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CONTENT

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CORRELATION OF SPECIFIC COORDINATION BY YOUNG FEMALE VOLLEYBALL PLAYERS AND PERFORMANCE LEVEL OF TECHNICAL ELEMENTS IN VOLLEYBALL

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SUMMARY

In a study with transversal character participated 40 female volleyball players, selected by clearly defined critiques. The tests that were conducted are from the domain of specific volleyball coordination (predictors) and the precision of playing a ball with "bump" (criteria). The aim is to examine the relationship of predictors on the criterion variables and on that way create a precondition for predicting the level of precision of the female volleyball players.

The female volleyball players have shown that they coordinating skills are statistically significant at the test shooting horizontal target with "bump" (ČEHOR). In the test shooting vertical target with "bump" (ČEVER) they showed up two types of coordination, coordination in space and coordination by the volleyball net, while in the third test, shooting horizontal target with "bump" in position 2 (ČEPOZ2), as significant have shown coordination by the volleyball net and one-handed juggling ball through the hoop.

The importance and complexity of coordination in this and similar transversal research is evident, so the conclusion is that there is an relationship specific coordinative abilities with the correct performance of volleyball techniques and that latent factors, who have determined the coordinating ability of the female volleyball players can act independently, but also depend on each other. Without a doubt, without a well coordinated volleyball player, we can not expect efficient performance of the set technical-tactical structures in the volleyball game.

Key words: volleyball, coordination, precision.

INTRODUCTION

Volleyball is a sport activity that has a many different movements of the players. It's clear that, to perform these such demanding movments, learning of new movements and for rapid change of one movement with another (Drabik, 1996), coordination is the unavoidable factor for success of one volleyball player. For coordination abilities it says that they are a form of motor intelligence because during the game it participates, more or less, in all the movments and activities (anticipating the ball trajectory, time alignment of the movement to the ball (timing), observation of a player's and opponents' movement, high time pressure during the transition period of defense and attack, feeling for the ball at service reception, blocking, and precise addition, spiking or serving). There is no doubt that its multidimensionality and complexity requires a clear definition of factors, with latent character, which can even be universal for this motor ability. Complexity of this motor skills has been established long time ago. Previous research (Verstegen & Marcello, 2001; Stein, Simonidis, Seemann & Schwameder, 2010; Idrizović, 2011; Karamatić, Vuljanić & Peršun, 2011; Macner, 2011; Njaradi, 2011; Tomljanović, Krespi & Bešlija, 2011; Vučetić, Sukreški & Zuber, 2011; Urgesi, Savonitto, Fabbro & Aglioti, 2012; Milanović, Šalaj & Gregov, 2012; Yasumitsu & Nogawa, 2013; Button, Wheat & Lamb, 2014; Pion, Fransen, Deprez, Segers, Vaeyen, Philippaerts & Lenoir, 2015; Šimonek, 1998; 2006; 2009; 2014; 2016) largely