping Association International (https://kinesiotaping.com/), was applied to group A, consisting of 30 people. An “I” placebo tape without stretching was applied to group B, consisting of 30 people. The results were compared without kinesio taping, immediately after application and after 30 minutes. The results showed that there was an improvement in both groups, the same for both group A and group B. The authors mentioned as a possible problem the absence of a third group to which none of the types would be applied. The authors see the reason for the improvement in the jump in the fact that skin and skin mechanoreceptors were stimulated in roughly the same area in both cases, both in group A and in group B. Other testing of the effect of kinesio taping on the gluteus maximus et medius was conducted by Strutzenberger et al. (2013), who found that kinesio taping applied to the above muscles improved the result in a 20 meter sprint, but reduced jump height. In contrast, Fu et al. (2008), who tested 14 healthy athletes, reported that there was no change in muscle strength in the musculus quadriceps femoris and hamstrings, neither immediately after kinesio taping was applied, nor 12 hours after application. When monitoring the effect of kinesio taping on physical performance, differences between the results of the athlete and non-athlete population were found. As an example, Vithoulk et al. (2010), who studied the effects of kinesio taping in non-athlete women, can be mentioned. A group of women were subjected to research to determine whether kinesio taping has an effect on increasing the muscle strength of the musculus quadriceps femoris. Three groups were tested in this study: without any tape, with a kinesio tape and with a placebo tape. Strength was measured using a dynamometer at a maximum torque of 60° and 240°. No significant changes in muscle strength were measured in all groups in the study. Wong et al. (2012) give the same conclusions. Wong et al. (2012) tested 30 healthy probands in flexion and the extension of the knee joint with and without kinesio taping of the musculus vastus medialis. Their study also found no demonstrable results suggesting that kinesio taping increases muscle strength.

As is clear from the above studies, the results of whether kinesio taping improves muscle strength are questionable. The only measurement similar to our measurement is presented by Huang et al. (2011), who measured the effect of kinesio taping of the musculus triceps surae in the vertical standing long jump, as opposed to our study, which focused on the horizontal standing long jump.

The second category which we believe could be influenced is that of exteroreceptors. Exteroreceptors can also be referred to as skin receptors that receive stimuli from the external environment, leading them to the central nervous system through nerve pathways to be processed, evaluated and, subsequently, responded to by the motor system. Skin receptors are divided into Merkel disks, Meissner corpuscles, Ruffini corpuscles, Vater-Pacini corpuscles and thermoreceptors, see Čihák (2011). It should be noted that stimulation of skin receptors by applying kinesio taping influences afferent pathways and the subsequent motor system response. In their study, MacGregor et al. (2005) state that if a tape is applied over the patella, more motor units are activated in the musculi vasti. The effect of skin stimulation by taping was also studied by Thedon et al. (2011), who analysed the effect of a tape applied to the Achilles tendon on upright posture before and after muscle fatigue. The results in this case showed that if the muscles are tired, posture can be improved through skin stimulation.

We would like to mention another category in connection with afferent transmission from muscle, tendon and joint receptors, which provide the central nervous system with information on the condition of all body segments of the musculoskeletal system. And, as Véle (2006) states, it is possible to influence movement through the use of proprioception. However, there are not yet many studies dealing with kinesio taping and its effect on proprioception, and their results are inconsistent. Halseth et al. (2004) studied the effect of kinesio taping on ankle area proprioception in healthy individuals, and their results did not indicate an increase in proprioception if kinesio taping was used. In contrast, De La Monte et al. (2008) give positive results in their study in terms of increasing proprioception if kinesio taping was used. Kinesio taping had a greater effect on the probands in the group of unhealthy individuals than on the healthy probands.

The last category we have in mind in relation to the effect of kinesio taping on the selected movement is the influence of nociception. Pain is very important information from the organism that something is wrong, so it is very important to assess what the body wants to tell us before pain is suppressed. There are several theories of pain. According to the "gate control theory" presented by Melzack and Wall (in Véle, 2006), there are two places in the human body where pain is interpreted and where it can be alleviated. At the spinal level, where it can be suppressed by stimulating thick fibres, for example by caressing, and in the brain, where pain can be suppressed by endorphins, such as those produced by sports. An integral part of the treatment of pain is the psychological component and the so-called placebo, as Véle (2006) states. García-Muro (2009) assessed the effect of kinesio taping on pain and the range of motion in the shoulder joint. The results showed that kinesio taping supported an increase in the range of motion, but had no effect on pain. Thelen et al. (2008) confirms that kinesio taping applied to a painful shoulder joint helps to increase the painless range of joint movement immediately after application, but on the third day after application the condition of the kinesio taping group was the same as in the placebo tape group.

Objectives And Tasks Of The Study

The aim of this study was to determine and evaluate the effect of the application of kinesio taping on muscle strength in the standing long jump and to make a comparison with the results without using kinesio taping. The musculus triceps surae was selected for testing. Thus, we assume that the application of facilitation kinesio taping to the musculus triceps surae will have an effect on the probands' performance in the standing long jump. Measurement was conducted without kinesio taping and, subsequently, after kinesio taping was applied.

Tasks Of The Study

1. Conducting research into literature and gathering theoretical materials;
2. Setting the goals of the study;
3. Choosing a study methodology;
4. Conducting measurement and data collection;
5. Data analysis;
6. Data evaluation and interpretation.

Hypothesis

Based on the study of professional literature and practical experience with athletes and with the kinesio taping method, we formulated the following hypothesis:

H1: Correct application of a kinesio tape will increase muscle performance under the point of application – musculus triceps surae, thereby improving performance in the standing long jump.

Methodology

Brief characteristics of the monitored set

Necessary data were obtained from experimental measurements in which n=20 probands participated based on an informed consent. The tested group mainly consisted of secondary school students who had long practised sports at a competitive level. None of the probands tested had any leg injuries or previous kinesio tape testing experience. It was a heterogeneous group consisting of 16 men and 4 women. The average body height was 177.6 cm (± 6.6), the average age was 16.25 years (± 0.76), and the average body weight was 66.1 kg (± 7.02). All probands signed an informed consent and underwent the testing voluntarily. None of the probands were ill or injured at the time of measurement.

All probands had to meet the following criteria:

- no acute disease;
- no disease in the calf area;
- no lower limb disease;
- no previous lower limb injury;
- no chronic or acute pain;
- no internal disease;
- no neurological disease;
- full understanding of the task;
- active sporting activity at a competitive level.

Brief description of the work procedure

Prior to the start of the experiment, all probands were advised on the course of the experiment and signed an informed consent.

Both measurements were conducted in the Liberec POWER FITNESS gym, the second taking place 14 days after the first, always under the same temperature conditions (20°C) on the UnoBAT 50 sports surface. As mentioned above, the experiment took place on two dates. In order to prevent potential lower limb injuries, the measurement itself was preceded by a 15-minute warm-up in the following form: 7-minute jogging, 7-minute dynamic stretching, 6-minute static stretching focused primarily on the lower body.

On the first date, the first measured performance was the standing long jump without kinesio taping, with three repetitions. This was followed by a 5-minute break. After completing the measurements without using kinesio taping, kinesio taping was applied to proband No. 1. After the kinesio taping application was completed, the proband immediately went to the jumping sector, where his/her performance was measured in the standing long jump in three repetitions. Measurement of the performance achieved with kinesio taping was the same as that without kinesio taping. There was a 5-minute break between the two measurements. This procedure was repeated with the second through twentieth proband. On the second date, the methodical procedure of measurement was conducted in a similar way as in the first measurement.

Measurement without kinesio taping was done first on both dates, because if we had first applied kinesio taping, motoneurons would have been stimulated under the point of application, so the resulting measured values could be misleading; in addition, removal of a kinesio tape after a short application time may be very painful and could damage the probands' skin.

The results of the measurement of the standing long jump without and with the use of kinesio taping are shown in the results section in Table 1.

Method of kinesio tape application

TEMTEX blue kinesio tape was chosen. The probands were properly instructed before the tape application itself, so the entire course of tape application was known to them in advance. Their skin was shaved and degreased before application, which we consider to be very important for measurement, especially given good adhesion and maximum tape effect. The length of the kinesio tape was measured on each proband separately, depending on the size of his/her lower limb. Two tapes were applied to each proband. The first tape, "Y", 8–10 squares long, was applied from the Achilles tendon attachment to the beginnings of the musculi gastrocnemii. The second tape, "I", 4–5 squares long, was applied from the Achilles tendon attachment cranially. The initial position of the limbs for application was knee joint extension and dorsal flexion of the ankle. The tape was applied at average tension; the 2.5 cm anchor and the 1.5 cm base zones were applied without tension. The application procedure was consulted and recommended by the kinesio taping specialist PhDr. Iva Hnátová, Ph.D.

The measured values were recorded in units (mm), converted to metres for easier processing and rounded to two decimal places. The average was then calculated from these values. The average values were processed; the results section in Chart 1 shows the overall average and the difference of the results.

Results

At the beginning of the results section, we would like to point out that the measurement took place on two dates and that 12 values were measured for each proband on each date. Table 1 shows the average values of the standing long jump without kinesio tape application from both dates and the average values of the standing long jump after kinesio tape application from both dates. All values are given in metres and, for the sake of clarity, rounded to two decimal places. The data were processed in Microsoft Excel.

Table 1 below shows the average values of the standing long jump with and without a kinesio tape, calculated from the six attempts made by each proband. The last column indicates whether there was any change in performance after a kinesio tape was applied and whether it was positive or negative. To evaluate the substantive significance we used the Cohen´s coefficient d because of its independence from the sample size.

Table 1 *Average values of the standing long jump and difference in performance with and without a kinesio tape*

Probands	Standing long jump without KT (m)	Standing long jump with KT (m)	Difference in performance with KT (m)
P1	2.25	2.31	**0.06**
P2	2.26	2.39	**0.13**
P3	2.32	2.44	**0.12**
P4	2.14	2.18	**0.04**
P5	2.33	2.35	**0.02**
P6	2.29	2.37	**0.08**
P7	2.42	2.4	**-0.02**
P8	2.07	2.2	**0.13**
P9	2.04	2.07	**0.03**
P10	1.99	1.98	**-0.01**
P11	2.53	2.46	**-0.07**
P12	2.38	2.42	**0.04**
P13	2.2	2.21	**0.01**
P14	2.48	2.47	**-0.01**
P15	2.17	2.35	**0.18**
P16	2.45	2.47	**0.02**
P17	1.81	1.83	**0.02**
P18	1.92	1.9	**-0.02**
P19	1.76	1.83	**0.07**
P20	1.71	1.8	**0.09**
$\bar{X}$	2.176	2.221	Cohen´s d = -0.1927
σ	0.237	0.230	Effect size (r) = -0.0959

For ease of reference, Chart 1 illustrates the performance achieved in the standing long jump with a kinesio tape (KT) and in the standing long jump without a kinesio tape (KT). The comparison of values shows whether or not the application of a kinesio tape had an effect on the probands. It can be seen at first glance from Chart 1 that the effect of kinesio taping on probands may be different. In general, the effect of kinesio taping on performance in the standing long jump was positive. There was an average increase in performance by 5 cm. Therefore, it can be stated that the hypothesis was confirmed. However, if we look at the results of the individual probands, they are very different. Five probands displayed deterioration in performance. The greatest deterioration occurred in proband No. 11, namely by 7 cm. The smallest improvement was achieved by proband No. 13, who improved by 1 cm. The greatest improvement was achieved by proband No. 15, who improved by 18 cm.

Since the results of the pilot study were positive, we can admit that kinesio taping may also have an effect on muscle strength and, therefore, contradict the studies (Fu et al., 2008; Janwantanakul, 2007; Vithoulk et al., 2010; and Wong et al., 2012) which indicate that kinesio taping has no effect on muscle strength. On the other side we have to mention small effect of kinesio taping. Cohen coefficient d is *d= -0.1927.*

If we look at the results of the individual probands, there are significant differences. We must take into account the fact that all probands are athletes in different sports. Every type of sport places great physical demands on athletes, and although compensatory exercises now form an important element, all athletes are specifically focused and trained to achieve the best results in their discipline; therefore, for example, swimmers cannot be expected to have high explosive strength of lower limbs. We must also take into account that every sport has a competition season in a different part of the year so physical fitness may vary throughout the year. Another factor that may influence athletes' performance is physical fatigue after training units or races. The probands could also have been influenced by fatigue from a large number of attempts, but due to the accuracy of the experiment, we decided not to reduce the number of attempts. A large number of attempts could have influenced the acquisition of a better form, which is also a very important factor in this experiment.

What we see as a drawback of the experiment is the fact that only attempts without a kinesio tape and with an applied kinesio tape were measured. There were no attempts in which a placebo tape was applied, which could clarify the question whether kinesio taping influences humans only mentally, not physiologically. A placebo tape has been applied in a large number of studies, so if it had been applied to my probands, the results could be compared.

The biggest drawback of this study is, unfortunately, the absence of the application of EMG to the relevant muscles to support the results obtained in this study. The EMG study thus prepared could then be compared with the results presented by Slupnik (2007), Murray (2000), as well as Huang et al. (2011), who applied EMG directly to the triceps surae.

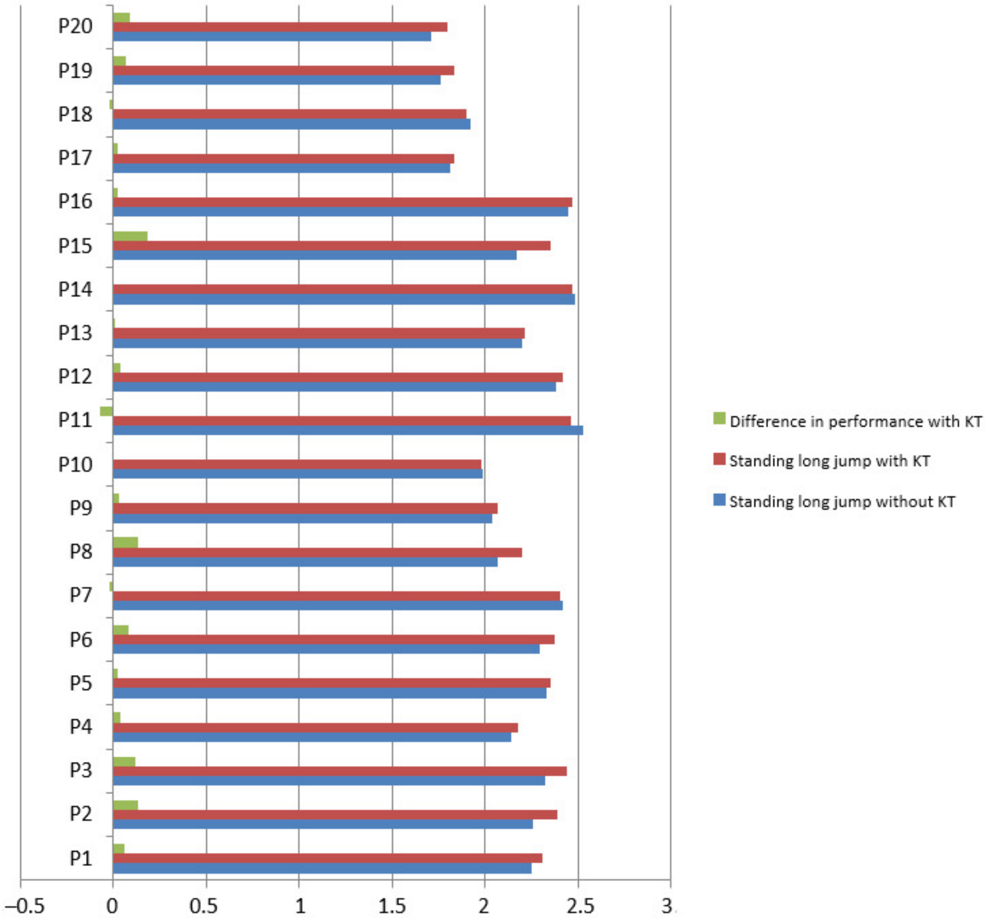

Figure 1 *Average values of the standing long jump and the difference in performance with and without a kinesio tape*

Discussion

In this study we assessed an influence of a kinesiology tape on musculus triceps surea on a standing long jump. The goal of this study was to evaluate an influence on a performance increase. Many foreign authors have dealt with similar topic, for example Huang et al. (2011), Vithoulk et al. (2010), Wong et al. (2012) and more. Based on the results of our experiment, we can say, that there is a positive effect of the kinesiology tape on standing long jump. We are aware of the size of the experimental group and we know very well we need a larger group of athletes to confirm the result.

There are many questions coming along the results. For example if the results of standing long jump improved due to increased muscle strength or if the tape helped to "harmonize" the tissues underneath it and actually activated the muscle and tissue functions physiologically. Functionality of muscle tissues is usually limited among athletes due the overwork hence the tissues cannot reach the maximal performance. We must also consider a variety of changes in a level of engagement of musculus triceps surae and its increasing effectivity on functionality of the particular muscle. Tape can also affect the timing of the musculus triceps surae in muscle chain that might play its role in the results. Different ways of influence bring changes in timing of muscle engagement. The muscles might also work in wrong stereotype patterns for example due to a unilaterality of a sport or the muscles could be in a hypertonia because of an abnormal training work and lack of regeneration.

We did not use a placebo tape in this experiment as was used in a study of Moster-Wentzel et al. (2012), when they applied a tape without a tension. We assume an increase of the performance within that group too due to fluid dynamic changes, eventually stimulation of skin receptors. We can also consider, although not probable, an effect of a mechanostransduction.

Conclusion

The aim of this paper was to point out the kinesio taping method using literature research and to experimentally verify its effect on muscle strength. There are still very few theoretical materials in the Czech Republic, so we have drawn from foreign literature, mainly from articles on the scientific portals available. We must state that some authors present a positive effect of kinesio taping on athletes' performance, but some negative. There are a large number of articles that ascribe great influence mainly to psychological effects. The most important part of the study is an experiment that was to explain whether or not kinesio taping has an effect on muscle strength. We must state that, unfortunately, no placebo tape was applied that would help to eliminate thoughts about the psychological effects of kinesio taping, which remains a question. In our opinion, the goal of the experiment was achieved. The selected group of probands showed an effect of kinesio taping on performance in the standing long jump. The question is whether, given the number of n=20 probands and a certain number of repetitions of jumps, the results of the field experiment can be considered significant. We used Cohen´s coefficient d for the quantification of effect size. This coefficient d *(d= -0.1927)* shows small effect.

In the next phase of the study, it would be very beneficial to apply EMG to the musculus triceps surae in order to monitor muscle involvement. We also see another necessary extension of the study in the application of a placebo tape to eliminate the psychological effects of KT.

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THE EFFECT OF ISOMETRIC HIP ADDUCTORS FORCE ON CHANGE OF DIRECTION SPEED OF PROFESSIONAL ICE -HOCKEY PLAYERS

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Roman Švantner[1,2], David Brůnn[1,2], Martin Pupiš[1], Dávid Líška[3], Jozef Sýkora[1,2]

[1]*Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banská Bystrica, Slovakia*

[2]*Fit Factory, Nemce*

[3]*Slovak Medical University in Bratislava, Faculty of Health in Banská Bystrica, Slovakia*

ABSTRACT

Introduction: Ice-hockey is a sport that requires high acceleration of players for optimal performance. The speed of sports players is influenced by several factors. The aim of research was to determine the effect of the isometric muscle strength of hip adductors on speed with directional changes in ice-hockey players.
Methods: The sample consisted of 15 members of the Slovakian national ice-hockey team, the average age was 27 years, the average height was 186.46 cm (SD ± 5.04), the average body weight was 90.87 kg (SD ± 5.91). Players completed a GroinBar Test of 60° to determine the isometric force of the hip adductors. We used the 5-10-5 test to determine the speed with directional changes. The 5-10-5 shuttle consists of rapid directional changes in a linear plane. It is commonly used as an assessment in different sports. The 5-10-5 Shuttle Drill, also known as the Pro Agility Drill, is a great tool for working on your agility and short-distance explosiveness.
Results: In the research sample consisted of professional hockey players was measured a low degree of correlation (r = 0.006) between isometric muscle strength of the hip adductors and the speed with the directional changes in the 5-10-5 test. The average ice-hockey player's adductors strength was 476.83 N (SD ± 88.50) and the average time achieved in the 5-10-5 test was 4.984 s (SD ± 0.15). We also found low degree of correlation between right adductor force and right side of 5-10-5 test (r = 0.047) as well as left adductor force and left side of 5–10-5 test (r = 0.067).
Conclusion: Research shows a very low degree of correlation in ice-hockey players between the hip adductor strength in the GroinBar Test 60° and the speed with the directional changes in the 5-10-5 test.

Keywords: isometric strength hip adductors; speed with directional changes

Introduction

„A typical game is very dynamic and involves exposure to intermittent high intensity activity, typically in 30 second shifts. Both high-velocity collisions and unpredicted changes of directions are common. This demand for ability requires the athlete to be able not only to accelerate and decelerate repeatedly but also to change direction intermittently while remaining in motion" (Jay, 2019, p. 198). Taft (2015) is adding, that the ability to quickly change direction in field and court separates great athletes from the good ones. This fact we can also apply to the ice ring or ice-hockey players. Terry (2019) states, that when we deconstruct skating, it is series of muscle contractions, which generates the force to move the skater across the ice. The stronger those muscles are, the more force they can generate and the faster the skater will be. “When changing direction or taking off for a loose puck, the more powerful athlete will be able to generate his or her maximum force more quickly, which translates to a more explosive first few strides and the advantage over a less powerful athlete” (Terry, 2019, p. 5). The issue of fitness in hockey is mostly centered around injury prevention and strength and power development (Lutz, 2016). Because of that, we want to be clear what an ice-hockey player needs, which muscle groups he mostly uses and therefore we should develop these abilities according to specific demands. Chang (2009) is also confirming the increasing importance of adductor muscle group with skating speed.

Neeld (2018) states that in forward skating stride (FSS) and forward cross-over stride (FCS) is only stride leg (during FSS) abducting the hip. In all other cases among FSS and FCS (stride leg, stance leg, push under leg, cross-over leg) both legs are hip’s adductors. And because ice-hockey is all about change of direction, accelerations and decelerations, Neeld (2018) states that the 5-10-5 is a transitional speed test that assesses quick starts, rapid decelerations, and explosive direction changes. Terry (2019) is adding that adductors (brevis, magnus, pectineus, and longus) are among primary involved muscles. Vald Performance (2018) published NHL average adduction (413.84 N, SD 117.65) and abduction (408.94 N, SD 98.37) groin strength. They are adding NHL average adduction (5.49%, SD 4.52) and abduction (5.24%, SD 3.89) imbalances between right and left leg.

“The ability to recover in skating stride is primarily achieved by engaging the adductors. Strong adductors enable you to pull the extended leg back under the body quickly and forcefully to then push off and propel into the next stride. The abductors and adductors should be balanced to prevent groin and lower-abdominal strains” (Terry, 2019, p. 89). In this case Vald Performance (2018) states, that players should have the strength ratio between adduction and abduction above 1.01 (SD 0.20) (GroinBar 60° test – According to Vald Performance 2018, the most popular Test Type in the NHL 2017/2018 season). The assessment of isolated adductor and relative adductor/abductor strength is used for the identification of at-risk players (Thorborg et al. 2011a, 2014; Thorborg et al., 2011) and for early detection of groin problems (Cow et al., 2010; Wollin et al., 2018a). Ryan, DeBurca & Mc Creesh (2014) and Whittaker et al. (2015) identified that athletes with low hip adductors strength (isolated measure and relative to abduction strength) have four times greater chance of hip and groin pain.

Skahan (2016) is in this case indentifying groin area like a probably most common place for soft tissue injuries among ice-hockey players. He suggests to keep their groins healthy and strong especially when they change direction a lot. Hip and groin problems are also common in all kinds of sports and can impact on player’s ability to play, result in pain, or motor deficits (Mosler et al., 2018). Early detection of strength deficits allows appropriate intervention as required (Thorborg et al., 2018). The part of these assessments is also indicating when an athlete is ready for increased resistance in exercise, progression of exercise or higher workloads in general (O’Brien, 2018).

Aim

The aim of research was to determine the effect of the isometric hip adductors´ muscle strength on speed with directional changes of ice-hockey players.

Methods

The sample consisted of 15 members of the Slovakian national ice-hockey team, the average age was 27 years, the average height was 186.46 cm (SD ± 5.04), and the average body weight was

90.87 kg (SD ± 5.91). The research took a part during July 2019, with assistance of FiT Factory facility in Nemce, Banská Bystrica. Players completed several tests as a part of their initial pre-season testing and within that we took a deeper look to the laying GroinBar 60° isometric adductor test as well as change of direction 5-10-5 speed test. GroinBar 60° isometric test was performed on GroinBar device, where players were laying on the floor with feet placed on the platform and 60 ° angle in knee joints. The force pad was positioned perpendicularly to the medial femoral epicondyle and on a signal players performed 2 repetitions of maximal squeezes to force pad in a perpendicular direction. Device software recorded each try and each limb independently. GroinBar is Modular carrier system allows for dozens of positions to be standardised and tested repeatedly. The dimensions of device are length 150 cm, width 103 cm, height 97 cm, weight 27 kg. It communicates via mini-USB or USB cable as well as Bluetooth. It contains chargable lithium ion battery with life approximately 100 hours active use mode and weeks if inactive mode. There are 4 load cell sensors placed on device with capacity of 100kg / 220lb/ 980N and sampling rate moves from default 50 Hz up to 400 Hz (maximum). The GroinBar´s (uniaxial) sensors are precision force transducers, designed for taking accurate measurements at high levels of force. The device is provided with a software, which allows to stream data from GroinBar in real time, it provides real time analytics: maximum and average abduction and adduction force and AB:AD ratio. It also provides immediate, quantitative feedback to athletes with live graphing, targeting absolute or relative strength zones, uploading results to player profiles in DashBord etc. For the second test players performed 5-10-5 m sprint with changes of direction. 5 and 10 meters distances were measured and the lines were market on 0, 5 and 10 meters points. 1 pair of Microgate photocells was used and placed exactly on a 5 meters distance. Player started in the middle right between photocell´s beam, in low stance with 1 hand placed on the ground facing the photocell. On a self-cue player started sprinting 5 meters to a direction of placed hand followed by crossing the line with the other leg as placed hand, cutting and change direction to opposite site, when he ran 10 meters distance, cut to the **same** leg again and ran back to the middle with full speed. Each player performed 2 tries on each side. Microgate Polifemo photocells work as a coaxial optical system. Also, the Polifemo line employs an intelligent link to the timer using the standard 2-wire banana connection. Microsoft Excel 2016 and IBM SPSS v25 software had been used for calculating data´ normality, statistical significance and effect size, causal analysis and synthesis were use for appropriate concusions.

Results

15 members of Slovakian national ice-hockey team participated on measurements of hip adductors isometric strength test as well as test for determining speed with change of direction. Results are presented in *Table 1.*

Table 1 *Test performance summary*

	Left ADD Force (N)	Right ADD Force (N)	Difference L : R (%)	5-10-5 R (sec.)	5-10-5 L (sec.)
Average	467.87	485.80	3.50	4.95	5.02
SD	87	95.10	7.08	0.16	0.13

In *Table 1* you can see team average score as well as score variability presented via standard deviation value. When it comes to adductor isometric force production, most of the players had stronger dominant right leg and achieved faster time to the right side of 5-10-5 test. When it comes to speed with change of direction most of the players are able to cut and change the direction faster on the right side (meant deccelerate and reaccelerate by right leg). For further information see *APPENDIX A***,** where detailed test statistics are presented.

Since we wanted to determine, whether hip adductor isometric strength level does have any effect to speed with change of direction we calculated data distribution in IBM SPSS software. Kolmogorov-Smirnov test´s result revealed, that data were normally distributed within a sample in each variable therefore we used Pearson corelation non parametric test for calculate if there exist any corelation between hip adductor isometric force and speed with changes of direction. Results are presented in *Table 2.*

Table 2 *Pearson correlation results*

	Pearson correlation results
Right leg adductor force vs Right side COD test	**0.047**
Left leg adductor force vs Left side COD test	**0.067**
Right and Left leg adductor force vs COD test	**0.006**

From *Table 2* we can declare, that there is no relation between right leg hip adductors force and ability to change direction with right leg (0.047). We can also declare no relation between strength of left leg hip adductors and ability to change direction with left leg (0.067). We cannot consider the adductors isometric strength as prerequisite for change of direction speed ability.

Discussion

The study demonstrates no correlation (0.006) between adductor's strength (GroinBar 60° isometric test) and speed with directional changes (5-10-5 test), while Chang (2009), Neeld (2018) and Terry (2019) states big importance of adductor muscles strength during skating and changing of direction on ice. Our experiment provides a new insight into the relationship between speed with directional changes and adductor strength, because no other research have dealt with the same research problem yet. These data contribute to a clearer understanding of change of direction kinesiology where adductors strength does not play so big role as we expected.

The generalizability of the results is limited by the fact, that we used only one test (GroinBar 60° isometric test) for proclaiming the final correlation. Vald Performance (2018) is offering many other testing positions and options (Unilateral and bilateral supine neutral, supine 60°, supine 90°/90°, seated 90°/90°, seated interval/external hip rotation) which can be used in next researches. The next question for us is, if there possibly is positive correlation between change of direction 5-10-5 test and excentric adductor strength. For this case we plan to use excentric based test type like Copenhagen exercise and try to find, if excentric adductor strength plays bigger role in changing of direction in ice-hockey and sport in general. Our findings are challenge for the existing assumptions and therefore create the space for the next research.

Conclusion

This research aimed to correlate the speed with directional changes with adductor's strength. Based on a quantitative and qualitative analysis of our results, it can be concluded that there is no relationship (0.006) between adductors strength and speed with directional changes. The results indicate that there are other muscle groups and movement qualities which make a difference in final performance. For our research we chose GroinBar 60° test which is according to Vald Performance (2018) the most popular Test Type in the NHL 2017/2018 season. The 5-10-5 test is not only part of the NHL Combine test battery (Marrazza, 2017), but also recommended by Neeld (2018) to assess important speed qualities of hockey players. This research clearly illustrates no correlation between chosen variables, but the question of the most important muscle group involved in changing of direction still remains. Further research is needed to determine the relationship between strength of the adductor muscle group and speed with change of direction.

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THE LEVEL OF EXPLOSIVE STRENGTH OF LOWER LIMBS OF SLOVAK REPUBLIC REPRESENTATIVES IN SWIMMING

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Zuzana Pupišová

Department of Physical education and Sport, Faculty of Arts, Univesity of Matej Bel in Banská Bystrica, Slovakia

ABSTRACT

The aim of the study was to detect the current level of explosive strength of lower limbs. Results were compared with the best individual personal performance which is evaluated through FINA points. 10 male and 14 female junior representatives in swimming (n=24; height = 178.7 ± 7.59 cm; weight = 67.5 ± 7.76 kg) and 10 male and 8 female senior representatives in swimming (n=18; height = 179.8 ± 5.54 cm; weight = 72.6 ± 8.32) from the Slovak Republic participated in testing. The explosive strength of lower limbs was measured by standing broad jumps and by the diagnostic device Myotest where CMJ and SJ tests were used. The results were compared by Pearson correlation coefficient with the best point performance of a particular proband. The average height of the junior representatives in the SJ test was 33.0 cm and of the senior representatives was 40.9 cm. The average height of the junior representatives in the CMJ test was 36.0 cm and the value of the senior representatives was 45.9 cm. The average value of junior representatives in the standing broad jump test was 220.0 cm and in senior representatives was 269.3 cm. Senior representatives achieved better results in all tests. The average point performance in junior representatives was 708.0 points and in senior representatives was 761.7 points. Percentual difference between the groups was detected in tests at values from 18.1% to 21.6% and the difference in FINA points was 7.1%. Pearson correlation coefficient showed high and medium values on statistical significance of 1% between tests of explosive strength, although, it showed the low values between the explosive strength tests and value of FINA points. The explosive strength of the lower limbs is one of the factors of sports performance that affect swimming performance. However, its level of impact needs to be verified by further research.

Keywords: comparison; Jump height; junior representatives; swimming performance; senior representatives; testing

Introduction

A structure of sports performance in swimming is constructed on the definition of factors which influence the performance itself. The speed-strength performance is dominant in swimming, of course, it is influenced by the length of the discipline and choice of swimming stroke. Ružbarský & Turek (2006) stated that the improvement of strength abilities is irreplaceable in swimmer´s training preparation but the swimmer´s individuality must be taken into consideration. The explosive strength of upper and lower limbs is a limited factor of the performance in the shortest swimming disciplines. Mutual dependencies between explosive strength of lower limbs and swimming performance were confirmed by Pupišová (2013), whose research focused on performance of senior representatives in swimming. Fast and explosive strength is determined by the force´s intensity and time period that the athlete achieves a certain percentage of maximal strength. It is partially determined by the intensity of maximal strength and intramuscular and intermuscular mechanisms (Sedláček & Lednický, 2010). The explosive strength can be characterized as a dynamic strength ability which grants the largest acceleration to the organism and its parts thanks to the creation of fast muscular effort, which can be seen during kick realization in particular swimming strokes, starts and turns in swimming (Kasa, 1995). Take-off and its follow-up jump height is a precondition of effective realization of the following task which is coordinately difficult in swimming. Swimming turn or take-off are the most difficult tasks which are connected with another function after water entry (Zemková & Hamar, 1999, Zemková & Hamar, 2006). Two phases are distinguished in the push off technique. The first phase is characterized by rapid extension of knees and hips towards the wall prior to contact (i.e., no countermovement), and the active phase where the swimmer glides into the wall, letting the wall flex the knees in an approximate countermovement or eccentric phase (from shrug of lower limbs, ends with flex up to fingers of the feet). It is important to be able to pass quickly from a compliant regime of muscles´ work to a surpass regime. It is called reactive ability of muscle apparatus (Kremnický, 2005; Kremnický, 2014, Kremnický Kremnická, 2016). In swimming, it is demonstrated by realization of the first swimming kicks during the time when the whole body is under the water. Wendi et al (2019) stated the following: ,,During the eccentric phase, the water would aid the swimmer in slowing the movement toward the wall, and during the concentric phase the drag would provide increased resistance“. In a freestyle flip-turn, the eccentric phase consists of the initial wall impact and any countermovement when the swimmer is still moving towards the wall. The countermovement considered for this study was flexion of the knees and hips in addition to dorsiflexion at the ankle joints. The active force production phase consisted of the concentric contraction of the plantar flexors, quadriceps, and hip extensors in order to create velocity away from the wall.” (Weimar et al. 2019). This phase is composed of a forceful extension about the knees and hips and plantar flexion at the ankles in the horizontal direction, which in turn, would provide the swimmer more force during the push-off than during a no countermovement push off technique. The preloading in the muscle and associated tissue permits a faster contraction with a greater force than for a muscle that has not been pre-stretched.

The explosive strength of lower limbs improvement is influenced by specific water environments (water) in swimming. The resistance swimming aids (resistance swimsuit, kickboards, swimming flippers, etc.) are mainly used in training. The improvement does not have to be realized only in a water environment but also it is very effective to realize some exercises for strength improvement on a „dry place“ and subsequently, to transfer them to movements in the water. Wilson et al. (1993), Kent (2006), Garrido et al. (2010a), Morouco et al. (2011) and Potdevin, Alberty, Chevutschi, Pelayo & Sidney (2011) recommend the use of traditional training programmes as the most frequent training methods. Training programmes use resistance, plyometric exercises as well as the combination of traditional methods with resistance use and plyometric training.

The level of explosive strength of the lower limbs should be improved and diagnosed during the whole sport preparation. The need for diagnosis is inevitable mainly during preparation and race periods when we have to detect the current state of explosive strength level in the beginning of the preparation period, and, to select an appropriate method, way of improvement, volume, degree, and intensity of selected exercises and then diagnose. Regular measurements are required to detect the changes in selected physical skill and analyze the level of their impact on the performance.

Previous researches (Garrido et al. (2010b); Tonhauserová (2010); Tonhauserová (2011); Pupišová (2013); Pupišová, Pupiš, Giničová, Sýkora, Brunn & Pavlović (2018)) focus on the fact that the current level of swimmers´ explosive strength in the lower limbs is shown in Squat jump tests on levels from 3,6% to 16,1% and in standing broad jump tests on levels from 4,6% to 8,5%. The level is, of course, influenced by the age and the performance of the monitored sample. We can see the increased demands on performance quality in the swimming pool as well as on limited factors of sport performance, where there is also the explosive strength of upper limbs as a dominant factor.

Methods

Experiment sample

The sample consisted of 42 Slovak republic representatives (n = 42) in swimming where there were 10 male and 14 female junior representatives (n = 24; height = 178.7 ± 7.59 cm; weight = 67.5 ± 7.76 kg) and 10 male and 8 female senior representatives (n = 18; height = 179.8 ± 5.54 cm; weight = 72.6 ± 8.32).

Organization

The study focused on the explosive strength of the lower limbs of Slovak republic representatives in swimming. The second aim was to detect the best performance of particular swimmers, which were correlated with achieved results in explosive strength tests. We wanted to know the mutual dependence with realized tests of explosive strength. The research was realized in January 2017 with senior representatives and in January 2019 with junior representatives. We focused on detection of the current level of best performance (evaluation through the achievement of FINA points) and on detection of the explosive strength of lower limbs by using Myotest® PRO device. Three tests were realized: standing broad jump, squat jump (SJ) and countermovement jump (CMJ). Results presented the best tries, while each proband was performed for three tries. The testing was realized after a collective warm-up which lasted for 20 minutes. Results were evaluated in average values. We compared the junior and senior team´s results and we looked for the connection and mutual dependence between the best performance of particular swimmers and the explosive strength results. Results also present min and max achieved performance values in particular tests, standard deviation, and median. The statistical analysis was realized by statistical program Statistica 20, where we realized a Pearson correlation.

Results

Results section presents particular scores in all realized tests. Results also present min and max values, average values of particular samples, median, and standard deviation. We also present detected values of proband´s best performance (junior and senior samples), which were monitored because of the difference of swimming strokes and swimming disciplines of probands by FINA points. Test results are presented on Tables 1–4.

Table 1 *Results of Squat Jump test (JS)*

cm	Juniors	Seniors
Min	23.1	35.3
Max	43.7	50.8
Average	33.0	40.9
Median	32.1	39.4
Standard Deviation	5.69	4.74

Table 1 presents detected results in the Squat Jump test. We can see that better results were achieved by senior representatives, where the average performance was on the level of 40.9 ± 4.74 cm. The average performance of junior representatives was detected on the level of 33.0 ± 5.69 cm. The difference in average values was on the level of 7.9 cm (19.3%). The best performance was achieved by senior representatives, who also achieved the best point performance (100 m breaststroke discipline).

Table 2 *Results of Countermovement Jump test (CMJ)*

cm	Juniors	Seniors
Min	24.1	40.5
Max	50.0	56.9
Average	36.0	45.9
Median	35.6	44.3
Standard Deviation	6.63	5.13

Senior representatives also achieved better results in the countermovement Jump test. The average performance value was on the level of 45.9 ± 5.13 cm. The average performance of junior representatives was on the level of 36.0 ± 6.63 cm. The difference between average values was 9.9 cm in favor of senior representatives (21,6%). Senior representative T.K. achieved the best performance in the test again (FINA body = 909).

Table 3 *Results of standing board jump*

cm	Juniors	Seniors
Min	166.0	228.0
Max	274.0	294.0
Average	220.6	269.3
Median	214.0	276.5
Standard Deviation	27.61	18.72

Table 3 presents results of the standing board jump test, where senior representatives achieved better results again. Their average performance was 269.3 ± 18.72 cm. The performance of junior representatives was detected on the level of 220.6 ± 27.61 cm. Sample´s difference was on the level of 48.7 cm in favor of senior representatives (18.1%).

Table 4 *Point performance of probands*

points	Juniors	Seniors
Min	642	634
Max	822	909
Average	708	762
Median	69.5	754
Standard Deviation	50.2	78.6

Table 4 presents the most valuable proband´s performance in points. A minimum value presents that junior representatives have more valuable point performance (642 points). A maximum value presents that senior representatives have more valuable performance (909 points). Difference in average values is 54 points between the senior sample (762, SD = 78.6) and the junior sample (708, SD = 50.2) in favor of the senior representatives (7.1%).

Figure 1 presents percentage differences between junior and senior samples in particular tests. Senior representatives achieved 19% better results in average values of the squat jump test and they achieved 21.6% better results in the countermovement jump test. Senior representatives also achieved 18.1% better results on the standing broad jump test. The seniors achieved better average results by 7.1% when we recalculated their performance to FINA points.

Discussion

The explosive strength of lower limbs is important not only in cyclic movement of legs during kicks realization but also in starting technique (starts) and turns.

Our study focused on the explosive strength of the lower limbs by using 3 tests which were not realized in a water environment: (Squat jump, Countermovement jump and standing board jump). The main aim of the study was to detect the current level of the selected physical ability´s state and to compare samples of junior and senior representatives. The second aim was to detect if there is a mutual difference between the level of explosive strength of the lower limbs in swimmers and their most valuable performance. According to the difference in swimming discipline, we took into consideration a recalculation of the performance on FINA points.

Results have shown that senior representatives achieved better values in squat jump test by 19.3%, in countermovement jump test by 21.6%, and in standing board jump by 18.1% when compared with the junior samples. The senior representatives also achieved better average results by 7.1% when FINA points were recalculated. According to mentioned results, we expected a more significant difference between average values of swimmers in swimming performance (FINA points).

Statistical analysis has shown that there are medium and high values of correlation coefficients between explosive strength´s results (r = 0.6–0.89). Although, we detected small values of correlation coefficients between points score and explosive strength. The medium dependence was detected only in the senior sample between the standing board jump test and FINA points. According to this fact, we can state that there was not any significant impact on swimmers´ performance.

Conclusion

According to the mentioned results, we state that the better values of explosive strength of the lower limbs were measured in senior representatives, which is what we expected, but the difference between the best swimming performance was not significant (due to differences in selected explosive strength tests).

Finally, the explosive strength is not as determinative as we expected from the point of view of a specialized level of swimmer's performance. Despite this fact, we assume that the level of monitored physical performance can have an impact on swimmers´ performance. It can be minimally monitored in chosen parts of the swimming performance (starts, turns and kicks of lower limbs). The next research will focus on the explosive strength of the upper limbs and we suppose that its impact will be more significant on swimmers´ performance.

Despite this fact we can state that the level of the explosive strength is a limited factor for the movement of the lower limbs of swimmers, which can be monitored in kicks during the realization of all swimming disciplines as well as in turns and starting performance.

Practicing exercises which are focused on the explosive strength of the lower limbs is limited and it is effective to train it in a dry place. Researches by Tonhauserová (2010), Pupišová (2013), Pupišová, Pupiš, Giničová, Sýkora, Brunn & Pavlović (2018) etc. confirmed the positive impact of plyometric exercises on the explosive strength of the lower limbs and its current transfer to swimming performance, but the point is that the research was not focused on the improvement of the explosive strength of the lower limbs.

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DECISION MAKING OF SEMI-PROFESSIONAL FEMALE BASKETBALL PLAYERS IN COMPETITIVE GAMES

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Tomáš Vencúrik, Dominik Bokůvka, Jiří Nykodým, Pavel Vacenovský

Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

ABSTRACT

Purpose: Nowadays, not only the research but also coaching is focusing on decision making in basketball. Decision making is critical in basketball, especially in relation to offensive skills (with ball). Generally, the players have to decide what to do with the ball (make an appropriate decision) and in the shortest time possible. From this point of view, the study aims to identify the factors which can affect the decision making of offensive skills of female basketball players.
Methods: Eight semi-professional female basketball players participated in this study. Basketball players played five competitive games in the second division. During all games, the heart rate was monitored. Decision making was assessed according to Basketball Offensive Game Performance Instrument (BOGPI) and categorized as appropriate and inappropriate. For this purpose, the notational analysis was used. Based on previous research, the four main factors were set as independent variables. Each of these factors was categorized. The first factor was the intensity of load (< 85%, 85–95%, and > 95% of HR_{max}), second factor was ball possession duration (0–8 s, 9–16 s, and 17–24 s), third factor was game period (1st quarter, 2nd quarter, 3rd quarter, and 4th quarter), and the fourth factor was defensive pressure of an opponent (low, moderate, and high). Objectivity was verified by the method of inter-rater agreement, and reliability was using intra-rater agreement. The influence of factors on decision making was expressed by binary logistic regression. Method of backward stepwise selection was used to find predictors of inappropriate decisions and to find the best model.
Results: One regression coefficient in the final model was statistically significant – defensive pressure of the opponent. When the defensive pressure is moderate or high, the chance for inappropriate decisions increased.
Conclusion: Based on these findings, the coaches should take into consideration these factors when preparing individual training sessions.

Keywords: basketball; decision making; logistic regression; offensive skills

Introduction

One of the main interests (in recent decades) in basketball and other sports games, is the evaluation of information that leads to effective decision-making in the implementation of offensive skills (OS). Perception-sensory processes and cognitive processes play an essential role in the decision-making process and the choice of the appropriate movement response. According to Schmidt & Wrisberg (2004), cognitive processes are those that, during the player performance, process stimuli from the external environment, thus forming an integral part of the OS. During the game, cognitive processes serve the current needs of managing player skills, regulation of stimuli, and decision-making. Cognitive processes can be understood as a player's ability to control and specifically manage their actions in a particular game situation.

Based on the perception of the game situation and the game situation anticipation, the player decides on the choice of activity. The decision-making is an intermediary link between thinking and movement. The decision implies that existing alternatives to action are limited to one, which is assumed to meet the situational conditions and objectives related, for example, to the team offense.

Cognitive processes are influenced by many important factors, from the natural origin of information stimuli to the type of movement performed. Thus, the correctness of the decision can be affected by both endogenous and exogenous factors in the game conditions. Endogenous factors may include; e.g. psychological processes (emotional arousal or anxiety), intensity of load, and as exogenous factors; e.g. score difference (development of the game), time to end of the match, ball possession duration, defensive pressure of opponent, localization of the game (home, away), phase of the competition (in-season, play-off), etc.(Csataljay, James, Hughes, & Dancs, 2012; Gómez, Lorenzo, Sampaio, Ibáñez, & Ortega, 2008; Lorenzo, Gómez, Ortega, Ibáñez, & Sampaio, 2010; Parejo, García, Antúnez, & Ibáñez, 2013; Sampaio, Drinkwater, & Leite, 2010; Sampaio, Lago, Casais, & Leite, 2010) trying to identify which game-related statistics allow to discriminate winning and losing teams. The sample used corresponded to 306 games from the 2004–2005 Regular Season of the Spanish Men's Professional League. The game-related statistics gathered were: 2 and 3 points field-goals (both successful and unsuccessful.

Cognitive processes should be evaluated and observed in specific and natural game conditions, which would have a more significant impact on streamlining the training process and cultivating game performance. This study aims to determine the effect of selected endogenous and exogenous factors on the decision-making of a female basketball player in competitive games.

Methods

Subjects

Eight players of the second highest women's competition participated in the research. The mean calendar age was 20 ± 2.8 years. The average sports age was 10 ± 3.2 years; the average body height was 179.8 ± 4.9 cm, the average body weight was 66.8 ± 5.7 kg. All basketball players were informed of the purpose of the research, carried out according to the principles of the Declaration of Helsinki. They have signed informed consent.

Procedure

Before the beginning of the research, the players completed a beep test to determine the maximum HR. Commercially available Suunto Team Pack telemetry system (Suunto Oy, Vantaa, Finland) was used to monitor HR during the beep test and games. (Klusemann, Pyne, Foster, & Drinkwater, 2012; Montgomery, Pyne, & Minahan, 2010). Overall, basketball players played five competition games, according to FIBA 2012/2013 rules. All games were recorded with a digital video camera.

To determine the correct decision of the player with the ball (what to do with the ball) was used standardized Basketball Offensive Game Performance Instrument (BOGPI) (Chen, Hendricks, & Zhu, 2013). BOGPI is designed to observe and code players' behavior based on video analysis. The decision-making was coded on the basis of a binary criterion (Table 1), quality code 1 was a code for a appropriate decision and quality code 0 was a code for an inappropriate (inadequate) decision (French & Thomas, 1987; Chen et al., 2013; Memmert & Harvey, 2008; Oslin, Mitchell, & Griffin, 1998; Psotta & Martin, 2011).

Table 1

code	Dribbling	Passing	Shooting
1	• dribble-drive towards the basket thus gaining an advantage over the opponent • position adjustment on the court using dribbling • drawn foul while dribbling	• pass to a free teammate in a more favorable position • foul drawn while passing	• a shot from a distance of up to 7.5 m when the player is in an advantageous position (open), and another teammate is not in a better shooting position • foul drawn while shooting
0	• turnover while dribbling (breaking the rules) • dribbling when another teammate is open in a better position • dribbling to a disadvantageous position on the court	• a pass to a teammate who is not in a better position • a pass to a teammate, while another teammate is in a more favorable position • turnover by a bad pass	• shot from a distance of more than 7.5 m • the player shoots in a disadvantageous position • when shooting, another teammate is in a better shooting position • blocked shot

As factors with possible influence on the decision-making were chosen (Álvarez, Ortega Toro, Salado, & Gómez, 2009; Refoyo, Sampedro, & Sillero, 2009; Alejandro Vaquera, Cubillo, García-Tormo, & Morante, 2013)analyzing the difference in relation to success (efficacious or non-efficacious defenses: a) defensive pressure (low, medium, high); b) possession duration (0–8 s, 9–16 s, 17–24 s); c) game quarter (first, second, third, fourth); d) intensity of load (< 85% of HR_{max}, 85–95% of HR_{max}, > 95% of HR_{max}).

A total of 925 decision-making situations were evaluated. Notational analysis and Dartfish Team Pro 6.0 software was used to code the decision-making (Fribourg, Switzerland) (Hughes & Franks, 2015).

The Inter-observer agreement was ensured by the evaluation of 10% of randomly selected situations by two independent experts. The Intra-observer agreement was also guaranteed by the assessment of 10% of randomly chosen situations by one expert at two different time periods (O'Donoghue, 2015). The time difference between the first and second observation was 12 weeks.

Statistical analysis

Inter-observer agreement and intra-observer agreement were expressed by the kappa coefficient (κ) (O'Donoghue, 2012). A binary logistic regression was used to determine the predictors affecting the decision-making process since the dependent variable (decision-making process) only assumed binary values of 1 or 0. The backward stepwise selection method removed insignificant predictors from the model. The regression coefficients were estimated to utilize the maximum likelihood estimation method. The likelihood ratio test verified the statistical significance of each regression model. The results are interpreted as the odds ratio and its 95% confidence intervals, which indicates the chance of an inappropriate decision. Statistical significance of regression coefficients was verified by Wald's test (Landau & Everitt, 2004; Malek, Coburn, & Marelich, 2018). The first option in the line (low defensive pressure, 0–8 s, first quarter, intensity < 85% of HR_{max}) was chosen as the reference category of independent variables. All statistical tests were assessed at a level of statistical significance of $\alpha = 0.05$ and were calculated using the IBM SPSS Statistics 24 statistical software (IBM Corp., New York, USA).

Results

The inter-observer agreement in the decision-making was almost perfect (κ = 0.871). The intra-observer agreement in evaluating the decision-making at two different times was also almost perfect (κ = 0.954).

Table 1 shows the distribution of relative frequencies of the dependent and independent variables in all watched games. Based on the backward stepwise selection, the saturated model with all predictors (independent variables) was eliminated at each step by an insignificant predictor. The saturated model with four predictors was reduced to a model with one significant predictor. As a statistically significant predictor, Wald's test identified the defensive pressure variable. In Tab. 2 shows standardized beta weights (B), standard error of estimation (SE), values of Wald's test (Wald), the statistical significance of regression coefficients (p value), odds ratio (Exp (B), and the 95% confidence intervals (CI). The chances of making an inappropriate decision at moderate defensive pressure are 1.78 times higher (95% CI; 1.034–3.064) than at low defensive pressure. When the defensive pressure is high, the chances of inadequate decision increase to 7.627 times (95% CI; 4.693–12.396) compared to low defensive pressure. The percentage of the adequacy of the decision-making with respect to individual independent variables is shown in Fig.1.

Table 2 *Distribution of relative frequencies of variables*

VARIABLE	Description	Frequency [n]	Percent [%]
Dependent variable			
Passing performance	Appropriate	806	87.1
	Inappropriate	119	12.9
Independent variables			
Defensive pressure	Low	689	74.5
	Moderate	140	15.1
	High	96	10.4
Ball possession duration	0–8 s	411	44.4
	9–16 s	449	48.6
	17–24 s	96	7
Intensity of load	< 85% of HR_{max}	106	11.5
	85–95% of HR_{max}	682	73.7
	> 95% of HR_{max}	137	14.8
Game quarter	1^{st}	233	25,2
	2^{nd}	222	24,0
	3^{rd}	280	30,3
	4^{th}	190	20,5

Table 3 *Independent variable included in the final model*

Independent variable		B	SE	Wald	df	p value	Exp (B)	95% CI for Exp (B)	
								Lower	Upper
Defensive pressure	low			67.255	2	.000			
	moderate	.576	.277	4.322	1	.038	1.780	1.034	3.064
	high	2.032	.248	67.236	1	.000	7.627	4.693	12.396

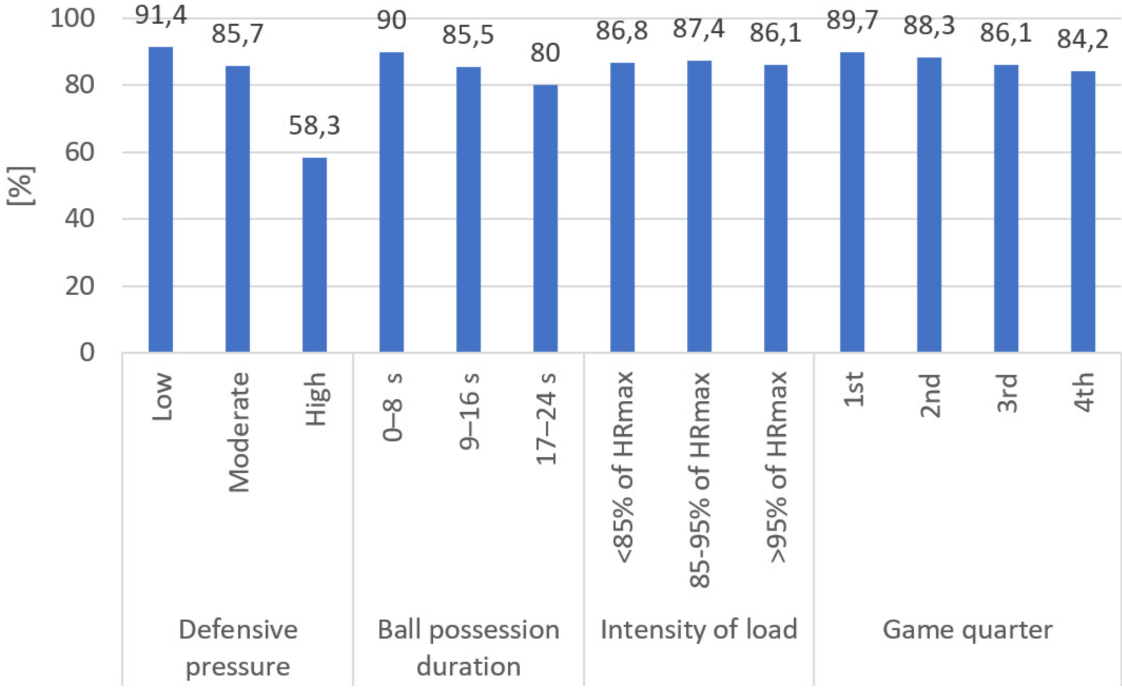

Figure 1 *Percentage of the decision-making process adequacy*

Discussion

The adequacy of the decision-making process with respect to defensive pressure had a downward tendency. This means that with increased defensive pressure, the appropriateness of players' decisions has decreased. For low defensive pressure, the decision-making adequacy was 91.4%, while for moderate defensive pressure, it was 85.7%, and for high defensive pressure, the decision-making adequacy dropped to 58.3%. Binary logistic regression identified only an independently defensive pressure variable as a statistically significant predictor of inadequacy. The chance of making an inappropriate decision at moderate physical pressure was 1.78 times higher than the minimum pressure during the defense. In the case of maximum defense pressure, the chance for a poor decision was up to 7.627 times higher than at the minimum defense pressure. Refoyo et al. (2009) obtained similar results, citing decision adequacy at 95.4%, 86.9% and 65.1% for minimum, average, and maximum defense pressure in the training process, respectively. Training conditions could have caused minor differences and slightly higher decision-making adequacy in this study. Studies Csataljay, James, Hughes, & Dancs, (2013) a Vencurik & Nykodym (2017) also point to the negative impact of increasing defensive pressure on the successfulness of shooting in basketball. For ball possession duration between 0–8 s, the adequacy of decision-making was 90%, between 9–16 s was 85.5%, and between 17–24 s was 80%. With the shot-clock running down (for the offense), the adequacy of decision-making also decreased slightly. For the independent variables of the intensity of load and game quarter, the appropriateness of decision-making was approximately the same. Nevertheless, the independent ball possession duration, intensity of load, and game quarter variables were not identified as statistically significant predictors. On the other hand, Vaquera, García-Tormo, Ruano, & Morante, (2016) and Gómez, Alarcón, & Ortega (2015) found a statistically significant effect of possession duration on pick-and-roll effectiveness. The cause of the impact could be the fact that the defense was disorganized in the last seconds of the offense, and the defenders could be more tired.

Conclusion

This work aimed to determine the influence of selected endogenous and exogenous factors on the decision-making. Binary logistic regression has identified defensive pressure as the only significant factor. These findings are of practical relevance to the training process. If coaches want to improve the decision-making process of female players within offensive skills, they should train at moderate and high defensive pressure. For more specific conclusions, it is necessary to increase the number of measurements and participants.

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HYPOXIC TRAINING FROM THE ATHLETE´S BIOLOGICAL PASSPORT POINT OF VIEW

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Martin Pupiš, Vladimír Franek, Zuzana Pupišová

Department of Physical education and Sport, Faculty of Arts, University of Matej Bel in Banská Bystrica, Slovakia

ABSTRACT

Purpose: Hypoxic training is frequent part of preparation of endurance athletes, but in the last years there are many polemics about effects of hypoxic training on the haematological parameters analysing in athlete´s biological passport. *The aim* of the research was to detect the effect of three different methods of hypoxic training (high altitude training, intermittent hypoxic training, sleeping in hypoxic tent) on haematological parameters which are analysing in athlete´s biological passport. *Methods*: Three types of hypoxic preparation were compared. The ensemble contained of 7 long-distance men race walkers (age 27.4 years (SD ± 3.6); body height 177.0 cm (SD ± 8.1); body weight 63.1 kg (SD ± 5.3).
Results: We detected statistical significant increase in haemoglobin level about 12.57 $g.l^{-1}$ ($p < 0.05$) after staying in high altitude, increase about 11.69 $g.l^{-1}$ after sleeping in hypoxic tent and increase about 8.58 $g.l^{-1}$ ($p < 0.05$) by influence of intermittent hypoxic training. The same trend was detected in reticulocytes where the increase of number (%) of reticulocytes after high altitude training was about 0.23 % ($p < 0.05$), increase after sleeping in hypoxic tent about 0.43 % ($p < 0.05$) and increase after intermittent hypoxic training was about 0.45 % ($p < 0.05$). When comparing off-score value, the resulting differences were not confirmed statistically. The effect of training in high altitude caused the increase of off-score about 5.52 ($p > 0.05$), the decrease of off-score after sleeping in hypoxic tent was about 1.8 ($p > 0.05$) and the decrease of off-score by intermittent hypoxic training was about 5.46 ($p > 0.05$).
Conclusion: Participation of hypoxic preparation can significantly influence parameters in athlete biological passport. According results of our research, we assume that all methods of hypoxic training can affect haematological parameters analysing in athlete´s biological passport (haemoglobin, reticulocytes).

Keywords: hypoxic training; haematological parameters; athlete´s biological passport.

Introduction

In recent years, the athlete biological passport (hereinafter ABP) is one of the key instruments in fight against doping. As stated by the World Anti-Doping Agency (WADA, 2017), the term “athlete biological passport” was first proposed at the beginning of the 21st century by the scientific community when monitoring of selected haematological variables (markers of blood doping) which served as a means of defining an individual’s haematological profile. Along with several other stakeholders and medical experts, WADA started to further develop and validate this concept, result of which was the formal operating guideline and mandatory standards known as the Athlete Biological Passport, first published in 2009, which concerned exclusively the haematological module. In 2014, the original ABP was complemented with the steroidal module, which was introduced in order to establish longitudinal profiles of an athlete's steroid variables. Despite the fact that the athlete biological passport consists of two modules, this study will concern only the changes produced in the haematological module of the ABP. Haematological module gathers information about the individual haematological variables which values can indicate usage of prohibited substances or methods that are designed to improve the transmission or oxygen supply in the blood, including any form of blood manipulation or blood transfusion.

This study focuses on the levels of haemoglobin and reticulocytes and the OFF-score value. Our goal is to point out the potential risk of misinterpretation of the results in the athlete biological passport that could lead to false doping accusations of otherwise clean athletes. Several studies confirm that the hypoxic training has a remarkable impact on the haematological variables observed in the ABP (Pupiš & Korčok, 2007; Pupiš & Čillík, 2012; Rusko et al., 2004; Wilber et al. 2007). We assume that the hypoxic training will significantly impact the markers analysed in the haematological module of the athlete biological passport. Within the VEGA 1/0621/19 grant assignment (Optimization of Training and Competition Load in Top-Level Athletes), we decided to focus on the different impacts of hypoxic preparation on the markers analysed in the athlete biological passport. to the fact that the ABP cannot be considered as a direct proof of doping and several false doping accusations (such as those of Roman Kreuziger, Matej Tóth, Claudia Pechstain etc.) raise doubts about the reliability of this instrument in the fight against doping. It is important to mention that there are multiple studies (Banfi, 2011, Banfi et al., 2011; Lippi et al., 2010, Lippi & Plebani, 2011; Sanchis-Gomar et al., 2011) that question the reliability of ABP and point out deficiencies in the interpretation of the ABP as such.

Methodology

The experimental group consisted of seven endurance athletes - national team members of the Slovak Republic. The average age of the participants at the beginning of the research was 27,4 ± 3,6 years, their average body height was 177 ± 8,1 cm and their average body weight constituted 63,1 ± 5,3 kg. The research participants were subjected to altitude hypoxic training, intermittent hypoxic training and sleeping in a hypoxic tent. All the athletes completed three altitude training camps at 1,800 - 2,100 metres above sea level that lasted from 8 to 24 days. Each of the athletes has completed other altitude training camps at least three times before. The camps took place within three annual training cycles. The periods when the athletes completed the camps ranged from the sixth until the third week prior to major competition. Other hypoxic preparation methods used in the study were intermittent hypoxic training (completed 3 times by 4 research participants) and sleeping in hypoxic tents (completed 3 times by 5 research participants). All the research participants had their blood samples taken in course of three days preceding the hypoxic preparation. The output measurements were carried out 10–14 days after completion of the altitude hypoxic camp. All the blood draws were taken at 7 am after an overnight fast.

The results were assessed from the point of view of statistical significance and effect size. The statistical significance level was set at $\alpha = 0.05$. For the purpose of determination of the effect size, we used Cohen's d which can be used to indicate the effect between two independent variables (Blahuš 2000). To determine the statistical significance, we used Wilcoxon's matched pairs test (a single-pair test set at level $\alpha = 0.05$) (Gajda & Zvolská 1997).

To verify our assumptions, we observed the levels of haemoglobin, reticulocytes and the OFF-score value (OFF-Score = Hgb x 10–60x (√reticulocytes %), (World Anti-doping Agency 2017).

Results

After completion of the hypoxic preparation we detected statistically significant increase of haemoglobin levels by 12.57 $g.l^{-1}$ (increase from 153.62 $g.l^{-1}$ to 166.19 $g.l^{-1}$, $p < 0.05$, $d = 1.06$) in the experimental group as a result of such. Significant statistical increase from 0.87% to final 1.10% ($p < 0.05$, $d = 1.06$) was also detected in reticulocyte count which increased by 0.23% on average. We also detected some differences comparing the input and the output values of the OFF-score. As presented in Table 1, the input value of the OFF-score increased from the initial 98.19 to the final 103.71 ($p > 0.05$; $d = 0.44$), however this difference hasn't proved to be statistically significant, nor affected the effect size.

Table 1 *Comparison of ABP parameters before and after hypoxic preparation in High altitude*

	Input value	**Output value**	**Stat. significance**	**Effect size**
Hgb ($g.l^{-1}$)	153.62(SD ±)	166.19(SD ±)	$p < 0.05$	$d = 1.06$
Rtc (%)	0.87 (SD ±)	1.1 (SD ±)	$p < 0.05$	$d = 1.06$
OFF-score	98.19 (SD ±)	103.71 (SD ±)	$p > 0.05$	$d = 0.44$

Upon completion of the intermittent hypoxic training by the experimental group, we detected statistically significant increase of haemoglobin levels by 8.58 $g.l^{-1}$ (from 159.75 $g.l^{-1}$ to 168.33 $g.l^{-1}$, $p < 0.05$, $d = 1.32$). Significant statistical increase from the initial 0.73% to the final 1.18% ($p < 0.05$, $d = 2.75$) was also detected in the reticulocyte count, which increased by 0.45% on average. We also detected some differences comparing the input and the output values of the OFF-score. As presented in Table 2, the input value decreased from the initial 108.68 to the final 103.22 ($p > 0.05$; $d = 0.79$), however this difference hasn´t proved to be statistically significant, nor affected the effect size.

Table 2 *Comparison of ABP parameters before and after hypoxic preparation with IHT*

	Input value	**Output value**	**Stat. significance**	**Effect size**
Hgb ($g.l^{-1}$)	159.75 (SD ±)	168.33 (SD ±)	$p < 0.05$	$d = 1.32$
Rtc (%)	0.73 (SD ±)	1.18 (SD ±)	$p < 0.05$	$d = 2.75$
OFF-score	108.68 (SD ±)	103.22 (SD ±)	$p > 0.05$	$d = 0.79$

After staying in the hypoxic tent, the experimental group experienced statistically significant increase of haemoglobin levels by 11.69 $g.l^{-1}$ (from 155.69 $g.l^{-1}$ to 167.38 $g.l^{-1}$, $p < 0.05$, $d = 1.46$). Significant statistical increase from 0.76% to final 1.19% ($p < 0.05$, $d = 1.89$) was also detected in the reticulocyte count, which increased by 0.43% on average. We also detected some differences in the input and the output values of the OFF-score. As presented in Table 3, the input value decreased from the initial 103.91 to the final 102.11 ($p > 0.05$; $d = 0.23$). This decrease hasn´t proved to be statistically significant, nor affected the effect size.

Table 3 *Comparison of ABP parameters before and after hypoxic preparation in Hypoxic Tent*

	Input value	Output value	Stat. significance	Effect size
Hgb ($g.l^{-1}$)	155.69 (SD ±)	167.38 (SD ±)	$p < 0.05$	$d = 1.46$
Rtc (%)	0.76 (SD ±)	1.19 (SD ±)	$p < 0.05$	$d = 1.89$
OFF-score	103.91 (SD ±)	102.11 (SD ±)	$p > 0.05$	$d = 0.23$

Upon the statistical processing of the data, we detected substantial statistically significant differences and important effect size differences between the input and the output values of haemoglobin and reticulocytes. From the point of view of ABP it is necessary to take into consideration not only the statistical assumption, but also the individual specifications. When it comes to haemoglobin, we detected maximum individual differences of 36 $g.l^{-1}$ between the initial and the final measurements in the course of the altitude hypoxic training (while the difference was higher than 20 $g.l^{-1}$ on five occasions). The maximum difference between the initial and the final values during the intermittent hypoxic training was 18 $g.l^{-1}$ and the maximum difference between the initial and the final values during the athletes' stay in the hypoxic tent was of 28 $g.l^{-1}$ (with the difference being higher than 20 $g.l^{-1}$ on one occasion). The maximum individual differences between the initial and the final measurements of reticulocyte count in the course of the altitude hypoxic training constituted 0.7%, 0.1% during the stay in the hypoxic tent and 0.7% during the intermittent hypoxic training (as many as four times). The maximum differences in the initial and final values of the OFF-score detected during the hypoxic training at high altitude were of 36.68. The maximum difference in case of intermittent hypoxic training was of 21.93 and of 17.05 in the hypoxic tent (we detected decrease in the values in both cases).

The results of our research confirm the well-known fact that the values of blood variables analysed in the ABP according to the established interpretation of such are changing under the different methods of hypoxic preparation used with high statistical probability. Our findings demonstrate that on the one hand, the average changes comply with the statistical probability, on the other hand, we need to consider the intraindividual correlation which shows the intraindividual specifications of the adaptive response to hypoxia. We believe that upon cumulation of different influences (like for example haemodilution, hyperhydration, dehydration, medical treatment or detraining) there can be changes in the blood variables (analysed in ABP), which may result to false doping accusations of clean athletes, whose destiny will subsequently lay in hands of three evaluators who make decisions and draw conclusions based only on their present knowledge and experience. We may not forget to mention that there have been several false doping allegations in the athletic world which prove the discrepancies in the interpretation of the ABP.

Discussion

The results of this research bring up the necessity to polemicize about the use and the interpretation of results of the ABP. Some studies describe the ABP almost as unquestionable (Schumacher et al., 2015). On the contrary, there are many studies that point out to the deficiencies in the interpretation of its results. Schumacher et al., 2015 claim that it is not certain if the hypoxic stay and hypoxic training can affect the variables (in a way that the produced changes might be classified as prohibited blood manipulation or doping usage) that are contained in the calculations by means of mathematical algorithms, that are used in the athlete biological passport to define the intervals (referential scales) of the individual values of the haemoglobin levels, values of the reticulocyte count or the OFF-score value. Based on the results obtained, they came to a conclusion that the abnormalities observed in the haematological module of the athlete biological passport in the course of our research conducted in the alpine environment comply with the expected physiological changes.

On the contrary, our research, same as researches of other authors, demonstrates that the hypoxic preparation has got a significant impact on the markers that are analysed in the ABP. Moreover, we assume that the variability of the haematological parameters is highly individual and the variability of the haematological markers might be part of the athlete's talent. Based on this assumption, we may expect higher occurrence of such variability in elite endurance athletes. We agree with Banfi and Lippi (2011) who believe that the ABP is a suitable instrument to indirectly prove the usage of prohibited substances. However, if there is a mismatch in values that the anti-doping agency uses to raise a doping suspicion, it does not take individual biorhythms or training methods applied into account, while we believe that both considerably affect the values in the ABP. Banfi and Lippi (2011) claim that the impacts of the training and competition load play a decisive role in the longitudinal evaluation of haematological values in athletes. Their research drew to the conclusion that, during the season, haemoglobin levels in athletes performing various athletic disciplines decreased by 3 to 8 %, while the reticulocyte count ranged from 5 to 21 %. They found out that the reticulocyte count tends to decrease due to long-term training and upon completion of competition season and their variation is directly related to the variation of haemoglobin. For doping-related research purposes, the authors recommend several research studies focused on the haematological variations produced during the competition season.

Conclusion

The results of this research confirm that the hypoxic training significantly affects the values that are recorded in the athlete biological passport. Upon completion of the altitude hypoxic training we detected substantial statistically significant increase of 12.57 $g.l^{-1}$ ($p < 0.05$) in the levels of haemoglobin. After the stay in the hypoxic tent, the athletes' haemoglobin levels increased by 11.69 $g.l^{-1}$ ($p < 0.05$) and upon completion of the intermittent hypoxic training, their haemoglobin levels increased by 8.58 $g.l^{-1}$ ($p < 0.05$). The same trend was observed in case of reticulocytes – an increase of 0.23% ($p < 0.05$) upon completion of the altitude hypoxic training, an increase of 0.43% ($p < 0.05$) upon staying in the hypoxic tents and an increase of 0.45% ($p < 0.05$) as a result of the intermittent hypoxic training. The differences discovered upon analysis of the OFF-score values haven't proved statistically to be statistically significant, nor affected the effect size. As a result of altitude hypoxic training in the alpine environment, the OFF-score increased by 5.52 ($p > 0.05$), decreased by 1.8 ($p > 0.05$) upon staying in the hypoxic tent and decreased by 5.46 ($p > 0.05$) as a result of the intermittent hypoxic training. Based on the results of our research, we may draw to the conclusion that the hypoxic preparation can have substantial impact on the markers analysed in the athlete biological passport, while upon cumulation of different factors (e.g. sickness, medical treatment, detraining, dehydration, hyperhydration or time of day when the measurements are made) it can substantially influence the results acquired for the needs of ABP and their subsequent interpretation. Therefore, in case there is a doping suspicion raised upon deviations in the ABP, we recommend that along with the expert opinions of three independent evaluators, every athlete had a right to undergo free medical examination that would match the situation from the time when the suspicion was raised. Despite these facts, we consider the ABP to be a suitable instrument in fight against doping. However, since we are convinced that any unjust punishment of an innocent athlete is very much unacceptable, we think that the ABP results should be interpreted in a more delicate way.

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PHD STUDENTS

EFFECT OF A 3-MONTH EXERCISE INTERVENTION ON PHYSICAL PERFORMANCE, BODY COMPOSITION, DEPRESSION AND AUTONOMIC NERVOUS SYSTEM IN BREAST CANCER SURVIVORS: A PILOT STUDY

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Marie Crhová, Iva Hrnčiříková, Radka Střeštíková, Klára Šoltés-Mertová, Martin Komzák, Kateřina Kapounková, Anna Ondračková

Faculty of Sports Studies, Department of Health Promotion, Masaryk University and Masaryk Cancer Institut, Brno, Czech Republic

ABSTRACT

Purpose: Breast cancer patients are at increased risk of developing comorbidities such as lymphedema, sarcopenia, osteoporosis and cardiovascular disease after breast cancer treatment. These complications contribute to a decrease in quality of life, cardiorespiratory fitness and muscle strength. Regular and long-term physical activity is an effective non-pharmacological strategy that can improve physical, psychological and social outcomes. The aim of our research was to evaluate the effect of various modes of an exercise intervention on *physical performance, body composition, depression and autonomic nervous system in breast cancer survivors.*
Methods: 16 women after surgery with hormonal treatment enter the research. Thirteen of them completed the controlled, quasi-experimental study (54 ± 9 yrs, 164cm ± 6cm, 72 ± 12kg) and were divided into 3 groups according to their place of living: trained under supervision (n=5) (SUPERV), trained at home without supervision by videos (n=7) (HOME) and with no prescribed physical activity (n=4) (CON). Exercise intervention lasted 3 months and comprised of 60 min training units 3 × week (aerobic with resistant exercise in a 2 : 1 mode combined with regular weekly yoga and breathing exercises). The exercise intensity was set individually at 65–75% of HRR based on spiroergometry and was continuously controlled by heart rate monitors. The same principles applied to the HOME group, which, in addition to heart rate monitors, recorded frequency, length, HRmax, HRavg, and Borg scale of intensity perception. VO_{2max}, BMI, fat mass, depression level (Beck's depression inventory) and the power of the autonomic nervous system (total power and sympatho-vagal balance) were analyzed. For data evaluation we used descriptive statistics and Cohens *d* effect size.
Results: 3 women dropped out of research because of medical reason. In all groups VO_{2max} values increased. The largest increase in VO_{2max} values was in SUPERV group by 36%, in HOME group by 20% and in CON group by 2%. Body weight decreased for groups SUPERV (-1.2 kg) and CON (-0.1kg), for HOME group there was an increase (+0.2 kg). Body mass index decreased for SUPERV group (-0.4), for HOME and CON it increased (both +0.1). Total power decreased in SUPERV (-0.6) and HOME group (-0.2), in CON has not changed. The same results were achieved by the sympatho-vagal balance, only the CON group increased. Values from Beck's depression inventory decreased for all groups, most for CON group.
Conclusion: A 3-months of supervised and controlled exercise had a significant effect on physical fitness and body composition in comparison with non-supervised home-based physical intervention. Our results indicate that it is strongly advisable to apply a supervised exercise program to induce positive physiological changes in breast cancer survivors as part of aftercare.

Keywords: cancer; physical activity; anthropometric changes; Beck's depression inventory; spectral analysis of heart rate variability

Introduction

In 2016, breast cancer was the most frequent cause of death of women in the Czech Republic age category 20–54 years („MAMO.CZ: Rakovina prsu”, 2018). The annual average of newly diagnosed breast cancer cases is around 7.000 women, with about 1.900 of them dying from the disease (Mužík, Šnajdrová, & Gregor, 2018). The incidence is steadily increasing, with mortality stagnating, even slightly declining, due to early detection and improvement of treatment (Fernández et al., 2018). A common method of treating breast cancer is surgery in combination with chemotherapy, radiation therapy, and hormone therapy („WHO | Cancer country profiles 2014”, 2014). Patients who survive breast cancer are at increased risk of developing comorbid conditions such as lymphedema, sarcopenia, osteoporosis (due to hormonal treatment) and cardiovascular disease (Ording et al., 2013) as a result of treatment, thus reducing quality life. Health problems caused by breast cancer treatment include, but are not limited to, persistent psychosocial anxiety, including depression, fatigue (Vigo et al., 2015), sleep disorders (de Jong, Courtens, Abu-Saad, & Schouten, 2002; DeSantis et al., 2014; Knobf, 2011), a reduction in fitness, called deconditioning, which can lead to increased body weight. These side effects can be eliminated through a healthy lifestyle, including a balanced diet and physical activity (Macêdo et al., 2010). Physical activity recommendations for cancer patients report 150 minutes of moderate intensity weekly aerobic activity (walking, ballroom dancing, gardening) or 75 minutes of higher intensity weekly aerobic activity (running, walking uphill). For resistant exercise, 20–30 minutes of moderate intensity at least twice a week is recommended, ideally under supervision (Schmitz et al., 2010). These recommendations concern most types of tumors, more specific recommendations for breast cancer patients are unknown, and it is clear that regular and long-term physical activity is an effective non-pharmacological strategy that can improve results in physical, psychological and social aspects (Goss et al., 2008; Mishra et al., 2012; Peterson & Ligibel, 2018)patients who received placebo (PLAC. Specifically, physical activity performed to a sufficient extent has a positive effect on quality of life (Kramer et al., 2000), physical fitness and cardiovascular system (Rodrigues et al., 2014), body composition (Grabenbauer, Grabenbauer, Lengenfelder, Grabenbauer, & Distel, 2016), fatigue and frequently occurring fatigue syndrome (Radbruch et al., 2008)”container-title”:”Palliative Medicine”,”page”:”13-32”,”volume”:”22”,”issue”:”1”,”source”:”PubMed”,”abstract”:”Fatigue is one of the most frequent symptoms in palliative care patients, reported in .80% of cancer patients and in up to 99% of patients following radio- or chemotherapy. Fatigue also plays a major role in palliative care for noncancer patients, with large percentages of patients with HIV, multiple sclerosis, chronic obstructive pulmonary disease or heart failure reporting fatigue. This paper presents the position of an expert working group of the European Association for Palliative Care (EAPC. In addition, physical activity can reduce the risk of breast cancer recurrence while helping to increase patient survival (de Boer, Wörner, Verlaan, & van Leeuwen, 2017; Ferrer, Huedo-Medina, Johnson, Ryan, & Pescatello, 2011; Meneses-Echávez, González-Jiménez, & Ramírez-Vélez, 2015). In view of the results of the above studies, we can assume that the exercise and nutrition program should be a common part of aftercare for breast cancer survivors.

Method

Participants

The group consisted of 16 women (54 ± 9 yrs, min age 42 and max age 70; 164cm ± 6cm, 72 ± 12kg) with breast cancer. For all participants the research started in February 2019. Participants were divided into 3 groups based on deliberate selection based on the distance of individual patients’ residence from Brno, while maintaining the homogeneity of the sample (supervised exercises = SUPERV, unattended exercises = HOME, no controlled exercises (usual care) = CON). 3 women dropped out of research because of medical reason.

Inclusion criteria

Inclusion criteria for research were evaluated by doctors from the Masaryk Cancer Institute and are as follows: age over 18, age range 40–70 years; the estimated life expectancy of at least 1 year; 0–III stage of breast cancer; after systematic neoadjuvant or adjuvant chemotherapy, radiation therapy; with ongoing hormone therapy; performance status (PS 0,1); ability to walk 400 meters without sitting, leaning or helping another person.

Exclusion criteria

Exclusion criteria were IV stage of cancer; functional disability impeding exercise; uncontrollable heart, joint or lung disease; untreated hypertension; pregnant or nursing; patients who have not been approved by the oncologist for physical activity and patients who have refused to sign informed consent.

Research design

Participants attend an information meeting where they learn all the important information and receive informed consent. In the case of consent to participate in the research, each participant undergoes an input and output measurement. The SUPERV and HOME groups attended exercise intervention, as described below.

1. Input measurements included:
    - load test on a bicycle ergometer to determine ventilation parameters;
    - body composition measurement using bioelectric impedance;
    - spectral analysis of heart rate variability to determine autonomic nervous system function;
    - Beck's Depression Inventory.
2. Physical intervention according to the attributes of the group, see below.
3. Output measurement was identical to input measurement.

Measures

To gain an appreciation of aerobic capacity (VO_{2max}) we used standardized incremental bicycle ergometer test with a set duration of about 10 (±2) min. The protocol was a continuous ramp exercise where the load increase was 15–20 W/min, until subjects reached a respiratory quotient (RQ) ≥ 1.1. A pedalling frequency of 60/70 rev/min. The maximum of the VO_2 curve was taken as peak. During baseline, exercise and recovery heart rhythm and frequency were monitored from 12 leads ECG. Expired air was collected using a breathing apparatus and analyzed with a metabolic measurement cart (V_{max} Encore, Viasys, CareFusion, San Diego, CA) to determine ventilatory and gas exchange variables on a breath-by-breath basis. Body composition was examined by bioelectric impedance using InBody 230. Contraindications for each participant were excluded. Depressive symptoms were measured by Beck's depression inventory (BDI) (Beck, 1961), which consists of 21 questions about last week's feelings. The filling person has a choice of 4 options (from 0 to 3). The sum of point measures the depth of the depression symptoms: 0–10 points signifies normal mood, 10–20 mild depression, 20–40 moderate depression and 40–60 severe depressive symptoms. DiANS PF8 and Medical DiANS PC software were used to measure heart rate variability. The examination of heart rate variability was performed by changing the position of the body (lie – stand – lie). The investigated person was in every position, with 300 R-R oscillations measured for five-minute interval. All measurement data was transferred to a desktop computer and then analyzed by Medical DiANS PC software. For this work, we chose from the analysis complex indicators, such as a sympatho-vagal balance (SVB) and total score (TS).

Exercises intervention

The duration of the intervention was 3 months and included 60min of training unit 3 times a week (aerobic exercise with strength training elements combined with 2 : 1 yoga and breathing exercises). The intensity of the exercise was continuously monitored by heart rate monitors and was gradually increase as shown below. These principles applied to the SUPERV group and HOME group. HOME group performed exercises at home according to instructional videos. There was a regular educational meeting with the HOME group where we will explain the new exercise videos for the next month and check the heart rate monitors. The control group (CON) did not perform any controlled physical activity.

Content of training unit:

1. Warm-up (10min): 40–50% of HRR.
2. Main part of TJ (40min): combination of aerobic and resistant exercise:
   - **Aerobic exercise** – walking on a belt, spinning bike and elliptical trainer. Individually set training zone from spiroergometry results: 1st month, 30 min, 55–70% of HRR; 2nd month 25 min, 70–80% of HRR; month 25 min, 70–85% of HRR.
   - **Resistant exercises** – free squat, lunges, pelvic bridge, sit-ups, exercise with strength rubber: rowing in a sitting position, tightening behind the head, tightening, biceps strokes and triceps extensions. 1st month 10min – 10 reps, 2 series; 2nd month 15min – 12 reps, 2 series; 3rd month 15min – 15 reps, 2 series.
3. Cooldown and stretching (10min) – 40–50% of HRR.

Yoga: Asanas – training of individual positions at the beginner level (stretching techniques for warming up, standing, lying, side and sitting positions), each stance last 10–30s, rest between 30s to 1 minute Pranayama – work with breathing, breathing techniques. At the end of training there were meditation and relaxation on the back side.

Statistical analysis

To evaluate data, we used descriptive (mean, standard deviation, maximum and minimum) and analytical statistics (paired T-test) and Cohen's d (effect size). Data were calculated in the program Statistica 13.2.

Results

The comparison between the physical activity, body composition, depression level and autonomic nervous system is presented in Tab. 1. The most significant changes among the tested groups are changes in physical fitness (VO_{2max}) of the SUPERV ($p = 0.047$) and HOME ($p=0.002$) groups as evidenced by the high level of effect size (SUPERV $d = 1.211$, HOME $d = 1.034$). Average values of body mass index decreased in SUPERV group, slightly in CON group. HOME group has seen an increased in BMI values. Depression level and total score decreased in all study group. All these changes are not statistically significant and there was no effect size. Other significant changes were noted in the post-intervention SVB values ($p = 0.004$), where there is a medium level of effect size (d = 0.531). A high effect size value was also measured for the SVB values of the control group (CON $d = 0.523$).

Table 1 *Changes in examined variables in breast cancer patients after physical intervention*

	Baseline Mean (SD)	Post-intervention Mean (SD)	P value	Effect size (Cohen‘s d)
Physical fitness (VO_{2max})				
SUPERV (n=4)	20.2 (5.6)	26.8 (5.3)	0.047	1.211
HOME (n=7)	21.6 (3.4)	25.9 (4.8)	0.002	1.034
CON (n=2)	18.3 (0.8)	18.7 (2.0)	0.744	0.263
Body composition (BMI)				
SUPERV (n=4)	25.3 (3.3)	24.9 (3.4)	0.094	0.120
HOME (n=7)	26.3 (4.9)	26.4 (4.6)	0.737	0.021
CON (n=2)	30.1 (3.7)	30.0 (4.2)	0.844	0.025
Depression level				
SUPERV (n=4)	8.5 (2.9)	7.3 (4.3)	0.312	0.327
HOME (n=7)	10.7 (6.2)	9.1 (5.0)	0.494	0.284
CON (n=2)	20.5 (7.8)	17.0 (8.5)	0.090	0.430
Autonomic nervous system (TS)				
SUPERV (n=4)	´-1.8 (3.0)	´-2.4 (2.8)	0.292	0.207
HOME (n=7)	´-2.0 (3.1)	´-2.2 (2.6)	0.767	0.070
CON (n=2)	´-4.8 (0.2)	´-4.9 (0.1)	0.832	0.632
Autonomic nervous system (SVB)				
SUPERV (n=4)	1.5 (2.4)	1.2 (1.3)	0.837	0.155
HOME (n=7)	0.4 (2.4)	´-0.9 (2.5)	0.004	0.531
CON (n=2)	1.3 (1.2)	2.1 (1.8)	0.322	0.523

Discussion

Breast cancer treatment is challenging for the body and can lead to various disorders including decreased bone density (Chen, 2005) and cardiometabolic profile (Caro-Morán et al., 2016)controlling for known confounders. This descriptive case-controlled study included 22 breast cancer survivors and 22 healthy age- and sex-matched controls. Short-term HRV was measured using an accepted methodology to assess the cardiac autonomic balance. One-way analysis of covariance results revealed that heart rate was significantly higher ($F = 15.86$, $p < .001$, persistent psychosocial anxiety including depression, fatigue (Vigo et al., 2015), sleep disorders (de Jong et al., 2002; DeSantis et al., 2014; Knobf, 2011), decreased physical fitness. Regular and long-term physical activity can improve the results in physical, mental and social aspects of breast cancer patients (Mishra et al., 2012; Peterson & Ligibel, 2018).

Currently, physical activity is an important part of aftercare in breast cancer patients, but it is not still performed as a standard. The aim of our research was to evaluate the effect of various modes of 3 months exercise intervention on physical performance, body composition, depression and autonomic nervous system in breast cancer survivors. The project was completed by 16 participants with diagnosed breast cancer, of which 4 patients underwent a movement program under supervision, 7 patients exercised without supervision and 2 patients were in the control group. Due to the deliberate selection of probands and the consequent low number of probands who completed the physical intervention, we evaluated that statistical significance is not a suitable tool for evaluating changes in the variables examined and therefore we decided to mention especially those results that had at least effect size.

The results show that the most significant changes before and after exercise intervention were with VO_{2max} values, namely in the group under supervision and without supervision at home while for supervised group, the change was more significant. This result is consistent with the study result from Casla et al., (2015). They experienced significant changes in VO_{2max} values by the 12 weeks combination training, twice a week against the control group with usual care. (Dieli-Conwright et al., 2018) also noted a significant decrease in VO_{2max}, which is an indicator of cardiorespiratory fitness in the exercise group (16 weeks, 3 times per week) compared to baseline and the usual care group. Our results of sympatho-agal balance values indicate significant decrease with effect size after exercise intervention, but the values are still within normal limits (Stejskal, Šlachta, Elfmark, Salinger, & Gaul-Aláčová, 2002). (Dias Reis et al., 2017) becoming thus an ultimate importance tool in both clinical and research setting, being a good predictor of cardiac events and mortality risk and also used in physical exercise and sports in general. The aim of the present study was to evaluate 12 weeks of exercise training and six weeks of detraining in cardiorespiratory capacity, and autonomic modulation in breast cancer patients.\nMETHODS: The sample was composed of 18 females (9 controls and 9 exercised did not reach the same results. They investigated that after 12 weeks exercise intervention with combined training values of LF/HF, which is sympatho-vagal balance indicator, significant increased, which may be due to age or gender (Li, Rüdiger, & Ziemssen, 2019).

Our results support the proposition that physical activity in breast cancer patients has positive effects on physical fitness, but we have not confirmed a positive effect on autonomic nervous system function. However, the complications that occur during and after treatment of the patient put further demands on research into improving the quality of life of patients in remission. Further research could focus on the most effective exercise protocol or the creation of appropriate educational materials for patients who cannot or do not want to commute to exercise for a variety of reasons, but could also carry out exercise at home.

The study limitations

Baseline values may be affected by ignorance of the tests. Furthermore, the probands showed a different level of motivation to exercise. This can be influenced by the current mental or physical condition. The data may have been influenced by the socio-economic factor and the period during which the intervention took place. It would certainly be advisable to monitor the adherence of the patients to exercise, whether it was higher in the group exercising under supervision or without it.

Conclusion

The pilot study examined changes in physical condition, body composition, depression levels and autonomic nervous system in breast cancer patients who had undergone 3 months exercise intervention. Sixteen patients participated in the research and completed the physical intervention. Slight statistically significant changes and high level of effect size were recorded only for the values of the physical fitness, namely in the group exercise under supervision and non-supervised group. Other significant changes were observed in the sympatho-vagal balance before and after the intervention in the non-supervised group (HOME). The measured data cannot be generalized due to the small number of participants. For a possible generalization, confirmed and deeper interpretation of the results, it is necessary to expand the research file and carry out further studies to confirm our data from the pilot project.

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ON SELECTED PROBLEMS OF LOW REPRESENTATION OF WOMEN IN COACHING

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Kateřina Jakubcová, Vladimír Jůva, Michal Roček

Masaryk University, Faculty of Sports Studies, Brno, Czech Republic

ABSTRACT

Coaches play a crucial role in the development of sport at all levels. However, there is often talk of a lack of coaches. This problem is compounded by the fact that female coaches make up only a much smaller part of the coaching staff. Significant deficits of woman are particularly noticeable in senior coaching positions (e.g., among head or national coaches). The issue of female representation in coaching has received considerable attention for forty years, especially within the broader topic of women and sport. At the same time, the literature reflects an interesting paradox. Political and sporting bodies at the international and national level address the shortage of female coaches, and many projects promoting women in coaching have emerged. Research but shows that female representation in coaching is practically not improving. Many organizational and interpersonal problems and myths about the possibilities of women trainers remain. Also, in the Czech Republic, in the last two decades, political and research activities pay considerable attention to the topic of women in coaching. Our study builds on Czech empirical findings in the field of women in sport from the first decade of the 21st century. A partial goal of our more extensive research was to find out the reasons for the low representation of women among sports coaches. We addressed women (questionnaire survey, n=103, average age 24.3 years), who at the performance or top-level are engaged in various sports and who are – at the same time – feel “at the end” of their active sports track, and realistically think about the professional future after finishing their sports career. We processed the results using statistical analysis and open coding. The most common reasons that negatively affect the continuation of the addressed female athletes as coaches, respondents report low financial remuneration of coaching work and loss of leisure time. Other reasons why women do not consider coaching include the lack of their professional ambitions and respect from sports associations and sports clubs. Research carried out shows that about half of the addressed female athletes are interested in staying in the sport as a coach, but they are aware of many obstacles in this area at the same time.

Keywords: coaching; women in coaching; lack of female coaches

Introduction

Coaches play a crucial role in the development of sport at all levels. However, there is often talk of a lack of coaches. In the Czech Republic, this problem is highlighted by the research of 2,000 sports clubs (Česká unie sportu [Czech Sports Union], 2018). The major problem is a lack of coaches for children and youth. Most representatives of sports clubs (94%) say there is no funding for coaches.

This problem is compounded by the fact that female coaches make up only a much smaller part of the coaching staff (Reade, Rodgers, & Norman, 2009). European Institute for Gender Equality (2016) points out that men dominate the profession of sports coaching. Based on figures in seven

EU Member States, it is estimated that only 20% to 30% of all sports coaches in Europe are women. The number of women coaches in almost all sports seems to be disproportionally low concerning women's overall membership of the sport (European Institute for Gender Equality, 2016, p. 7). Woman coaches often work in sports that have a high level of female athletes, yet in the Czech Republic, 72% of the female athletes were coached by a man and only 28% by a woman (Fasting & Knorre, 2005).

Significant deficits of woman are particularly noticeable in senior coaching positions (e.g., among head or national coaches). This was strongly emphasized already in the year 1994 by *The Brighton Declaration on Women and Sport* (1994, p. 1): "Despite growing participation of women in sport in recent years and increased opportunities for women to participate in domestic and international arenas, increased representation of women in decision making and leadership roles within sport has not followed." Women are significantly under-represented also in coaching, particularly at the higher levels. Carson, McCormack, and Walsh (2018) today highlight the lack of women in leadership positions in sport. This situation reflects a number of traditional gender ideologies. Megheirkouni and Muhammad (2017) also emphasize that the under-representation of women leaders in top management in sports organisations is an increasingly controversial issue.

The lack of female coaches is evident at the elementary and high school level. Women are particularly under-represented in the *National Collegiate Athletic Association* (NCAA –management of USA and Canada university sport), where making up just 5.6% of head coaches of women's sports, and only 3.5% of all head coaches (men's and women's teams) (Stark, 2017). Keményová (2018) states, there are projects at universities that promote gender equality. These support the homework of women, part-time work, and the use of flexible working hours. Unfortunately, this form of support is practically not applicable to sport coaching. Women coaches cannot coach their athletes from home or at different times.

The situation of head coaches is noticeable again in the Czech Republic, where there was not one female coach among the 13 founding members of the Union of Professional Coaches of the Czech Olympic Committee in 2013 (see http://www.olympic.cz/docs/upt/upt-zakladaci-listina.pdf). Currently (May 2018) out of the 131 members of the Union of Professional Coaches, only 7% (9) are women coaches (see http://treneri.olympic.cz/text/225--seznam-clenu). These particular cases correspond to the global situation summarized by Burton (2015, p. 163): "women continue to face challenges and obstacles when seeking leadership positions in sport organizations."

The issue of female representation in coaching received considerable attention more than 40 years ago, especially within the broader topic of women and sport, respectively gender and sports (for more details see Sekot, 2006; Coakley, 2017). Political and sporting bodies at the international and national level address the shortage of female coaches, and many projects promoting women in coaching have emerged. Already in 1974, *The Women's Sports Foundation* was established to advance the lives of girls and women through sport and physical activity (for more details see https://www.womenssportsfoundation.org). *The Foundation* was founded by a legendary tennis player and prominent advocate of social change and equality Billie Jean King in San Francisco. In particular, the current mission of this non-profit Foundation is to dedicate to creating leaders by ensuring girls access to sports. By supporting the participation of girls and women in sport, the Foundation also supports their social development and their professional careers. The Foundation also contributes financially to research and education in the field of gender equality in sport. The Foundation pays considerable attention to the support of female coaches, e.g., the project *Tara VanDerveer Fund for the Advancement of Women in Coaching*. The project emphasizes "as a coach is often one of the most important adults in a young person's life outside of their family, the lack of female mentors in sports has far-reaching consequences for the development of both girls and boys" (https://www.womenssportsfoundation.org/get-inspired/article/uncategorized/careers-for-women-in-sports).The project provides fellowships for aspiring female coaches in all collegiate sports. In partnership with universities and colleges, these fellowships offer aspiring coaches with the support needed to jump-start their careers.

The *International Council for Coaching Excellence* (ICCE; for more details see https://www.icce.ws) was established in the year 1997, and emphasizes since its inception leading and developing sport coaching globally. In this context, the ICCE supports and organizes many projects, also including the support of female coaches. The ICCE project *Women in Coaching* develops since 2014 a global 'call to action' to increase the number of women in coaching at all levels. A working group was set up to design develop, and integrate feedback of the women coaches. This project expands the network of organisations that can help influence positive change for women in coaching, gathers examples of good practice, showcases case studies from around the world, identifies volunteers to run pilot projects and activities, creates a network of women who want to further the advancement of women and coaching globally. The ICCE Project investigates also the impact of setting quotas and targets to increase the opportunities for women in coaching etc. (https://www.icce.ws/projects/women-in-coaching.html).

Significant political and research attention pays the topic of women in coaching, also in the Czech Republic in the last two decades. The Ministry of Education, Youth, and Sports of the Czech Republic promotes a balanced representation of women and men in decision-making positions and actively advocates for them. To this end, in 2018, it launched the media campaign *Women on Olympus*, which aims to raise the profile of selected prominent Czech women who have been or are still successful not only as athletes, but primarily have exercised their skills in important decision-making positions (Macura, 2018). The Czech Olympic Committee satisfies increased attention to the issue of women in sports and female coaches, especially in connection with the Olympic movement (Knorre, Kolář, & Dovalil, 2004). Other Czech Olympic Committee activities in this area include the *Project Female Coach of the Year*, and, above all, permanent work of the *Commission for Equal Opportunities in Sport* (for more details see https://www.olympic.cz).

In addition to scientific and research activity, and subsequent publications (e.g., Knoppers, 1987; Gieß-Stüber, 2009; Bruening, Dixon, Burton, & Madsen, 2012; Norman, 2012; Hargreaves & Anderson, 2014; LaVoi, 2016; Carson, McCormack, & Walsh, 2018), special professional journals contribute to the support of women in sport and at the same time to female coaches. In 1992, the *Women in Sport and Physical Activity Journal* (1992–2019) began to be published. The *Coaching Association of Canada* (https://www.coach.ca) developed several coaching support programs, including the program *Women in Coaching*. One of the successful results of this program is the publishing of the *Canadian Journal for Women in Coaching* since 2000. The premise of the Journal is that timely, accurate, targeted information goes a long way towards creating a healthier and more positive environment for women coaches, in Canada and around the world. One dominant subject is family life of woman coaches. Other pressing issues focus on negotiating equitable compensation and satisfactory contracts, breaking into the high-performance echelon, establishing personal behavior guidelines, understanding employee and employer rights, and working effectively with a board of directors (https://www.coach.ca/files/CJWC_JULY2014_EN.pdf).

At the same time, scientific literature reflects an interesting paradox. Research shows that female representation in coaching is practically not improving (La Voi, 2016). In some sports areas, the representation of female coaches has even deteriorated considerably. See for example, within women's college teams in The National Collegiate Athletic Association. In the 1970–1971 academic year, the woman was 90% of all head coaches for women's college teams. In 2017, female coaches had dropped to 40% (Stark, 2017).

Many organizational and interpersonal problems and myths about the possibilities of female coaches remain. The most common myths and misconceptions about women coaches still persist among athletes and publicity. For example, "Female coaches are not winning championships. ... Women are less intense. They are not as demanding of their players. They are not strong enough. ... Women turn other women off. It is easier to take coaching from a man..." (Do Female Athletes Prefer Male Coaches, 2017, p. 24). However, deeper analyses of these myths show that they are not true and that it is necessary to discuss these gender stereotypes with athletes and sports managers.

As we briefly pointed out, in the Czech Republic over the last two decades, political and research activity has devoted considerable attention to the topic of female coaching. We must also recall the fact that the representation of Czech women in physical activity and sport has a long tradition. For example, women were actively involved in the Czech Sokol Movement (the first Sokol unit was founded in 1862). Women in the Sokol Movement gradually formed the same male components. The first female coaches (physical activity female trainers) started to work on this Movement at the end of the 19th century (Ženy Sokolky, 2019).

Nevertheless, many problems arise in the field of women in Czech sport, and the representation of women in coaching is under-dimensioned. Extensive research based on experiences of female athletes "Woman in Sport in the Czech Republic" (Fasting & Knorre, 2005) has pointed to these facts.

Our study builds on the Czech empirical findings in the field of women in sport from the first decade of the 21st century. A partial goal of our more extensive research on *Gender Aspects of Coaching* was to find out the reasons for the low representation of women among sports coaches.

Methods

We addressed women, who at the performance or top-level are engaged in various sports and who are – at the same time – feel "at the end" of their active sports track, and realistically think about the professional future after finishing their sports career. We have prepared a questionnaire of our design for female athletes (potential coaches) entitled "Gender aspects of coaching". In addition to detailed personal and sports data, the questionnaire contained two main areas (total of 47 items). The first area (28 items), based on individual and sports experiences, identified problems related to the work of a female coach. The second area (19 items) focused on the issue of coach education from the perspective of future woman coach. The pilot questionnaire survey was attended by 20 respondents (April 2018).

From June to August 2018, the prepared questionnaire was distributed personally by members of the research team (the paper-and-pencil form). A snowball approach was used to recruit participants. The sample consisted of female athletes (n=103) recruited from sports clubs in South Moravia (one of the regions of the Czech Republic). The female participants ranged in age from 18 to 43 years (average age 24.3 years). The research sample included 61 female students, 30 full-time women, 11 part-time women, and two respondents were professional athletes. The interviewed female athletes were engaged in various sports disciplines. These were Olympic and non-Olympic sports, both individual and collective. Some athletes were also engaged in more sports. The most common sports were volleyball (21.4%), basketball (19.4%), athletics (16.5%), football (15.5%), and rugby (13.6%). 52% of the respondents had experience with their coaching – only one on a professional level.

We processed the results using statistical analysis and open coding. Ethical approval was granted by the Ethics Committee for Research of Masaryk University (Ref. EKV-2017-100).

Results

Research carried out shows that 49% of respondents would like to continue as a female coach after their sports career. The rest stated the reasons why they did not want to keep this work. The most frequent issues were financial remuneration and the loss of free time that women want to spend mostly on households and families. The female respondents state that it is impossible to combine coaching with family and household care without the help of another person (mainly a husband). For example, women coaches would welcome the babysitting service at sports clubs.

The severe problems mentioned by the addressed women athletes include low to zero support of young coaches from sports associations and sports clubs and the lack of respect for female coaches by athletes and the wider public. Addressed athletes say that it is difficult for women coaches to gain respect from their athletes. This problem is not only related to the interaction between adult athletes but is also striking in youth sport. However, it states that this is difficult, but not impossible. It depends on the personality of the coach, also mostly can to help his sports experiences or coaching success.

Furthermore, female athletes reported a lack of their ambitions. The low representation of female coaches in some cases is also related to individual concerns of the women themselves. But as one female participant said, *“Women should not be afraid of coaching, because they can often be more receptive than men”.*

Discussion

In a survey of women in Czech sport, 57% of female athletes replied that had future coaching plans (Fasting & Knorre, 2005, p. 48). This finding 15 years ago was 8% higher than our data. This suggests that the declared support for women in coaching probably does not produce the desired effect.

Currently, our female respondents perceive financial reward and time demands as the biggest problem in staying as a coach. While the time required for coaching (in addition to regular coachings, competitions, and races throughout the year, concentration, etc.) was one of the main reasons for the lack of interest in coaching at the beginning of the 21st century (Fasting & Knorre, 2005), financial aspects were not a barrier. There are similar financially opinions, for example, in Germany, where the majority of female coaches work part-time with low pay (Cachay & Benning, 2002, p. 227).

In our survey, women athletes wishing to work as female coaches would welcome more significant support from sports clubs, sports unions, etc., for example, in the form of mentoring. Much support for beginning coaches in the form of mentoring has proven to be one of the critical aspects of developing coach excellence (Picariello & Waller, 2016). It is imperative; however, that female start-up coaches can choose the mentor’s person and gender (Telles-Langdon, 2018).

One of the problems that contribute to the under-representation of women in coaching is the traditional situation where coaches are given a minimal opportunity to train men. This makes it very difficult for them to show their abilities and skills and gain sufficient respect. Coche and Le Blond (2018) draw attention to the critical public view of a woman coaching a top male athlete. Even our female respondents prefer coaching girls and women (38%) over coaching male athletes (27%) in their possible future coaching work.

Conclusion

Gender issues in coaching still represent a highly discussed topic. Research carried out showed that about half of the addressed female athletes are interested in staying in the sport as a coach. However, they encounter many problems that negatively determine the work of the woman coach. We cannot generalize the conclusions of the research carried out due to the type of research sample. However, the processed data show specific problems, the solution of which may help to increase the still low representation of women among Czech sports coaches.

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TRENDS IN BMI BY AGE PERIODS OF PUPILS WITH INTELLECTUAL DISABILITY

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Jitka Králíková, Hana Válková

Faculty of Sports Studies, Masaryk University Brno, Czech Republic

ABSTRACT

Childhood obesity is becoming increasingly important in children because it occurs in earlier age periods. Children with intellectual disabilities belong to a high-risk group in the area of obesity. Their disability limits them in everyday life both in the possibilities of participation in physical activities and in the field of lifestyle. Currently, there is not real data in BMI age trends for children with intellectual disabilities. The aim of the research is to find out the trends of BMI in children with mild and moderate intellectual disability in different age periods and to find out whether summer holidays have an effect in BMI trend in some age periods. The methods used were quantitative and comparative research. BMI indicators were measured using an In-Body machine. T-test was used to identify statistically significant differences between periods. Trends were measured in children aged 6–20 years (the number of participants in each measurement: n = 49, n = 55, n = 56, n = 55) in over two years in the region Zlín in the Czech Republic. Trends are evaluated using box charts. The conclusion is that the trend of BMI of school-age pupils is positively accelerating, summer holidays have no affect BMI values. The BMI trend in pubescence pupils is fluctuating with a decrease in BMI values during the summer holidays. The BMI trend in adolescence pupils is convex, summer holidays have no effect on BMI values. BMI trends of all ages are within the normal weight. A statistically significant difference in BMI is only for pupils of school age between September 2017 and June 2018. It is beneficial finding for practice that children with intellectual disability in the Czech Republic have much better results in BMI indicators and trends than children with intellectual disability in abroad.

Keywords: BMI trends; children with intellectual disabilities; school age; pubescence; adolescence

Introduction

The increase in childhood obesity applies to both developed and already developing countries, where economic and social conditions have changed for certain social strata. In this context, it should be emphasized that children's health is the key to the health of the entire adult population (Pařízková & Lisá, 2007, p. 13).

The basic principle of obesity is still the same. Energy intake exceeds energy expenditure. Simply put, the child's body cannot burn whatever child has eaten and drank. Bad eating habits and a lack of physical activity of the child play an essential role in the development of obesity. The diet of obese children is very unbalanced and inadequate with low levels of fiber, vitamins and minerals. A typical negative element in the diet of children is irregular eating. Children skip breakfast, snacks, or more meals during the day. Foods with a higher proportion of simple sugars, such as sweets, sweet carbonated drinks, sweet pastries and other sweet snacks, prevail in large quantities (Žára, 2020).

The prevalence of obesity is steadily increasing both in the Czech Republic and in other countries of the world. There is still no consensus how to solve this problem. Prevention of obesity by the state consists mostly in the control of food from which it is cooked in school facilities (Duramy, 2018). Obesity in children age 8–15 has been found more in children with behavioral, learning, emotional and somatization disorders. These children have experienced more stressful life events than their peers (Tanu, Manju, Rajesh & Vandana, 2018). According to data from the World Health Organization (WHO), one in four Czech children is currently overweight and one in ten is obese (Seďová, 2019). While only 4% of children had obesity 20 years ago, nowadays 14% of children have obesity and 25% have overweight (Eurozprávy, 2018).

Intellectual disability (ID) is not a disease, but a condition characterized by an overall decrease in intellectual abilities (Kvapilík & Černá, 1990, p. 7). It is a developmental intellectual disorder manifested by reduced intelligence (Valenta & Müller, p. 10). Intellectual disability arises during the development of an individual and is usually accompanied by adaptive disorders, i.e. lower ability to orientate in the environment (Kvapilík & Černá, 1990, p. 7). People with ID do not understand their surroundings and are unable to adapt to the required extent. They are characterized by a slowed pace and a narrowed range of perception that makes their orientation in the environment more difficult (Vágnerová, 2004, pp. 289–295).

People with intellectual disabilities can be affected by a number of other mental disorders that occur 3 to 4 times more frequently than in the general population. Their adaptive behavior is always disrupted, but in a protected social environment with accessible care, this disruption may not be conspicuous in persons with mild intellectual disabilities (Valenta, Michalík, Lečbych et al., 2018, p. 36).

Individuals with mild ID are characterized by an IQ in the range of 50–69 (Švarcová, 2000, p. 27). Persons are at the level of children aged 9–12 years old. They will be able to study in a special primary school. They use the language effectively in everyday life and they are able to keep conversation. Most of them achieve complete independence in personal care, i.e. food, washing, dressing, hygiene habits as well as practical household skills (Kocourová, 2014).

Individuals with moderate ID are characterized by an IQ in the range of 35–49 (Švarcová, 2000, p. 27). Persons are at the level of preschool children. The development of understanding and use of speech is significantly delayed. They can learn only on a practical level, i.e. common habits and simple skills (Kocourová, 2014). However, some pupils are able to attain the basics of reading, writing and counting under qualified pedagogical guidance. The ability to self-care is also limited and delayed (Švarcová, 2000, pp. 28–29).

School age (6–11 years) is a period with rapid growth that continues with a period of slow growth and development. For the child there is a change, begins to go to school, becomes social, must also focus on less attractive things (learning) and obeys the timetable. Other characteristic elements are cooperation with classmates, competitiveness, naive realism (they trust everything), dependence on authorities (parents, teacher), (Vágnerová, 2000, p. 207). Bio-somatic development in ID is same with general children, unless there is a combination with Down syndrome, cerebral palsy or organic brain disorders.

The period of pubescence (12–15 years) is characterized by the onset of hormone activity, the formation of secondary sex traits and the acceleration of growth. The child slowly becomes an adult both physically and mentally. As a result of hormonal changes, children are emotionally unstable, anxious, have feelings of loss of confidence and problems with self-acceptance. Group identity and first contact with the opposite sex are gaining importance (Psychology Study, 2016). In people with ID, the onset of pubescence is often delayed. This creates a disproportion between intellectual and biological matureness, which deepens further.

In the period of adolescence (16–20 years) significant milestones of life occur, compulsory education is terminated and entry into employment (Lečbych, 2008, pp. 43–52). At the end of the period, physical fitness, intellectual and emotional development culminate. Created interests and attitudes do not change for most people (Nakonečný, 2011, pp. 682–683). The development of cognitive functions in people with intellectual disabilities has stopped before their age of 15. A peer group in which a person with intellectual disabilities would like to integrate becomes more important. There are considerable problems in integrating into the non-disabled peer group (risk of bullying, humiliation, jeering), (Lečbych, 2008, pp. 52–55).

Childhood obesity is accompanied by many other diseases such as diabetes, hypertension, sleep apnea syndrome, depression (Esposito et al., 2014). Increased body weight is more common in people with ID than in the general population (Melville, Hamilton, Miller & Boyle, 2007; Rimmer & Yamaki, 2006). According to Melville, Hamilton, Miller & Boyle (2007), the prevalence rate of obesity is 15% to 50% for women and 2% to 45% for men (pp. 223–230). Children with intellectual disabilities are a high-risk group for the development of obesity, representing 5–6% of all obese children in population (Emerson, Robertson, Baines & Hatton, 2016).

Children with ID have a higher prevalence of overweight and obesity compared to their peers, contributing to an increased risk of cardiometabolic disease (Curtin et al, 2010; Rimmer et al., 2010). The prevalence of overweight in children with ID was found to be up to 65%, and obesity was 19%. While prevalence of overweight in general children was 29% and obesity was 13% (Rimmer et al., 2010).

The risk of obesity appears to be particularly high in women (Melville, Hamilton, Miller & Boyle, 2007; Hsieh, Rimmer & Heller, 2014). Women are more obese than men in all populations (Svačina & Bretšnajdrová, 2003, p. 35). Furthermore, the risk of obesity is high in people with Down syndrome and in people with mild degrees of intellectual disability (Melville, Hamilton, Miller & Boyle, 2007; Hsieh, Rimmer & Heller, 2014). Other factors include education, where higher financial income reduces the incidence of obesity, as well as alcohol, which leads to weight gain (Svačina & Bretšnajdrová, 2003, p. 35). Emerson, Robertson, Baines & Hatton (2016) also confirmed the association of obesity in children with ID in connection with their mothers' education.

Also, the way of living in people with ID was found in many researches as an important factor in the development of obesity. People living in institutional housing have the lowest prevalence of obesity and people living in their own homes have the highest (Melville, Hamilton, Miller & Boyle, 2007; Stanclife et al., 2011). Children with mild and moderate ID in school age and pubescence living in children´s home do not tend to be obese but tend to have normal weight. Children living in their own families tend to be obese and overweight. It is also typical for children to remain in the existing BMI category (e.g. normal weight) and not to change this category during development (Králíková & Válková, 2019, p. 42). This is also confirmed by Bellamy et al. (2020), which examined children with ID aged 9–13. Children showed low levels of physical activity in association with a higher prevalence of obesity. They had only 20% of the recommended daily physical activity. BMI did not change in children during the researched period.

Summer holidays have impact on the BMI trend in children with mild and moderate ID who live in their families. In children, there is an increase in BMI (weight gain) before the summer holidays (June 2017, June 2018) and after the holidays there is a decrease (weight loss) in BMI (September 2017, September 2018), (Králíková & Válková, 2019, p. 42).

It was also found in the Czech environment that more than half of children with mild and moderate ID have a normal weight. Obesity in boys is associated with early adolescence and mild and moderate ID. While in girls, obesity is associated with middle adolescence and mild level of ID (Králíková & Válková, 2019, p. 85). Anthropometric characteristics are directly correlated with the intellectual level of both general population of children and children with ID. Children with mild ID have approximately by 10% less motor performance than general children (Geshoski, 2015).

It was calculated that if the BMI did not exceed 25 (normal weight), the number of deaths from heart attack and atherosclerosis would be reduced by 15% to 30%. Furthermore, 64% of men and 77% of women would be prevented from developing type 2 diabetes (Svačina & Bretšnajdrová, 2003, p. 38).

The aim of the research, which is part of the Healthy Community project, is to find out the trends of BMI in children with mild and moderate ID in different age periods and to find out whether summer holidays have an effect in BMI trend in some age period.

Methodology

Participants

The research group consisted of pupils of primary school in Otrokovice and primary school in Zlín. The most of pupils have a simple ID disability, i.e. without other associated defects. Half of the pupils have mild ID and half the pupils have moderate ID. There are also half boys and half girls in the group. Pupils are from 6 to 20 years old and fall into three age groups: school age (6–11 years), pubescence (12–15 years), adolescence (16–20 years). We can see (Table 1) that the most pupils are in pubescence and school age, with about 20 pupils in each measurement. About 50 children participated in every measurement.

Table 1 *Number of pupils in each measurements (girls and boys together)*

	June 2017	**September 2017**	**June 2018**	**September 2018**
School age 6–11 years	17	23	22	20
Pubescence 12–15 years	22	22	21	24
Adolescence 16–20 years	10	10	13	11
Total	**49**	**55**	**56**	**55**

The measurements took place four times over a two-year period, each in June and September because we wanted to know if the summer holidays have some effect on the BMI trends. An ethical consensus was ensured, as well as the agreement with head-teachers and parents for measurements.

Data acquisition and analysis

For the BMI indicators was used In-Body 230, which detects the exact results of body composition, i.e. fat, active body mass and water. InBody uses the 8-point touch electrode method to measure body by segments. In the figure (Figure 1) we can see an example of measurements that took place at primary school. The measurements were always carried out in the gym so as not to interfere with the normal school regime. The measurement was spread over 2 days – we were 1 day at each school.

BMI is an index of body weight and it is used to indicate underweight, normal weight, overweight and obesity. For the adult population there is a universal table that does not take into account age or gender. Another option is to calculate the BMI as the weight (in kilograms) divided by the height of the person (in meters) squared. Because BMI shows the value in kg/m^2. For children aged 5–19, the WHO standardized a chart for boys and a chart for girls. Based on the child‘s sex and age, the child‘s category is determined in the graph.

Figure 1 *Measurement of BMI at primary school*

(Note: Parents' consent for measurement is part of the school's documentation for the given school year 2017/2018 and is stored in the school)

For the description of trends there is used the model of development trends according to Švancara (1980, p. 20) and Válková & Thaiszová (1989). There are 6 basic trends: stable, positive, negative, unbalanced, convex, concave.

Trends and T-tests were processed in program Statistica 12. Trends are presented in the form of boxed graphs, so it is possible to see the minimum and maximum value in the file. The median, which is a non-parametric quantity and is not distorted by extreme values, is used to represent the center of the trend.

Results

BMI trend in school age pupils

The BMI trend in pupils of school age (Figure 2) is positively accelerating, with the lowest value of 15.1 in September 2017 followed by a steady slight increase in BMI values to a final 16.7 at the end of the measurement in September 2018. The summer holidays have no verifiable equal effect on BMI (in September 2017 it is 15.1 but in September 2018 it is 16.7). If the BMI values are compared for a given age period in a WHO chart for both boys and girls, we find that these values correspond to normal weight in both sexes.

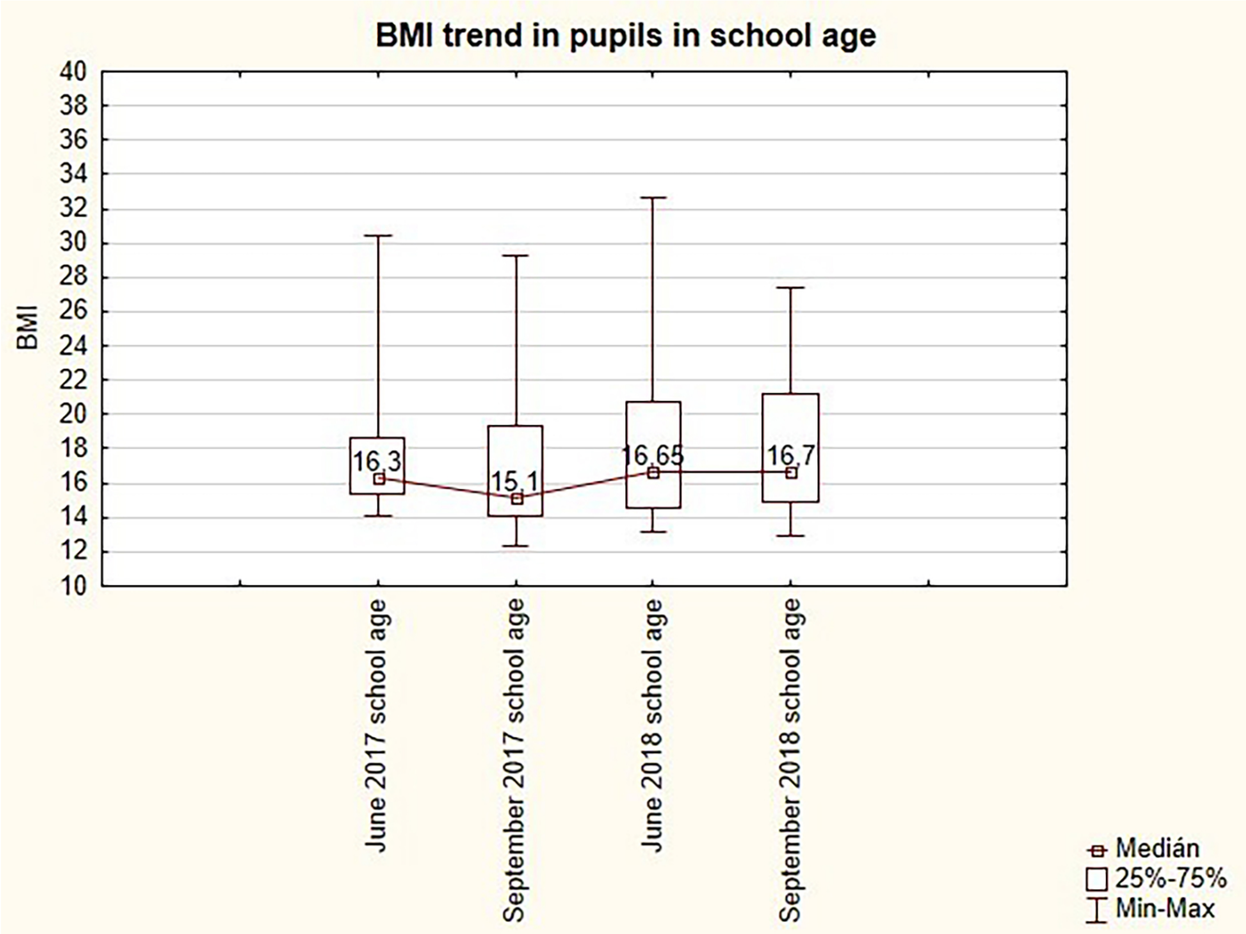

Figure 2 *BMI trend in school age pupils*

The following table (Table 2) shows the height and weight of pupils during the same period. There is no connection with holidays for pupils' height. After the summer holidays in September we can see weight loss (in September 2017 it is 27.9 and in September 2018 it is 31.35 kilograms).

Table 2 *Median of school age pupils in body height and weight*

School age	**June 2017**	**September 2017**	**June 2018**	**September 2018**
Height (cm)	131	134	140.5	136
Weight (kg)	29.4	27.9	31.85	31.35

BMI trend in pubescence pupils

The BMI trend in pubescence pupils (Figure 3) is fluctuating, with an increase and decrease in BMI values. The maximum BMI values of 21.7 are at the beginning of the measurement in June 2017 and the lowest BMI values of 19.1 are at the end of the measurement in September 2018.

In September after the summer holidays we always see a decrease in BMI values to 20.05 and 19.1. **Summer holidays have a verifiable effect on BMI and mean weight loss in pubescence pupils.**

If the BMI values are compared for a given age period in a WHO chart for both boys and girls, we find that these values correspond to normal weight in both sexes.

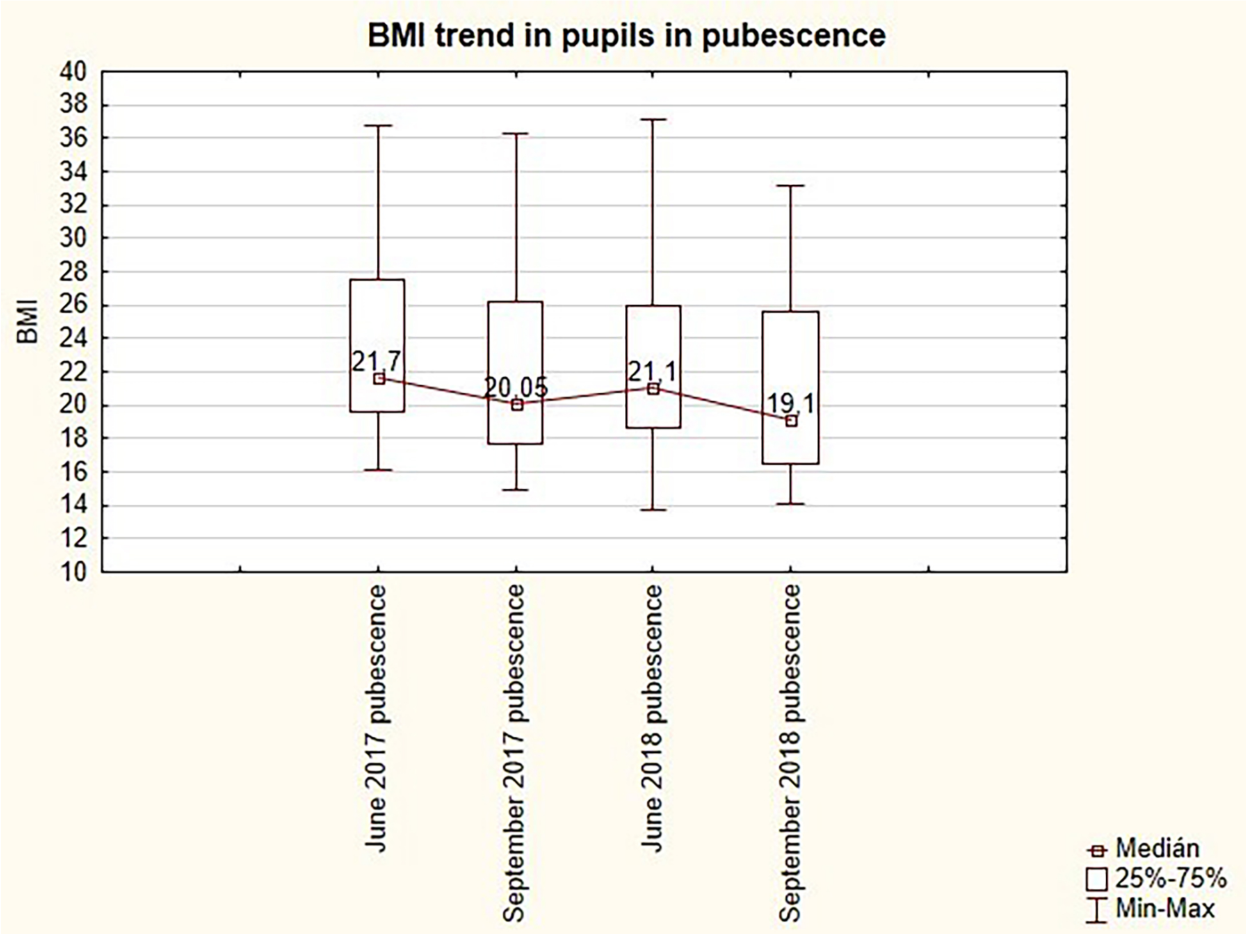

Figure 3 *BMI trend in pubescence pupils*

The following table (Table 3) shows the height and weight of pupils during the same period. There is no connection with holidays for pupils‘ height. After the summer holidays in September we can see weight loss (in September 2017 it is 53.9 and in September 2018 it is 54.1 kilograms). This is the same effect as is in BMI.

Table 3 *Median of pubescence pupils in body height and weight*

Pubescence	June 2017	September 2017	June 2018	September 2018
Height (cm)	159.5	163.5	160.5	160.5
Weight (kg)	57	53.9	56.3	54.1

BMI trend in adolescence pupils

The BMI trend in adolescence pupils (Figure 4) is convex, with the lowest values in the middle of the measurements of 18.3 in September 2017 and 19.6 in June 2018. Conversely, the highest values are at the beginning of the measurement 20.15 and at the end of the measurement 21. The summer holidays have no verifiable effect on BMI, since in September 2018 a decline to 18.3 followed, but in September 2018 followed by a rise to 21. If the BMI values are compared for a given age period in a WHO chart for both boys and girls, we find that these values correspond to normal weight in both sexes.

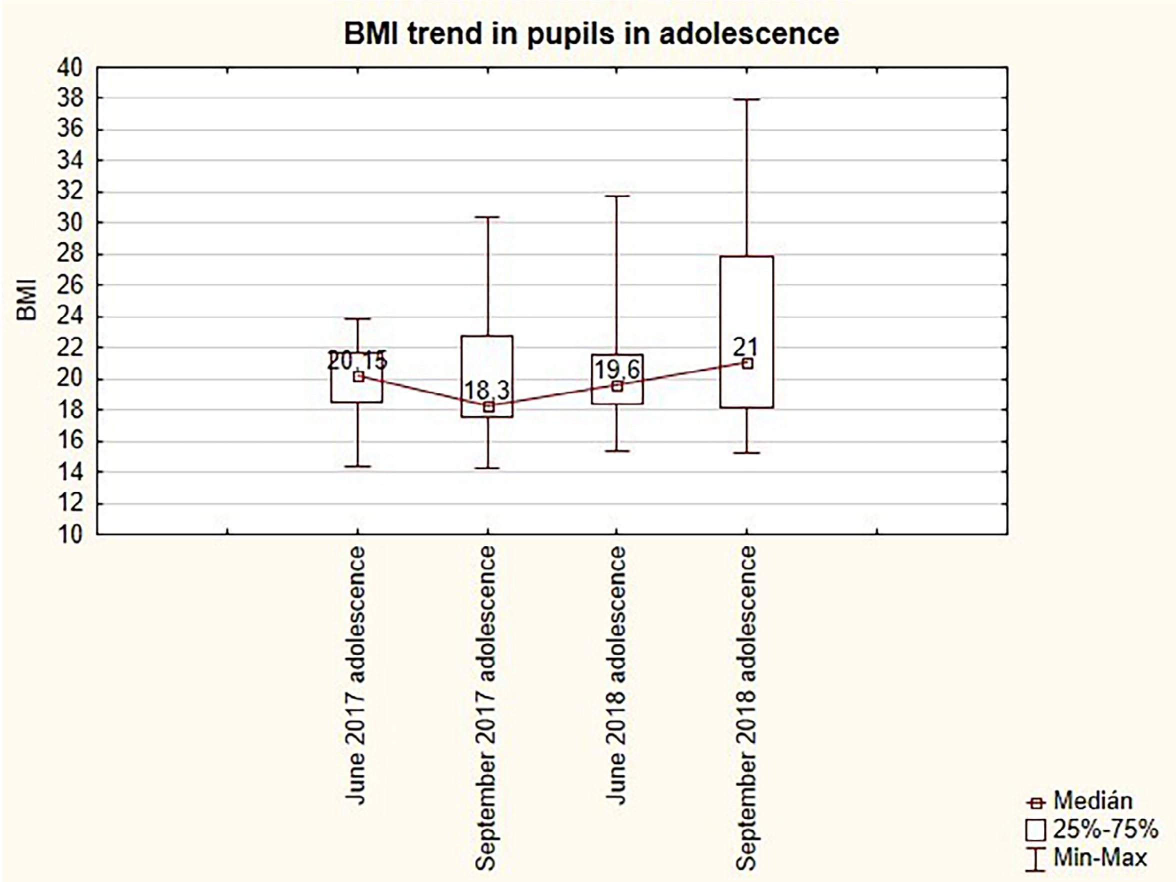

Figure 4 *BMI trend in adolescence pupils*

The following table (Table 4) shows the height and weight of pupils during the same period. There is no connection with holidays for pupils' height. After the summer holiday in September 2010 we can see weight loss but in September 2018 we can see increase in weight. The weight has the same trend as BMI.

Table 4 *Median of pubescence pupils in body height and weight*

Adolescence	June 2017	September 2017	June 2018	September 2018
Height (cm)	162	167	166.5	165.5
Weight (kg)	53.1	51.65	58.3	58.5

T-test for BMI according to age of pupils

The following table (Table 5) shows t-test in pupils in terms of age in BMI. The t-test determines the statistical significance between two periods. A level of less than 5% is considered statistically significant, i.e. $p < 0.05$.

A statistically significant change occurred only in pupils of school age between September 2017 and June 2018, namely $p = 0.044033$.

Table 5 *T-test in BMI*

T-test between measurements	School age	Pubescence	Adolescence
June 2017 + September 2017	0.393122	0.406768	0.612770
September 2017 + June 2018	**0.044033**	0.864122	0.734054
June 2018 + September 2018	0.408095	0.773533	0.183705

Discussion

The most of foreign authors agree that children with ID have a high tendency to be obese and that they have insufficient physical activity, much lower than general children (Bellamy et al., 2020; Melville, Hamilton, Miller & Boyle, 2007; Hinckson et al., 2013; Wouters, Evenhuis & Hilgenkamp, 2019). As reasons, the authors mention the connection with diabetes, Down syndrome, lower education of their parents, lack of exercise and type of housing. However, research in the Czech Republic shows something else. More than half of children with ID have weight in norm (Králíková & Válková, 2019). Also, a research of weekly physical activity in people with ID aged 14–35 years in the Czech Republic found that people with ID have physical activity comparable to the general population and it clearly depends on the conditions they have (in the family, in the institution), (Válková, Králíková & Dygrýn, 2018). The median of BMI trends in school age, pubescence and adolescence is in normal weight. It follows that children with ID have a much lower BMI, i.e. less weight than children with ID in foreign countries (Britain, USA, Australia).

It is possible that special primary schools in the Czech Republic devote much more attention to pupils with ID, offering them a greater number of activities in which pupils can participate. Pupils also have two hours of compulsory physical education weekly, and pupils with a severe degree of disability also have health physical education each week. It is also possible that in the Czech Republic there is greater involvement of parents in their child's physical activities. Both schools also cooperate with the Czech Special Olympics Movement and pupils have the opportunity to regularly participate in competitions that are organized.

Foreign authors Colley et al. (2011); Beets et al. (2010); Craig et al. (2010) point to the expected decrease in physical activity in children in adolescence. However, the value of the trend for both girls and boys of adolescents is in category normal weight. This corresponds to already realized researches that adolescents in the Czech Republic have physical activity comparable to the general population (Válková, Králíková & Dygrýn, 2018) and there is no reason to increase BMI. Because the BMI trend is convex, we can assume that adolescents do not have regular physical activity during the year.

From the trend of pupils of school age, which is positively accelerating, we can assume that pupils had higher physical activity after the first holidays in September 2017, when the BMI decreased. However, after further holidays in September 2018, they had reduced physical activity as BMI increased. This implies an irregularity in participation in physical activities, and rather it looks like occasional activities during the year that pupils experience. Their BMI trend is slightly increasing, which is probably due to the increasing age of pupils. The trend is contrary to the fact that young children have a greater need for physical activity (Colley et al., 2011; Craig et al., 2010).

A fluctuating trend in pubescence pupils indicates much more physical activity during the summer holidays. Physical activity is so intensive that it causes a reduction in their BMI. (Aging and acceleration may also have an effect in body height, but the median of height was the same in the last two measurements). It is also possible that this age category is most interested in sports camps organized for children with ID. Group identity and peer sharing can also play a role (Psychology Study, 2016).

Foreign researches inform about often worse health status of people with ID (Havercamp, Scandline & Roth, 2004, pp. 418–426; Cooper, Melville & Morrison, 2004, pp. 414–415; Bellamy et al., 2020). Trends in pupils in BMI at school age, pubescence and adolescence show beneficial values which are within normal weight. This indicates good physical and health condition of the pupils in the Czech Republic.

Conclusion

Research of BMI trends in children was carried out in the Zlín Region at two primary schools over two year. More than 50 children with mild and moderate ID participated in the research. Pupils are between 6 and 20 years of age and are into the age periods of school age, pubescence and adolescence. The trend in pupils of school age is positively accelerating, there is a slight increase in the values of the BMI trend. Summer holidays have no verifiable effect on BMI values which are in the normal weight.

The trend in pubescence pupils is fluctuating, the values in the BMI trend alternate. Summer holidays have verifiable effect on BMI. Within the summer holidays, BMI values are reduced, i.e. pupils' weight is reduced. BMI values are in normal weight. The trend in adolescence pupils is convex, with the highest values in the BMI trend at the beginning and at the end of the measurement. Summer holidays have no verifiable effect on BMI values that are in normal weight.

A statistically significant difference in BMI is only for pupils of school age between September 2017 and June 2018. It is beneficial finding for practice that children with ID in the Czech Republic have much better results in obesity and BMI trends than children with ID in foreign countries.

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THE LONG-TERM DEVELOPMENT OF SHOOTING SKILLS IN YOUNG BIATHLETES

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Michal Žák[1], Ivan Struhár[2], Jan Ondráček[1]

[1]*Department of Athletics, Swimming and Outdoor Sports, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic*

[2]*Department of Health Promotion, Faculty of Sports Studies, Masaryk University, Brno, Czech Republic*

ABSTRACT

This study is a major part of the dissertation research. It is focused on the development of shooting skills in young biathletes in a three-year training period. Specifically, the long-term development of the percentage success rate of prone and standing shooting in both training and races is described in study. It mentions marginally shooting skills such as the postural stability, the stability of aiming and triggering. The first part of our research, completed in 2017, brought findings that the relationship between exercise intensity and the biathlete's postural stability exists, but following part of it, finalized in 2018, did not demonstrate the dependence of exercise intensity on the aiming stability and triggering. Initially, the study involved 23 young biathletes (13 girls, 10 boys). Whole research was completed by 19 biathletes (11 girls: age 17.8±0.64 years; 8 boys: age 17.4±0.72 years) after three years. The results of our current study are based on the records of shooting on metal targets that were created during each biathlon shooting training and all biathlon races of the participants in the three-year period. Only shooting with previous physical load was involved into results, shooting at rest was not included in the study. The results show the improvement of the percentage success rate in both prone and standing shooting in the three-year training period in both girl and boy groups and in both training and races (total percentage success rate = the average of the training and races percentage success rate – girls in prone: 2016/2017: 71.3%, 2017/2018: 75.5%, 2018/2019: 80.0%; girls in standing: 2016/2017: 61.8%, 2017/2018: 67.7%, 2018/2019: 73.4%; boys in prone: 2016/2017: 72.0%, 2017/2018: 72.9%, 2018/2019: 75.3%; boys in standing: 2016/2017: 57.6%, 2017/2018: 63.5%, 2018/2019: 67.7%). Girls are better shooters than boys in this research group. In general, the gradual improvement of percentage success rate in time is expected to occur in young biathletes that are in the intensive training process, but our study brings unique data of concretely values at this age of athletes that has not been known yet. The obtained data could be used by biathlon trainers to compare the current level of shooting skills at a given age of their young athletes. At the same time, a normative standard of biathlon shooting skills in a given age could be created in the case of gathering more data. That is one of the goals of the Czech Biathlon Union.

Keywords: Biathlon training; Shooting analysis; Physical load

Introduction

The biathlon is a very popular winter sport of recent years in the Czech Republic. The number of young athletes has expanded considerably thanks to numerous successes of Czech biathletes in world competitions such as the World Cups or the Olympic Games. Temporarily, it brought problems with the personal and material ensuring of clubs in several last years. Currently, the situation has stabilized. The increasing number of new talents and their maintaining in this sport is one of aims of the Czech biathlon union, an umbrella organization of this sport in Czechia. The way to achieve desired results leads through the long-term systematic training in all categories (from youth to seniors) that is created by experienced and educated trainers.

The learning of biathlon shooting skills is a complex long-term process. It is influenced by many factors. Many researchers dealt with factors such as aiming stability, postural balance, triggering, physical load, etc. The researchers considered all above-mentioned parameters as one of the most important factors in the resulting shooting success (Gallicchio et al., 2018; Haug, 2018; Ihalainen et al., 2018; Laaksonen et al., 2018; Sattlecker et al., 2013; Sattlecker et al., 2015; Sattlecker et al. 2017; Žák et al., 2018). Høydal and Nord (2017) presented the importance of the heart rate monitoring during training and races by junior biathletes. They meant that the heart rate control is one of main predictors of the successful shooting. Gallicchio et al. (2018) showed that physical exercise influences the destabilizing effect of cardiac contraction on shooting accuracy by augmenting it and making it occur earlier with the cardiac cycle. Other studies confirmed the dependence between the intensity of physical load and the athlete's postural balance in the standing shooting position, especially in anterior-posterior axis (Haug, 2018; Ihalainen et al., 2018; Sattlecker et al., 2015; Sattlecker et al., 2017; Vonheim, 2012; Žák et al., 2018). However, no study has confirmed the direct relationship between the intensity of physical load and the shooting success yet (Haug, 2018; Ihalainen et al., 2018; Laaksonen et al., 2018; Mononen et al., 2007; Sattlecker et al., 2015; Sattlecker et al. 2017; Vonheim, 2012; Žák et al., 2018).

This study is the final summary of the dissertation research that has been in progress since 2016. It has been divided into below mentioned parts. The first part of the dissertation research, completed in 2017, showed the influence of the exercise intensity on the biathlete's postural stability (Žák et al., 2018). The following part of the dissertation research was focused on triggering skills in different exercise intensities (Žák et al., 2018). The results of this study demonstrate the level of triggering skills of the participating youth and junior biathletes, but do not demonstrate the dependence of exercise intensity on the aiming stability and triggering.

The aim of this study is to evaluate the percentage shooting success in prone and standing position in the three-year training period of youth and junior biathletes in both training and races. The shooting skills, balance abilities and the development of strength-endurance abilities have been the main components of the training process of participants.

Methods

Experimental approach to the problem

This study is the major part of the extensive dissertation research. It is focused on the development of shooting skills in young biathletes in the three-year training period. Specifically, the long-term development of the percentage success rate of prone and standing shooting in both training and races is described in the study.

Participants

Initially, the study involved 23 young biathletes (13 girls, 10 boys). Whole research was completed by 19 biathletes (11 girls: age 17.8±0.64 years; 8 boys: age 17.4±0.72 years) after three years. All of these participants were included into the national junior biathlon team or into so called the selection of talented athletes in the Czech biathlon system during at least one of three years, so they presented the high level of national biathlon standards of their categories. They were made aware the study protocol and all important terms at the beginning of whole research and during each partial study too. They confirmed their participation in the research by signing informed consent.

Measurements

The results of our current study are based on the records of shooting on metal targets that were created during each biathlon shooting training and all biathlon races of the participants in the three-year period. Only shooting with previous physical load was involved into results, shooting at rest was not included in the study.

Statistics

All shooting records were written by biathletes and coaches into the shooting diaries in shared Google sheets and were evaluated by the researchers using the statistical functions of this program.

Results

Only shooting with previous physical load was involved into results due to possible distortion of the results provided analysis of data of shooting at rest. The aim of the study is to analyze the shooting skills in situations that closely correspond to the shooting during racing load of biathletes. And in general, biathletes achieve better percentage success rate in shooting at rest. Therefore, shooting results were recorded only after the previous physical load.

The indicator of shooting performance is the percentage shooting success rate of shot down targets in five-shot series (5 shot down targets = 100% shooting success rate, none shot down target = 0% shooting success rate). The results show the improvement of the percentage shooting success rate in both prone and standing shooting in the three-year training period in both girl and boy groups and in both training and races.

The average percentage shooting success rate in prone in the group of girls (n=11) is: in training 2016/2017: 71.9%, 2017/2018: 76.7%, 2018/2019: 81.1%; in races 2016/2017: 68.9%, 2017/2018: 74.3%, 2018/2019: 79.0% (Figure 1.).

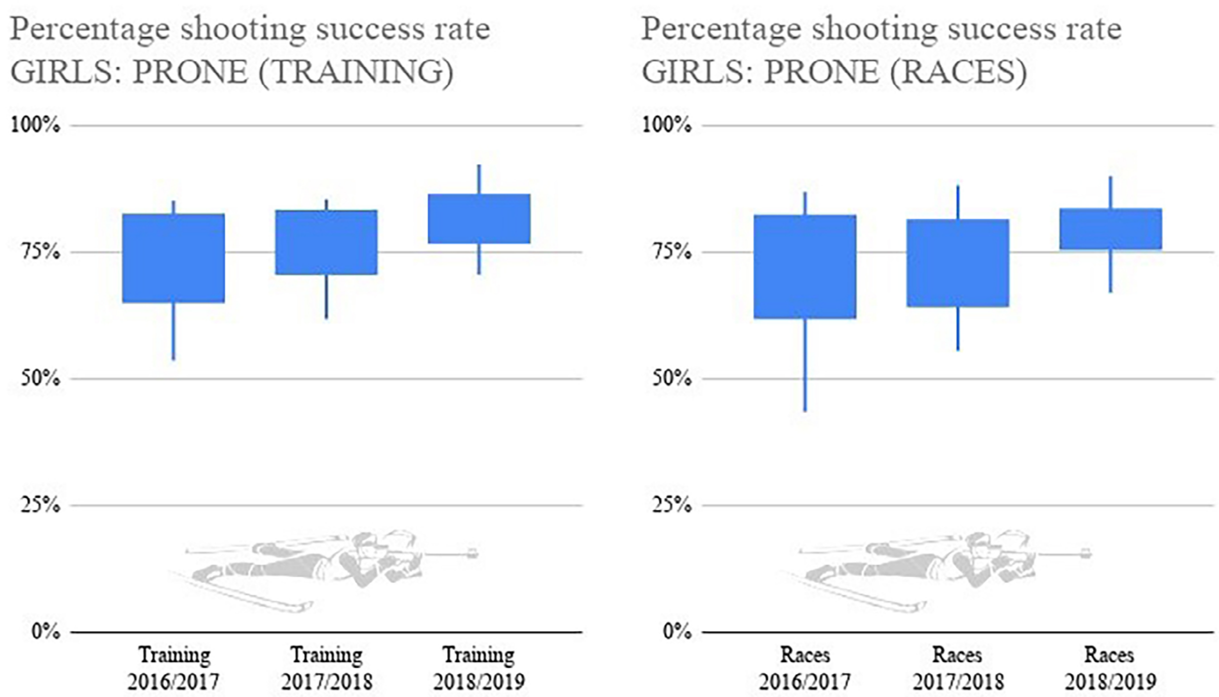

Figure 1 *The percentage shooting success rate in the group of girls (n=11) in both prone in training and races in the three-year period*

The average percentage shooting success rate in standing shooting position in the group of girls (n=11) is: in training 2016/2017: 63.9%, 2017/2018: 70.1%, 2018/2019: 77.3%; in races 2016/2017: 59.1%, 2017/2018: 65.4%, 2018/2019: 69.5% (Figure 2.).

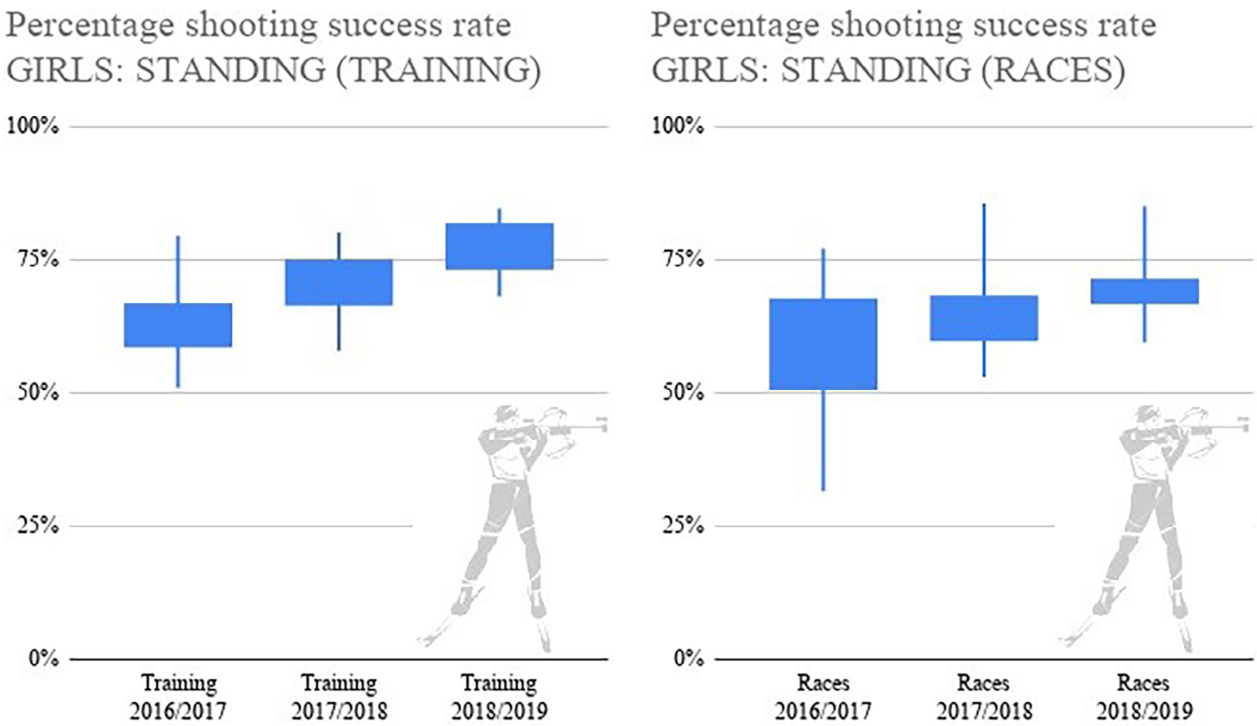

Figure 2 *The percentage shooting success rate in the group of girls (n=11) in standing in both training and races in the three-year period*

The total average percentage shooting success rate in the group of girls (n=11) is: total in prone 2016/2017: 71.3%, 2017/2018: 75.5%, 2018/2019: 80.0%; total in standing 2016/2017: 61.8%, 2017/2018: 67.7%, 2018/2019: 73.4% (Figure 3.).

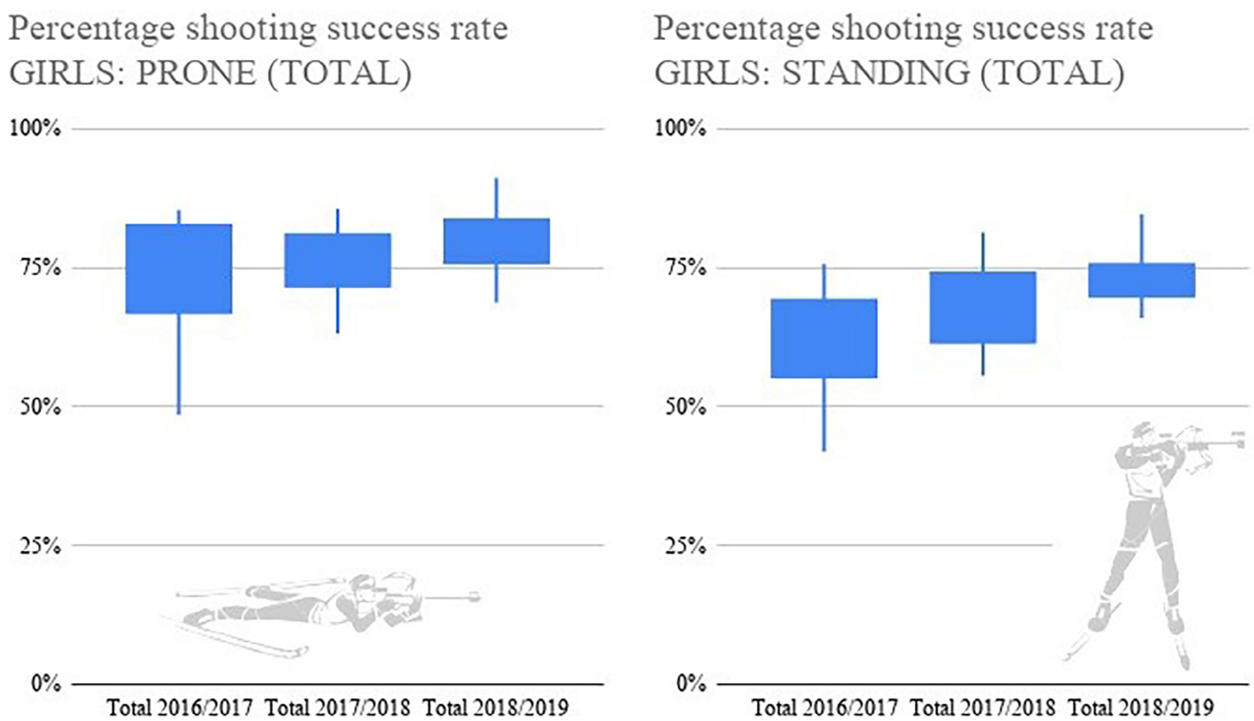

Figure 3 *The total percentage shooting success rate in the group of girls (n=11) in both prone and standing in both training and races in the three-year period*

The average percentage shooting success rate in prone in the group of boys (n=8) is: in training 2016/2017: 73.0%, 2017/2018: 75.1%, 2018/2019: 77.1%; in races 2016/2017: 71.2%, 2017/2018: 70.7%, 2018/2019: 73.6% (Figure 4.).

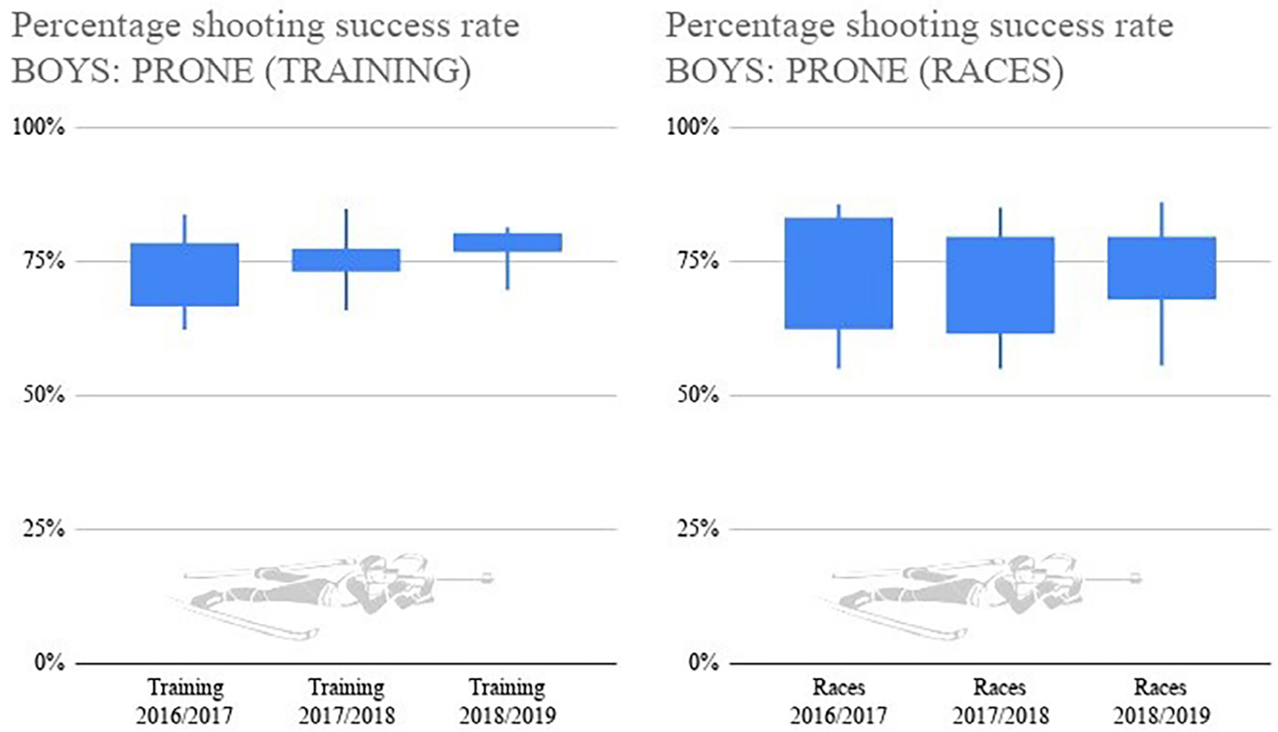

Figure 4 *The percentage shooting success rate in the group of boys (n=8) in both prone in training and races in the three-year period*

The average percentage shooting success rate in standing shooting positon in the group of boys (n=8) is: in training 2016/2017: 58.9%, 2017/2018: 66.3%, 2018/2019: 72.1%; in races 2016/2017: 56.3%, 2017/2018: 60.7%, 2018/2019: 63.3% (Figure 5.).

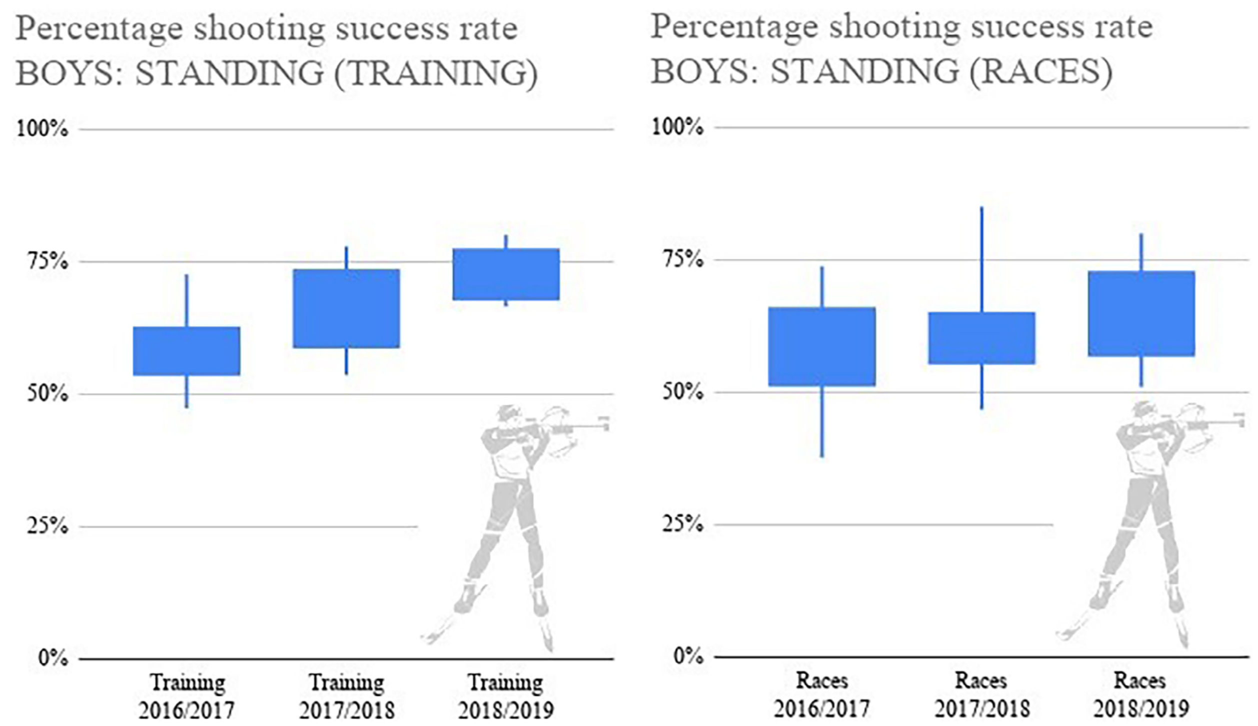

Figure 5 *The percentage shooting success rate in the group of boys (n=8) in standing in both training and races in the three-year period*

The total average percentage shooting success rate in the group of boys (n=8) is: total in prone 2016/2017: 72.0%, 2017/2018: 72.9%, 2018/2019: 75.3%; total in standing 2016/2017: 57.6%, 2017/2018: 63.5%, 2018/2019: 67.7% (Figure 6.).

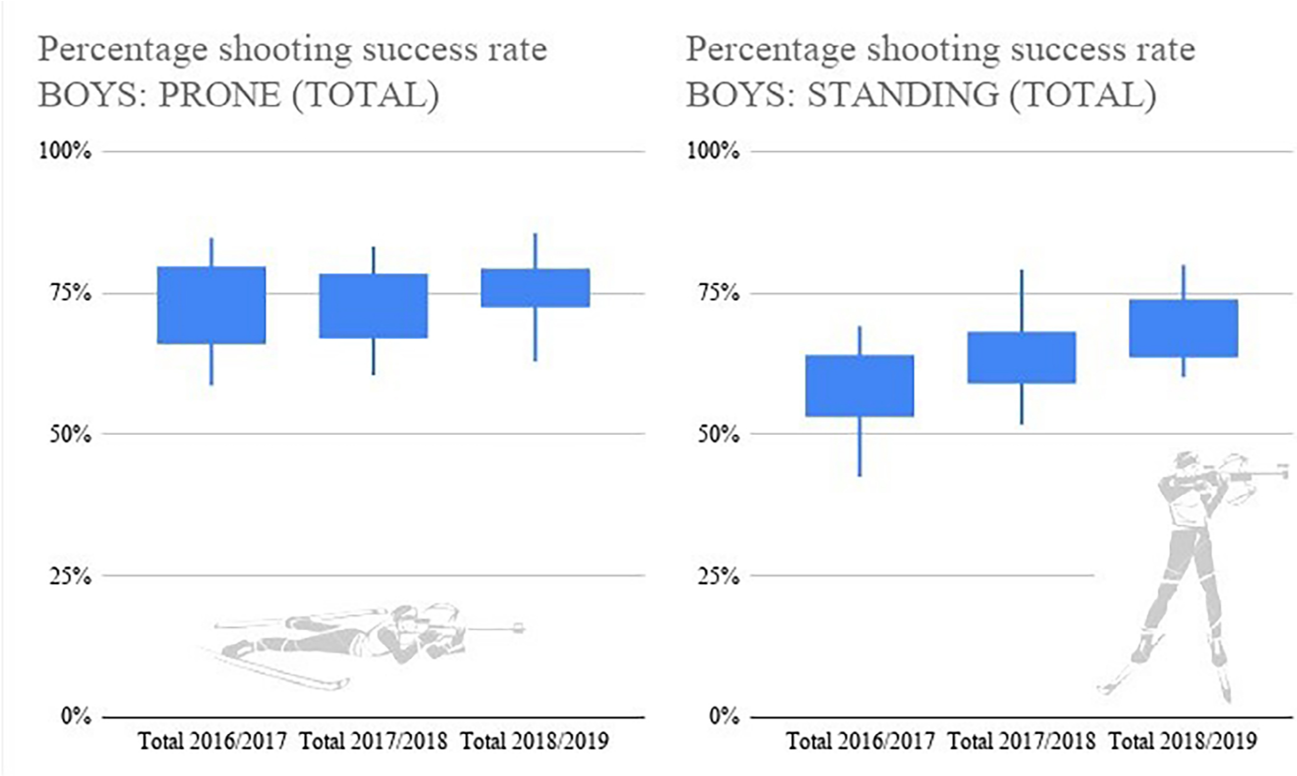

Figure 6 *The total percentage shooting success rate in the group of boys (n=8) in both prone and standing in both training and races in the three-year period*

Discussion

The results demonstrate the year over year improvement in shooting performance in both boy and girl groups in both prone and standing shooting position. The results of shooting performance in training show evident higher success rate than in races it is in both boy and girl groups. It closely corresponds with the real experience with this age category. However, it is necessary to take into account the fact that there is the considerable difference between the number of bullets fired in training and the number of bullets fired in races. Approximately 6000 bullets were fired during training in the appropriate exercise intensities but only about 300 bullets were used in races in the highest exercise intensities during every year of the research.

Furthermore, we must mention the limiting factors of our study. Firstly, a low number of participants (nineteen athletes) can be considered as one of them. This was caused by the strict rules of the selection of the biathletes to the study which we mentioned above. The next limiting factor was the season of the measurement. It was necessary to do it during summer time because the quality of measurement would be negatively influenced by frozen fingers of biathletes and other similar difficulties during winter.

The next important point relates with the fact that all participating biathlete were novices in long rifle shooting in the beginning of the research. Previously, they had been categorized into pupil categories and athletes use the air gun for training and races in these youngest categories. In addition, young biathletes manipulate with the air gun only in prone position. Biathletes start learning to shoot in standing position at the age of 15 and that is often difficult for them. They get good shooting skills in this new position after many months or years of the systematic training. Accordingly, it corresponds with results of our study that the greatest improvement of shooting skills was during the first year of the study on average (Žák et al., 2018).

The goal of youth biathletes and their coaches should be to achieve such the percentage shooting success rate as top biathletes racing in the World Cup. Their percentage shooting success rate is around 90% in both prone and standing shooting position in training. Skattebo and Losnegard (2018) presented in the study the percentage shooting success rate in races of the top ten biathletes in the World Cup at the 2005 to 2015 – on average of 87% in prone and on average 81% in standing shooting position.

In youth and junior categories there is the main objective to stabilize the percentage shooting success rate in training circa 85% in prone and 75% in standing. These percentage success rates are considered as very good in these age categories. The next step of the athlete's development is to transfer these success rates into races. In practice, it usually takes 4 or 5 years to achieve this, but it is very individual. In the study, Sattlecker et al. (2017) showed this age difference in several parameters compared to competitors of the World Cup, European Cup and young federal biathletes.

Among other things, the results show better ability to shoot cleanly in the girl group against the group of participating boys. In the real training process, girls are often able to concentrate better on shooting activities for longer time than boys that can related with above mentioned results. Furthermore, data of the study reveal slight decreasing or stagnation of shooting performance in the group of boys in prone (in both training and races) and in standing (in races) in the second year of research and, at the same time, their second year of learning long rifle shooting. This phenomenon corresponds with researchers' experience (Žák et al., 2018) because biathletes often work very hard and concentrate on all training activities (like so called dry shooting and so on) during the first year of training. However, their effort subsides in the following year. The coach must to intervene intensively in this case and to choose the right form of activation and motivation of his athletes for further shooting training.

Conclusion

In general, the gradual improvement of percentage success rate in time is expected to occur in young biathletes that are in the intensive training process, but our study brings unique data of concretely values at this age of athletes that has not been known yet. The obtained data could be used by biathlon trainers to compare the current level of shooting skills at a given age of their young athletes. At the same time, a normative standard of biathlon shooting skills in a given age could be created in the case of gathering more data. That is one of the goals of the Czech Biathlon Union.

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RELATIONSHIP OF THE RESULTS FROM FITNESS TEST AND POINTS FOR PERFORMANCE IN ALPINE SKIING OF THE CZECH NATIONAL TEAM OF U14 AND U16 CATEGORIES IN THE SEASON 2018/2019

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Jan Jurečka, Tomáš Horáček

Masaryk University; Faculty of Sports Studies; Czech Republic

ABSTRACT

The main motivation for the research is a verification of applicability of the fitness test as a predictor for specific alpine skiing performance of the Czech national team of U14 and U16 categories. We want to verify if the results from the fitness test correspond with points for the performance in alpine skiing disciplines (slalom, giant slalom, super giant slalom). In total, 42 men and women (U14 and U16 categories), members of the Czech national team, participated in the research. Participants were grouped by gender (women n=21, age 14.23 (± 1.04), men n = 21, age 14.19 (± 1.07)). Fitness test consisted of six individual tests and was used as a tool to examine the level of motor abilities (jumping over the Swedish bench, shuttle run 4 × 10m, standing long jump, hurdles agility run - boomerang test, twist test, 20m shuttle run - beep test). Points for the performance in alpine skiing show the best result from a single competition transferred to the points. In our research we were looking for relationship between the points from three different disciplines (slalom, giant slalom, super giant slalom) and the results from the fitness test. In the men category we found high correlation (at the significance level of $p < 0.05$) between super giant slalom and standing long jump ($r = -0.73$; $r^2 = 0.53$), between super giant slalom and boomerang test ($r = 0.62$, $r^2 = 0.38$) and between super giant slalom and shuttle run 4 × 10m ($r = 0.61$, $r^2 = 0.37$). Small correlation was found between slalom and box jump test ($r = -0.31$, $r^2 = 0.1$), between slalom and twist test ($r = -0.33$, $r^2 = 0.11$) and between super giant slalom and twist test ($r = -0.34$, $r^2 = 0.12$). In women category we did not found high correlation (at the significance level of $p < 0.05$). Small correlation was found between slalom and box jump ($r = -0.31$, $r^2 = 0.1$), between giant slalom and twist test ($r = 0.01$, $r^2 = 0.0001$), between super giant slalom and standing long jump ($r = -0.03$, $r^2 = 0.0009$) and between slalom and shuttle run 4 × 10m ($r = -0.05$, $r^2 = 0.0025$). Twist test had very small correlation in both men and women categories. We can say that it is not relevant for prediction of alpine skiing performance. Based on different significance of correlations between men and women (super giant slalom and standing long jump; slalom/super giant slalom and shuttle run 4 × 10m) it might be necessary to adjust fitness testing as a predictor of alpine skiing performance according to a gender.

Keywords: Alpine skiing; Slalom; Giant slalom; Super giant slalom; Fitness test; FIS; FIS points; Points for performance in alpine skiing; Motor abilities

Introduction

To predict performance and to select talented athletes in alpine skiing is a complicated process. Testing fitness in alpine skiing is a part of preparation for alpine skiing performance (Hydren et al., 2013; Vogt, 2013; Mueler et al., 2000). It is crucial to create an adequate battery of fitness tests. Hydren et al. (2013) introduces many different fitness tests which are used for testing of physical abilities in countries such as Canada, USA, Australia, New Zealand and of course European countries participating in alpine skiing competitions. Unified system of physical testing does not exist. Every country uses different fitness tests. The most commonly used tests are as follows: countermovement jump, average of 5 countermovement jumps, 1 repetition squat, V̇O2max, cycling ergometer wattage at 4 mmol of lactate (lactate threshold), lateral box jump test, hex test (Hydren et al., 2013); hurdles agility run (boomerang test), beep test (Gonaus & Müller, 2012); standing long jump (Müller et al., 2015) cooper test, drop jump, bench press (Raschner et al., 2013); twist test, Swiss cross (Vogt, 2013); shuttle run test, pull-ups, push ups, sit ups, zig zag run (Heikkinen, 2003).

Fitness testing serves as a tool to examine aerobic and anaerobic capacity, strength, velocity, endurance and coordination abilities (Raschner et al., 2013). The relationship between results of disciplines of alpine skiing (slalom, giant slalom, super giant slalom) and individual fitness tests is the main subject of our research. Similar topic was examined by Heikkinen (2003), Bogataj et al. (2018), Andersen et al. (1990), Turnbull et al. (2009), Duvillard (1995) or Jasmin et al. (1989). Current results show high correlation between giant slalom and standing long jump, giant slalom and box jump (Andersen et al., 1990; Turnbull et al., 2009). Anaerobic strength correspond more to alpine skiing performance than aerobic strength (Duvillard, 1995). High correlation was also found between alpine skiing performance and combination of four fitness tests (run from the flying start, ten jumps on both legs, 400m run, counter-movement jump, $r = 0.73$, $r^2 = 0.53$) (Bogataj et al., 2018). Heikkinen (2003) found high correlation between slalom/giant slalom and zig zag run ($r = 0.77$; $r^2 = 0.6$/ $r = 0.71$; $r^2 = 0.5$), between slalom/giant slalom and hexagonal jump ($r = 0.58$; $r^2 = 0.34$/$r = 0.69$; $r^2 = 0.45$) and between slalom/giant slalom and box jump ($r = -0.6$; $r^2 = 0.36$/$r = -0.67$; $r^2 = 0.45$). Similar high correlation between hexagonal jump and giant slalom ($r = 0.82$; $r^2 = 0.67$) and between slalom and box jump ($r = -0.8$; $r^2 = 0.64$) was also found by Andersen et al. (1990). Correlation of alpine skiing performance and results of hexagonal jump varies among authors. Heikkinen (2003) and Andersen et al. (1990) found high correlation. Jasmin et al. (1989) did not find high correlation. Heikkinen (2003) found very small correlation between sit-ups in 60 seconds and alpine skiing performance ($r = -0.05$; $r^2 = 0.0025$).

The aim of our research is to find relationship between the chosen fitness tests and points for performance in alpine skiing disciplines (slalom (SL), giant slalom (GS), super giant slalom SG)). We will also make a correlation between individual fitness tests. The results will be compared to the results of other authors. Based on the results some of the tests might be eliminated or replaced by more appropriate fitness tests.

Methods

- ***Participants***

For our research we selected intentionally members of the Czech junior representation team in alpine skiing. Number of participants n=42 (women n=21, age 14.23 (± 1.04); men n=21, age 14.19 (± 1.07)). Fitness test took place at the beginning of first preparatory period in 2019. Fitness test consisted of these individual tests: Shuttle run 4x10m, standing long jump, hurdles agility run - boomerang test, twist test, jumping over the Swedish bench and 20 meter shuttle run - beep test.

- ***Procedure***: description of fitness tests:

Shuttle run 4 × 10m

Procedure of the shuttle run 4 × 10m is described by Ramírez-Vélez et al. (2015). We measured two tries with accuracy of 0.1s. Better try counts.

Standing long jump
Procedure of the standing long jump is described by Müller et al. (2015). We measured two tries with accuracy of 1cm. Better result counts.

Hurdles agility run – Boomerang test
Procedure of the hurdles agility run is described by Gonaus & Müller (2012). We measured two tries with accuracy of 0.1s. Each run started to opposite direction. Both runs counts together.

Twist test
Procedure of the twist test including incorrect execution is described by Vogt (2013). Test takes 60s. Only correct repetitions counts.

Jumping over the Swedish bench
Participant is jumping over the up side down Swedish bench for 45s. Number of jumps counts.

20 meter shuttle run – Beep test
Procedure of the 20 meter shuttle run - Beep test is described by Heikkinen (2003). The results are set according the evaluating table. Time and distance counts.

All fitness tests had been done within one day in the order shown above. Before the testing day intensity of the training had been reduced. There was enough time for a rest between tests. Before the final endurance test (beep test) there was a 30 minute break.

The results from individual fitness tests correlated with points for performance in alpine skiing disciplines (SL, GS, SG). Points for performance were retrieved from 9th list of points from junior alpine skiers in season 2018/2019.

Points for performance in alpine skiing are counted as described below:
$P = (Tx/To - 1) \times F$
P – points for performance in alpine skiing
Tx – time of a racer in seconds
To – time of a winner in seconds
F – constant for individual disciplines

Constant F is counted before the racing period for equalization of different disciplines.
Constant F for the season 2018/2019:
SL = 730. GS = 1010. SG = 1190.

Penalty points set the quality of particular race and are counted as described in guidelines for season 2018/2019 published by Czech ski association (SLČR OSÚ AD, 2018)

In our research we could either use one best result transferred in points counted together with the penalty points in each discipline or mean value from two best results transferred to points without penalty points. We decided for the second option.

- ***Statistical analysis***

All data were processed by software Statistica 13.2. Based on Kolmogorov – Smirnov test the data does not come from normal distribution. For setting the correlations (r) we used Spearman Rank Order Correlations (r = 0–0.1 = very small correlation; 0.1–0.3 = small correlation; 0.3–0.5 = medium correlation; 0.5–0.7 = high correlation; 0.7–0.9 = very high correlation; 0.9–1 = perfect correlation). We also mentioned the Effect size (r^2), which represents quantitative measure of the magnitude of phenomenon (r^2 = 0.1 = small; 0.3 = medium; 0.5 = large). Some correlations might be negative. It is due to a fact that better results in alpine skiing equal lower points for performance.

Results

In the tab. No. 1 and tab. No. 2 there are men´s, resp. women´s results from individual fitness tests. In the tab. No. 3 and tab. No. 4 there are correlations between men´s, resp. women´s individual fitness tests and points for performance in individual disciplines of alpine skiing.

In men´s category high correlation was found between SG and standing long jump ($r = -0.73$; $r^2 = 0.53$), between SG and hurdles agility test ($r = 0.62$, $r^2 = 0.38$) and between SG and shuttle run 4x10m ($r = 0.61$, $r^2 = 0.37$). Medium correlation was found between SG and twist test ($r = -0.34$, $r^2 = 0.12$), between SL and twist test ($r = -0.33$, $r^2 = 0.11$) and between SL and jumping over the Swedish bench ($r = -0.31$, $r^2 = 0.1$). In women´s category no high correlation was not found. Medium correlation was found between SL and jumping over the Swedish bench ($r = -0.31$, $r^2 = 0.1$). Very small correlation was found between SL and shuttle run 4 × 10m ($r = -0.05$, $r^2 = 0.0025$), between SG and standing long jump ($r = -0.03$, $r^2 = 0.0009$) and between GS and twist test ($r = 0.01$, $r^2 = 0.0001$).
Correlation is significant at the level $p < 0.05$.

In the tab. No. 5 correlation between men´s individual fitness tests can be seen. High correlation was found between Shuttle run 4x10m and standing long jump ($r = 0.67$, $r^2 = 0.45$) and between hurdles agility test and 20m shuttle run ($r = 0.62$, $r^2 = 0.38$). In the tab No. 6 there is correlation between women´s individual fitness tests. Very high correlation was found between 20m shuttle run and twist test ($r = 0.71$, $r^2 = 0.5$).
Correlation is significant at the level $p < 0.05$.

Table 1 *Results from the fitness test men*

Variable	Mean	Minimum	Maximum	Std. Dev.
Shuttle run 4 × 10m (s)	10,595	9,650	11,210	0,4154
Standing long jump (cm)	227,810	180,000	277,000	26,0127
Boomerang test (s)	24,510	22,160	27,160	1,4541
Twist test (n)	122,571	94,000	140,000	11,4262
Swedish bench jump (n)	86,381	60,000	104,000	9,7646
Beep test (m)	1818,095	1080,000	2460,000	339,5235

Table 2 *Results from the fitness test women*

Variable	Mean	Minimum	Maximum	Std. Dev.
Shuttle run 4 × 10m (s)	11,064	10,3900	11,710	0,4305
Standing long jump (cm)	214,238	185,0000	238,000	15,8868
Boomerang test (s)	25,909	23,5400	28,380	1,3540
Twist test (n)	112,286	93,0000	133,000	11,3408
Swedish bench jump (n)	84,524	62,0000	120,000	12,4363
Beep test (m)	1495,238	900,0000	2100,000	340,0532

Table 3 *Fitness test and race points men*

Variable	SL (p)	GS (p)	SG (p)
Shuttle run 4 × 10m (s)	-0,055213	-0,140955	-0,272166
Standing long jump (cm)	0,118908	0,101365	-0,038337
Boomerang test (s)	-0,154545	-0,110390	-0,214286
Twist test (n)	-0,095641	0,013012	-0,091737
Swedish bench jump (n)	-0,315963	-0,167428	-0,206516
Beep test (m)	-0,251462	-0,149448	-0,041585

Table 4 *Fitness test and race points women*

Variable	SL (p)	GS (p)	SG (p)
Shuttle run 4 × 10m (s)	0,562520	0,491718	0,614485
Standing long jump (cm)	-0,503251	-0,457738	-0,736021
Boomerang test (s)	0,577922	0,610390	0,627273
Twist test (n)	-0,339083	-0,602670	-0,342988
Swedish bench jump (n)	-0,312948	-0,546520	-0,520495
Beep test (m)	-0,506357	-0,566312	-0,517436

Table 5 *Correlation between individual tests from the fitness test men*

Variable	Shuttle run (s)	Standing long jump (cm)	Boomerang test (s)	Twist test (n)	Swedish bench jump (n)	Beep test (m)
Shuttle run 4 × 10m (s)	1,000000	-0,665366	0,583956	-0,255534	-0,399935	-0,573667
Standing long jump (cm)	-0,665366	1,000000	-0,436931	0,369502	0,548534	0,293639
Boomerang test (s)	0,583956	-0,436931	1,000000	-0,204361	-0,379311	-0,616491
Twist test (n)	-0,255534	0,369502	-0,204361	1,000000	0,499837	0,349772
Swedish bench jump (n)	-0,399935	0,548534	-0,379311	0,499837	1,000000	0,444336
Beep test (m)	-0,573667	0,293639	-0,616491	0,349772	0,444336	1,000000

Table 6 *Correlation between individual tests from the fitness test women*

Variable	Shuttle run (s)	Standing long jump (cm)	Boomerang test (s)	Twist test (n)	Swedish bench jump (n)	Beep test (m)
Shuttle run 4 × 10m (s)	1,000000	-0,125772	0,352712	-0,113245	-0,305312	-0,248294
Standing long jump (cm)	-0,125772	1,000000	-0,386615	0,057617	0,555739	0,083875
Boomerang test (s)	0,352712	-0,386615	1,000000	-0,084581	-0,296419	-0,447693
Twist test (n)	-0,113245	0,057617	-0,084581	1,000000	0,303525	0,708008
Swedish bench jump (n)	-0,305312	0,555739	-0,296419	0,303525	1,000000	0,408085
Beep test (m)	-0,248294	0,083875	-0,447693	0,708008	0,408085	1,000000

Discussion

Based on the results we can see very small correlations between alpine skiing disciplines and the twist test. Similar results were also found by Heikkinen (2003) with very small correlation between results from alpine skiing disciplines and sit-ups for one minute ($r = -0.05$; $r^2 = 0.0025$).

As a result of correlation between the twist test and the beep test in women´s category ($r = 0.71$, $r^2 = 0.5$) together with very small correlation between alpine skiing performance and the twist test we can say that the twist test is not useful for prediction of alpine skiing performance and can be replaced by the beep test.

We found different significance of correlations between men´s and women´s categories. In particular the different correlation between GS and standing long jump; SL/SG and shuttle run 4 × 10m. The different significance of correlations between alpine skiing performance and results from fitness testing at men´s and women´s categories were found also by Heikkinen (2003). In the research from Šuc et al. (2018) high correlation was found between alpine skiing performance and learning of new gymnastic figures in men´s category but very small correlation in women´s category. It might be useful to adjust fitness testing according to a gender of skiers for more accurate prediction of the alpine skiing performance.

Conclusion

Alpine skiing performance correlate the most with results of those fitness tests: standing long jump, boomerang test and shuttle run 4x10m. Very small correlation was found between alpine skiing performance and the twist test. Higher correlations were found in men´s categories. This difference between men and women might be caused by different development of motor skills at a certain age. Current results of our research consist of correlations between alpine skiing performance in the season 2018/2019 and results of only one measurement of the fitness of skiers. In the future we would like to repeat the fitness testing and verify it´s usability as a tool for prediction of an alpine skier´s performance and also for selection of skiers to the national alpine skiing team.

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A COMPARATIVE STUDY OF PRIMARY SCHOOL TEACHERS' ATTITUDES AND OPINIONS TOWARDS INCLUSIVE EDUCATION IN THE SOUTH MORAVIAN REGION AND SPLIT-DALMATIAN COUNTY

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Nikola Stračárová

Masaryk University, Faculty of sports studies, Brno, Czech Republic

ABSTRACT

The research is focused on teachers‘ approaches, opinions, and visions concerning inclusive education in the South Moravian Region and the Split-Dalmatian County. Further to that, it analyses the degree of Inclusion in these areas. The relationship of pedagogues towards Inclusion, due to a steep increase of specific disorders, is extremely important. The research was made in the year when the inclusive education bill was passed in the Czech Republic. Data was collected in the first school year when schools in Czech Republic functioned as inclusive. Data collection took place in Split-Dalmatian county in 2016 and the South Moravian Region in 2017. The research is qualitative, an open-question questionnaire was made, and a non-structured interview was made when visiting schools. We set the following hypotheses. We assume that teachers of selected schools of the Split-Dalmatia County evaluate Inclusion more negatively than teachers of selected primary schools in the South Moravian Region. This hypothesis is not confirmed. We expect that Inclusion will take place in selected elementary schools in the South Moravian Region more than in selected elementary schools in Split-Dalmatia County. This hypothesis is not confirmed. This research is based on the methodology and data from the diploma thesis of Nikola Stračárová 2017 (Stračárová, 2017).

Keywords: Inclusion; South Moravian Region; Split-Dalmatian County; primary school teachers; physical education; International Classification of Diseases and Related Health Problems

Introduction

The terms “Integration” and “Inclusion” are being used in the context of the taking in, integrating, and effective education of special needs students into society (Votavova, 2013). In the Czech Republic, in September 2017 a bill n. 27/2016 Sb., o vzdělávání žáků se speciálními vzdělávacími potřebami a žáků nadaných (MŠMT, 2016) came into effect, which made major changes to the approach of public education towards Inclusion. In Croatia, as of 15th June 2013 the Ministry for Science, Education and Sport issued a public appeal to raise interest in participation in the project „EU & EU Council joint project to support regional inclusive education “. Schools that took part were supposed to create a regional „Inclusive School Net“ for mutual learning and experience exchange, with the support of corresponding internet platforms and subsidies (Council of Europe and the European Union, 2013; Osnovna škola Okučani, 2013).

Aim

The goal of this work was to determine the teacher opinions and positions on Integration and Inclusion in selected areas.

Research questions

RQ 1: What is the current level of Integration and Inclusion at selected elementary schools in the Split-Dalmatia County and the South Moravian Region?

RQ 2: How do teachers from selected schools of the Split-Dalmatia County and the South Moravian Region view the current state of Integration and Inclusion?

RQ 3: What should the practise of Integration and Inclusion look like according the teachers from selected primary schools in the Split-Dalmatia County and the South Moravian Region in practice?

Hypotheses

H 1: We assume that teachers of selected elementary schools of the Split-Dalmatia County evaluate Integration and Inclusion more negatively than teachers of selected elementary schools in the South Moravian Region.

H 2: We expect that Integration and Inclusion will take place in higher extend selected elementary schools in the South Moravian Region more than in higher extent selected elementary schools in Split-Dalmatia County.

Methodology

Research sample

Our sample consisted of 12 addressed schools in Split-Dalmatian County – 12 female teachers; 14 addressed schools in the South Moravian Region – 12 female teachers, 2 males teachers. Teachers aged 25–45. Turnout in the South Moravian Region was 80%, in the Split-Dalmatian county 66.6%.

Inclusion criteria

Teachers who have been active in the education system for more than two years and who are not of pre-retirement or retirement age. The teachers were therefore 25–45 years old.

Methods

The research is qualitative, an open-question questionnaire was made, and a non-structured interview was made when visiting schools. The data was then analysed using content analysis. Data collection took place in Split-Dalmatian county in 2016 and the South Moravian Region in 2017. It was conducted in ordinary elementary schools. Special types of schools were not a part of the study field. After that, we analysed socio-politically economic conditions in each country, and we confronted them with the results from the questionnaires.

The questionnaire contained the following questions

1. How does Inclusion work at your school?
2. How many pupils are there in the classroom?
3. How many are integrated into one class? What are their disabilities?
4. Are integrated pupils involved in PE?
5. How do they get involved?

6. Are they rated as other children? If not, how do you rate them?
7. How do other children treat these children?
8. Do you think this system of Inclusion is beneficial? Why?
9. What is the best way to integrate?

Evaluation method

The text analysis method was a content analysis of text documents. It applies to all research procedures in which written word is used (analysis of questionnaires, interview transcripts, observation protocols, etc.). Analogous to the content analysis of the verbal aspect of the text, there is also an analysis of non-verbal products-pictures, diagrams, graphs, etc. (Gavora, 2010)

Results

In Czech (tested) schools, individual Integration takes place, two schools stated they have no integrated students. In Split-Dalmatian schools, on the other hand, is Integration both individual and group-based, that takes place in all schools.

In selected Czech schools, there is a lower average pupil per class rate, but higher Integration rate (per class). Integrated students in selected schools in SDA are much more active in PE than the Czech ones.

Only 25% of the pedagogues think the system on their schools is beneficial. 50% of the pedagogue are convinced it is not. In Croatian schools, 60% of pedagogues are convinced the system on their schools is beneficial, only 20% think otherwise.

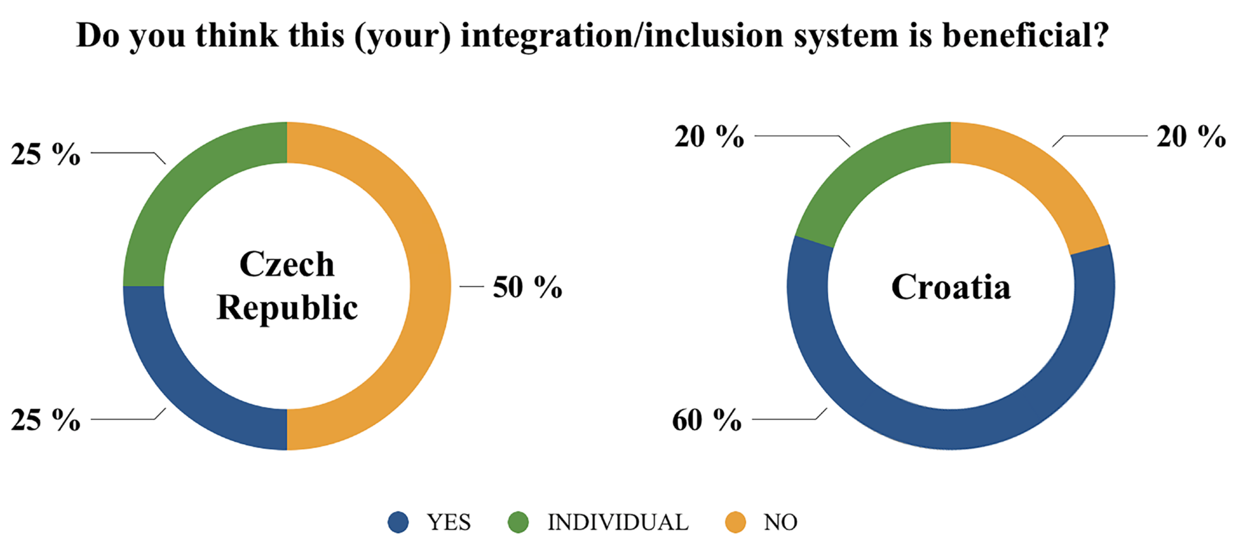

Figure 1 *Benefits of Inclusion system*

Pedagogues support segregation at 50% of the South Moravian tested schools. Another 30% support individual assessment of individual cases. Only 8% support individual classrooms in schools, where it's likely that they aren't much informed on this topic. In the Split-Dalmatian County, 40% support special classrooms in ordinary schools, 40% support Integration in regular classrooms.

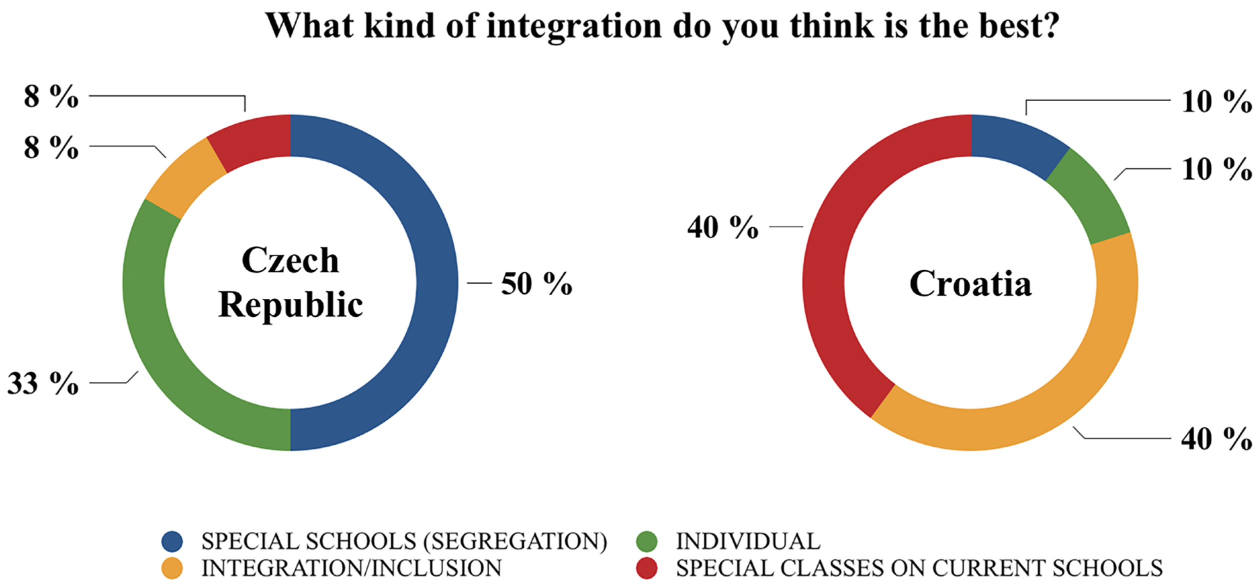

Figure 2 *Kinds of Inclusion system*

Discussion

Why are they more positive about Inclusion in Croatia? Here are some of the supposed reasons.

Employment

There is a higher unemployment rate in Croatia than in the Czech Republic. (11.3% versus 3.4%; reported by Eurostat 2017) In Brno in January 2017 it is 6.6% in Split in March 2017 it is 41.6%.

We assume that teachers, like other employees, appreciate any job more. In selected South Moravian schools, teachers were dissatisfied with the increase in administration for the same money, some were tired and burnt out, and in Croatia we did not meet similar complaints.

Table 1 *Unemployment in chosen countries (Eurostat 2017)*

	South Moravian Region	Split-Dalmatian County
Unemployment	3,40 %	11,30 %
	Brno	Split
Unemployment	6,60 %	41,60 %

Higher salary

The salaries of teachers in Croatia in 2015–2017 are higher than the average salaries of teachers in the Czech Republic. (Krémó, Piedrafita Tremosa, & Davydovskaia, 2016) We assume that if in a country with lower quality of life the same position receives higher salary, then the teachers are more open to innovations and, subsequently, inclusion.

Table 2 *Salary in chosen countries (Krémó, Piedrafita Tremosa, & Davydovskaia, 2016)*

Salaries	Czech Republic	Croatia
ISCED 1	9 238–12 174 €	9 051–13 378 €
ISCED 2	9 238–12 174 €	9 051–15 270 €
ISCED 3	9 238–12 174 €	9 051–15 270 €

Longer holidays

There are longer school holidays in Croatia. In contrast to the 90 days of school holidays that are enacted in our country, Croatian children and their teachers rest 25 days longer. Besides, holidays are grouped into larger units, which contributes to better rest.

Table 3 *Holidays in chosen countries (Kalendar tekuće školske godine 2015; Organizace školního roku 2016/2017)*

Croatia (2017)	
National holiday	14 days
Christmas holidays	12 days (17.12–11.1)
Easter holidays	6 days (13.4–21.4.)
Summer Holidays	82 days (14.6–5.9)
Total	**114 days**
Czech Republic (2017)	
National Holidays	14 days
Autumn holiday	2 days (26.10–27.10.
Midyear holiday	1. day (3. 2.)
Christmas holidays	6 days (23.12.–2.1.)
Spring Break	5 days (12. 3.–18. 3.)
Easter holidays	2 days (13.4–14.4)
Summer holiday	62 days (2.7.–3.9.)
Total	**90 days**

Greater religiosity, southern family

In Croatia, religion is taught in all schools. There are 67% of active believers in Croatia and 19% in the Czech Republic. Families more adhere to tradition, focus less on their careers and entertainment, spending more time together. This is based, inter alia, on the historical division of Europe by the Hajnal line into states of the northwest and southeast (Massimo 1999). According to this division, family access differs in countries above the line (northern and western Europe) and below the line (eastern and southern Europe). In the south, the family structure is strengthened, people live in multi-generation families and take care of all their members. This general awareness is reflected in the relationship of the young to the sick and disabled, taking them as part of their lives. In the Czech Republic, the model of a smaller single-generation family is preferred, people enter bonds later, often live unmarried, with an emphasis on the economy and social application. Here I see the reason for the increased number of pupils with learning disabilities, the increase in the number of children diagnosed, the increase in the number of these students in secondary schools. Parents want children to finish their education, preferably high school and if there is any problem at school, they do not oppose visits to counselling facilities.

Table 4 *Religiosity (Social values, Science and Technology 2005)*

Croatia	67 %
Czech Republic	19 %

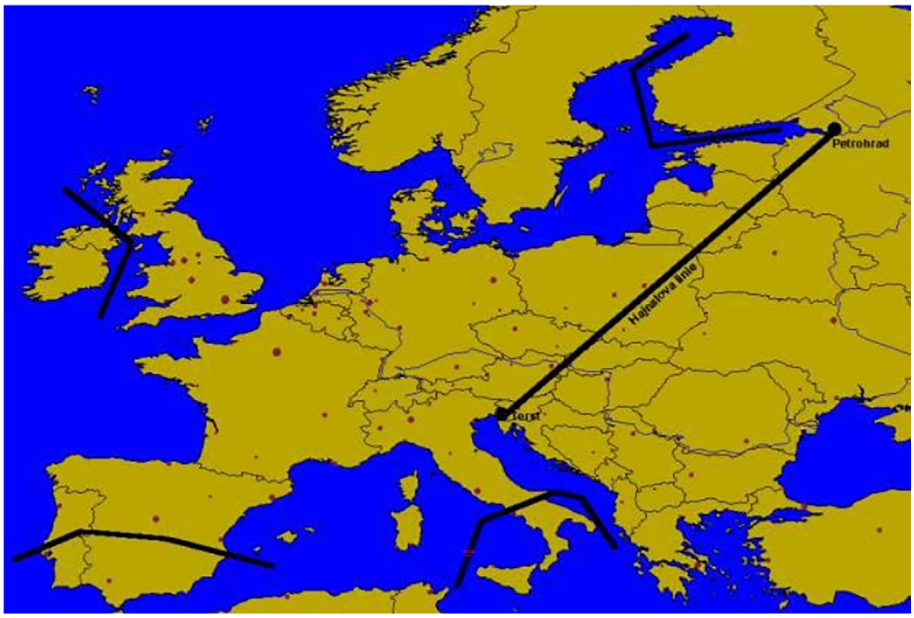

Figure 3 *Hajnal line (Livi-Bacci, Massimo: The population of Europe: a history 1999)*

Conclusion

Determined facts are in my opinion a probe into the Czech pedagogues ‘mentality. Split-Dalmatian County, where the system is running without larger problems for a considerable time now, I only took as a comparative sample and I wondered, why the opinions are so different here. Bad awareness about the issue between professionals surprised me greatly and I think that awareness betterment is pivotal in a change of Czech pedagogues ‘attitude towards the given issue.

By analysing the answers from the questionnaires, I can answer the research questions and confirm or refute my hypotheses.

RQ 1: What is the current level of Integration and Inclusion at selected elementary schools in the Split-Dalmatia County and the South Moravian Region?

In the tested schools in the Czech Republic, individual Integration takes place, two schools said that they do not have anyone integrated. In the schools of Split-Dalmatia County, in contrast to the previous one, Integration is individual and group-based, at all schools. But they don’t use the word Inclusion, they only use the word Integration. In selected Czech schools, there was a lower average number of children in the classroom, but a higher number of integrated children (per class). Over the last two years, the number of pupils with specific learning disabilities in the Czech Republic has doubled, so these disabilities ranked first among the handicaps of integrated pupils. In the tested Croatian schools, it was reduced intelligence and physical disability. Integrated children were much more involved in physical education lessons there than children in tested Czech schools.

RQ 2: How do teachers from selected schools of the Split-Dalmatia County and the South Moravian Region view the current state of Integration and Inclusion?

In South Moravian Region, only 25% of teachers think the system is beneficial in their schools. 50% believe that it is not beneficial. In Croatia, the ratio is 60% to 20%.

RQ 3: What are the teachers 'idea about Integration and Inclusion in selected schools in Split-Dalmatia County and South Moravian Region in practice?

In 50% of the tested South Moravian schools, teachers are in favour of segregation and another 30% of teachers are for individual assessment of individual cases. (However, each case is assessed individually, if teachers consider individual assessment as a separate category, I am not quite sure if they understood the amendment to the law well). Only 8% are in favour of individual classes in schools, and it is also likely that they are not well informed about this individuality. In the Split-Dalmatia County, on the other hand, 40% is for special classes in mainstream schools, 40% is for Integration into classes.

Furthermore, I set the following hypotheses forth:

H 1: We assume that teachers of selected schools of the Split-Dalmatia County evaluate Integration and Inclusion more negatively than teachers of selected primary schools in the South Moravian Region.

This hypothesis is not confirmed. I assumed that because of the inferior material equipment and the smaller space available in selected schools, the view of the Inclusion of disabled people would be more negative. But the reality was the opposite, opinions in selected Croatian schools were more positive.

H 2: We expect that Integration and Inclusion will take place in selected elementary schools in the South Moravian Region more than in selected elementary schools in Split-Dalmatia County.

This hypothesis is not confirmed. In the Croatian schools tested there was no school without an integrated pupil, although by law in Croatia the headteacher may refuse a child for Integration. In the South Moravian Region, on the other hand, 16.5% of the schools tested had no integrated pupil.

In the Split-Dalmatia County, where the system has been running without major problems for a long time, the relationship of teachers to Inclusion is very good. In our country, despite the steep rise in specific learning disabilities, awareness of the problem is poor, so I think that improving awareness is crucial in changing the attitude of Czech educators to Inclusion.

Limits

The studied sample is not representative. It would be appropriate to further continue in the research and address a larger number of schools. We assume that the situation will change due to a longer distance from the approved amendments.

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Contact Information:

Mgr. Nikola Stračárová

Email: 392489@mail.muni.cz

Tel:+420 603 377 000

EFFECT OF RESISTANCE TRAINING IN CHILDREN WHO ARE OVERWEIGHT OR OBESE – PILOT STUDY

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Kateřina Strašilová, Petr Vajda, Tomáš Hlinský

Faculty of sport studies, Masaryk University, Brno, Czech Republic

ABSTRACT

Overweight and obese children often suffer for many physiological and psychological issues. Resistance training allows them to excel over their peers due to strength ability which is related to their somatotype. The aim of this study was to examine the effect of an eight-week resistance training program on body composition in overweight and obese children. Study sample included 8 boys and 4 girls (age = 11.7 ± 1.54) who were involved in an eight-week strength specifically designed program consisted of two strength training unit per week. Resistance of exercise was set on 8–10 RM. Body composition were measured by InBody 720 two times before and after the training intervention. The Wilcoxon matched pairs test was used. Results showed increase in total body weight (2.7%), lean body mass (2.5%) and fat mass (3.7%). This effect indicates that used resistance training program is sufficient to lean body mass grow. Nevertheless, program proved to be inadequate to avoid an increase in fat mass. This could be caused by many factors which should be consider in further research (e.g. longer technique practice, diet, number of training units).

Keywords: Exercise; youth; obesity; strength training.

Introduction

Previous research has established that child obesity is a growing problem that is becoming global. According to Lobstein, Baur and Uauy (2004), there is an increase in childhood obesity annually by 0.5% in Brazil and the US, while in Europe, Canada, and Australia, this is up to 1% annually. This rapid increase in the incidence of childhood obesity in a relatively stable population, suggests that genetic predisposition will not be its primary cause. For instance, in Australia, 20-25% of children aged 2–18 are overweight or obese, and there are 22 million children with the same issue under the age of five worldwide Dias et al. (2015). Lobstein et al. (2004) maintain that it is not yet possible to estimate the extent of the burden on health services that the ever-increasing proportion of obese children will bring in the future. In addition to current problems, typical obese children are more prone to illnesses such as hyperinsulinemia, decreased glucose tolerance, increased risk of type 2 diabetes, hypertension, sleep apnoea, social exclusion, and depression. The increased incidence of childhood obesity will bring a significant increase in health problems to the future generation of adults. There is a risk of widespread heart disease, diabetes, some types of cancers, gallbladder disease, osteoarthritis, endocrine disorders, and other obesity-related conditions. Schonfeld-Warden & Warden (1997) states, that up to 80% of people with obesity in childhood are obese even in adulthood. In the industrialized countries, the most vulnerable group is children from low-income families, where the possibilities of physical activity and good eating habits are limited (Lobstein et al., 2004).

Children suffering from obesity are often encouraged to do aerobic activities. Commonly recommended activities for these children include; walking, jogging, skating, cycling, or dancing, 3-5 times a week with the medium to sub-maximum intensity and duration more than 1 hour (Daniels et al., 2005). However, the success of aerobic programs is very low. Overweight or obese children rarely achieve success compared to other ones, and exercise is often very difficult for them. As a combination of these two factors produce insufficient positive psychological or physiological effect of physical activity, they frequently lose interest in it (Schranz et al., 2013; Smith et al., 2014).

Resistance training seems to be an activity that gives these children a certain advantage over other children in terms of the possibility of success. Children who are overweight or obese have greater body weight and muscle mass and therefore greater strength. As a result, they can experience more success during exercise and perform better than other children (McGuigan et al., 2009).

The benefits of strength training for overweight and obese children include the development of muscle strength and endurance, and an increase in bone density and active muscle mass leading to positive change in body composition and improvements in blood lipid profile and a decrease in blood pressure (Kim, 2010; Lee et al., 2012; McGuigan et al., 2009; Shaibi et al., 2006). Resistance training positively affects the children's psyche and mental health of athletes, increases their self-confidence and self-efficacy and improves body image (Council on Sports Medicine and Fitness, 2008; McGuigan et al., 2009; Schranz et al., 2013).

Despite the growing popularity of strength training and the increasing number of studies recommending this type of training for overweight and obese children, only a few of them deal with the effect of strength training on body composition (several studies investigated combination of strength training with aerobic intervention or diet modification ((Dietz et al., 2012; Schranz et al., 2013)). The purpose of this study is to determine the efficacy of an 8-week resistance training program using multiple-joint exercises on body composition in children who were overweight and obese.

Methods

Twelve overweight and obese children (4 girls and 8 boys) in age on pre-measurement day = 11.7 ± 1.54 years were involved in this study. Anthropometric values were recorded during the initial measurement (mean body weight = 68.1 ± 20.7, mean body height = 156.0 ± 12.2 and mean BMI index = 27.5 ± 5.5). There were no limitations in physical activity for health reasons for any of the children. The influence of eight-week strength training was evaluated in this study. Strength training took place two times per week (always the second and fourth day of the week) at the same time in the afternoon. Each training session consisted of 10 minutes general warm-up, 3 sets of 8RM (excepted abdominal muscles exercise) and 10 minutes of cool down and final evaluation. The exercise training program was in circuit style and included squat, bench press, sit-up, pull-down, leg press and exercises for core strength and stability. One training session lasted 60 minutes.
Introductory training preceded resistance training for four weeks (two sessions per week). During this time, all subjects were taught the proper technique and maximum strength testing. (maximum strength testing were according 1-RM protocol excepted bench press and leg press. There were used testing on level 5-RM according to the same protocol and 1-RM were determined by calculation for safety reasons). Anthropometric and body composition measures (InBody 720) were done before and after the eight-week strength session. There were two measures for one week in the same time period. Mean values were used for results interpretation.

Maximum strength testing

All subjects completed 4 weeks of proper technique training. Maximum strength was tested according to the 1-RM protocol, where the correct technique is a necessary prerequisite for carrying out the test. The 1-RM value was recorded the resistance where children could be able to do throughout the full range of motion and with the correct technique just once. They started with 10 minutes of general warm-up, followed two series with 10 repetitions with 50% of the expected maximum. Finally, a series of single repetitions with increasing loads were done. In case that weight was lifted with proper technique, in full range of motion and disruption of tempo the weight was increased by approximately 0.5–2.3 kg followed by 2 minutes of rest. This was followed by another series of single repetition until the child was no longer able to meet all the criteria. Strength testing was supervised by a specialist instructor, with the instructor to subject ratio 1:1. Communication was positive, and the resistance was added based on the individual feeling of the children without external pressure. The children themselves determined whether they were able to increase the resistance (Faigenbaum, Milliken, & Westcott, 2003).

Statistical Analyses

Statistical analyses were performed using SPSS software (IBM SPSS Statistics 25 for Windows; SPSS, Inc., Chicago, IL). Data did not come from a normal distribution. The Wilcoxon Signed Ranks Test was used for evaluating the effects of the intervention. The criterion alpha level for significance was set at $p \leq 0.05$. Pre and post values were evaluated also by percentage evaluation and graphical method due to the small number of cases.

Results

12 overweight and obese children (4 girls and 8 boys) were involved in eight weeks of strength training sessions. Anthropometric values and body composition by InBody 720 were measured two times before (pre-value) and after (post-value) intervention. The mean values from both measurements are in table 1, for the whole sample, girls and boys separately.

Table 1 *Pre and post intervention means ±SD*

Mean ± SD	Age	Height (cm)		Weight (kg)		Lean body mass (kg)		Fat mass (kg)		BMI	
	pre	pre	post	pre	post	pre	post	pre	post	pre	post
Total (n=12)	11.7 ± 1.6	156.0 ± 12.2	156.3 ± 12.1	68.1 ± 20.7	69.9 ± 21.9	21.8 ± 5.7	22.4 ± 6.1	27.8 ± 12.4	28.8 ± 12.9	27.5 ± 5.5	28.2 ± 6.7
Girls (n=4)	10.3 ± 1.4	148.3 ± 11.8	148.5 ± 11.4	61.8 ± 16.9	62.9 ± 4.1	18.6 ± 4.1	18.8 ± 4.1	27.5 ± 10.7	28.2 ± 10.6	27.7 ± 5.4	28.3 ± 5.2
Boys (n=8)	12.5 ± 1.2	159.9 ± 11.1	160.3 ± 11.1	71.3 ± 22.8	21.9 ± 5.1	23.5 ± 5.9	24.3 ± 6.3	28.0 ± 13.9	29.0 ± 14.6	27.4 ± 5.9	28.1 ± 6.2

There was an increase for the whole sample for body weight 2.7 % ($p = 0.005$), for lean body mass 2.5% ($p = 0.004$) but also for body fat 3.7% ($p = 0.013$) and for BMI 2.5% ($p = 0.005$). If the girls and boys were explored separately the trend remained the same but its power was different. More obvious changes were observed in boys. Body weight increased about 2.9 % ($p = 0.017$), lean body mass about 3.2% ($p = 0.012$) but also there was enhancement of bodyfat about 4.3% ($p=0.05$) and BMI about 2.7% ($p = 0.017$). An increase in girls was found by 2.0%, $p = 0.15$; 2.1%, $p = 0.19$; 2.6%, $p = 0.19$ and 2.0%, $p = 0.14$ for body weight, lean body mass, body fat and BMI, respectively. The changes in the body proportion components are visible in figure 1–4.

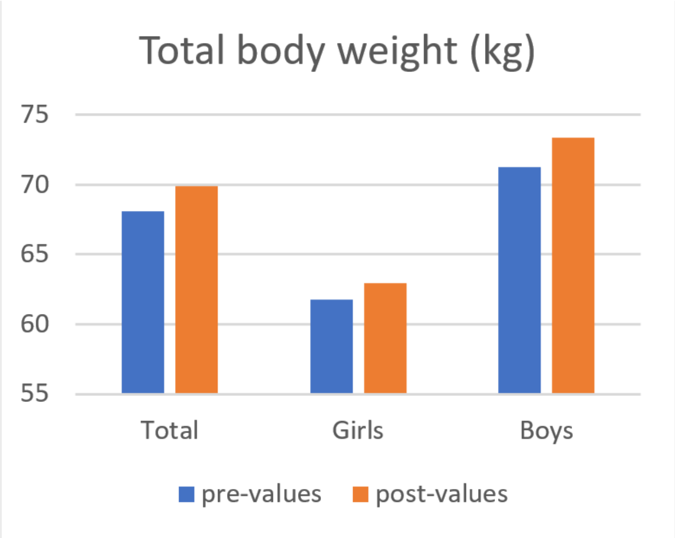

Figure 1 *Changes in total body weight*

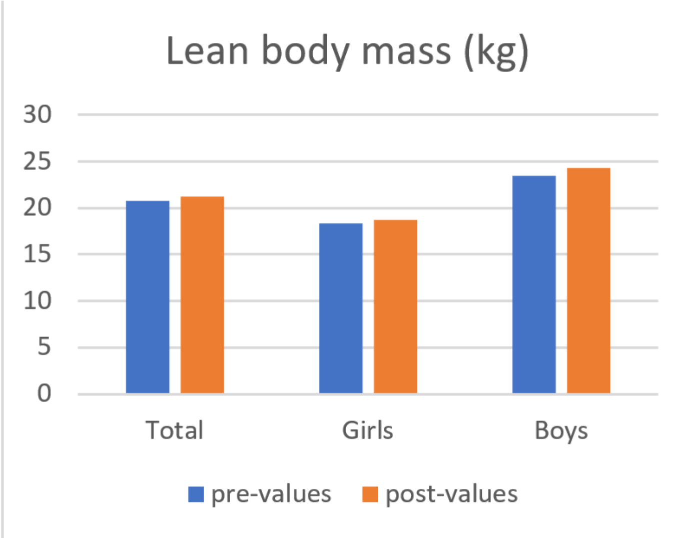

Figure 2 *Changes in lean body mass*

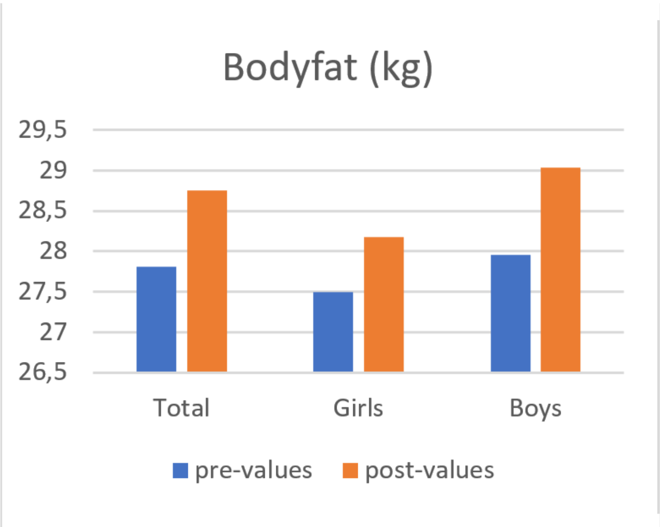

Figure 3 *Changes in bodyfat*

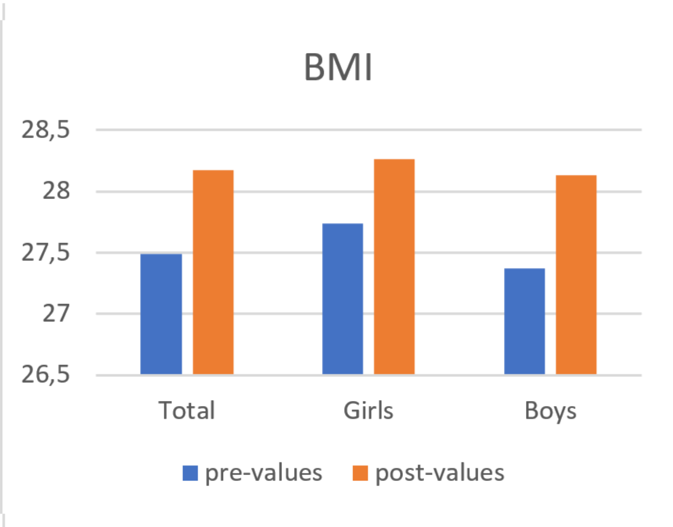

Figure 4 *Changes in BMI*

Discussion

The results suggest that strength training can significantly affect muscle mass in overweight and obese children. The positive effect was detected in both girls and boys, but more significantly in boys. This difference corroborates with earlier findings which showed that the effect is smaller in samples consist of girls only or children of prepubescent age (Shaibi et al., 2006). There was an increase of 2.5% for the whole group and 3.2% and 2.1% for boys and girls in our study. These results correspond to a previous study which showed an increase of 2.4% in mixed group (Yu et al., 2005). Active muscle mass growth can be beneficial for children who are overweight and obese due to increased basal metabolism affecting all-day energy expenditure.

Along with the increase in muscle mass, an increase in muscle strength is often described (Faigenbaum et al., 2003). In many cases it is not associated with muscle hypertrophy (lack of circulating androgens in pre-pubertal children), but with neuromuscular adaptation (especially increased motor unit activation, improved motor skills, and development of intra-muscular and inter-muscular coordination). According to Guy and Micheli (2001), the increase in strength due to these aspects is described in children up to several tens of percent after 8–10 weeks of strength training. We assume, that because of the great improvement in strength caused by neuromuscular adaptation, insufficient stimulation may occur during the intervention. The resistance was set to 8RM in our study. The 1RM was tested for each child and 8 training units (60 min) focused on the development of correct technique preceded resistance training. Despite that, most children have to increase their resistance after 3–4 weeks of research to meet 8RM. The average of such an increase ranged from 15–25% depending on the exercise (more distinctly for lower limbs). The validity and reliability of the 1RM test in this group of children may also be a possible cause. Although the Test-retest reliability after six weeks for the group of 32 girls and 64 boys between 6.2 and 12.3 years reached 0.93–0.98 (Faigenbaum et al., 2003). But it is possible that children who are overweight or obese may have a reduced degree of frustration tolerance because of their lack of experience with physical activity. This may affect the ability of children to perform the test to the maximum.

BMI and body weight raised for both boys (BMI = 2.7%; BW = 2,7%) and girls (BMI = 2%; BW = 2%). Aside from the increase of muscle mass, the body fat grew too (the whole sample by 3.7%, boys by 4.3% and girls by 2.6%). This result is uncommon as the changes in BMI and body fat are usually described as small (e.g. Yu et al., 2005). Also, review results Schranz et al. (2013) show that strength training has a small effect on body composition and fat loss, but a high effect on muscle strength. In contrast, McGuigan et al. (2009) reported that due to an 8–week strength training with a resistance level of 10–15 RM, some children lost about 7% of their fat mass. Lee et al. (2012) describe the loss in mean body fat of 3.5% in 45 obese boys as a result of three months of resistance training (8–12RM). It could be explained by using design with 3 training units per week or the fact that we decided to include abdominal muscle and core exercise with the absence of external resistance. While the lean body mass in our developed in all children (range 2.7–4.7%) except for one girl, the body fat changes were more variable. Three children experienced a decrease of 3.6–0.5%, six children had an increase of 0.7–4.5% and three children had an increase of 7.0–15.5%. This discrepancy between studies could point to the insufficiency of two training units per week. What more McGuigan et al. (2009) tested 8 exercises in three series with resistance size 8–15RM.

Sufficiency of using BMI evaluation for the resistance training intervention is questionable. Changes in body components are often not reflected in the BMI (McGuigan et al., 2009). We use InBody 720 to better assess the changes in the ratio of the individual body components. Notwithstanding that the measurement of bioimpedance analysis was held at the same time of the day, the condition was not all the same as the children were not on an empty stomach. We reduced this limitation by the doubled measurement and using average. Despite this, some values could be affected by food intake before the test. McGuigan et al. (2009) believe that Dual-energy X-ray absorptiometry appears to be the most reliable and valid method for measuring body composition changes. Absence of the control group did not allow to fully separate the effect of the intervention from the ontogenic body development. An additional uncontrolled factor is increase in strength during the intervention due to concerns with maximal strength testing for free-weight exercises in this population.

Conclusion

At the practical application level, we can say that short-term resistance training can significantly improve lean body mass in children who are overweight and obese. This type of training is well accepted by children and it seems they enjoy it. Regarding the effectiveness of strength sessions for body fat loss, training two times per week appear to be inadequate. However, this is difficult to evaluate. There are not many studies that use strength training twice per week or compare the efficiency of a different number of training sessions per week. Also, maximum strength testing and exercise resistance estimating seems to be problematic in this group of children. Future research should focus on finding the most appropriate strength training design to reduce children's overweight and obesity.

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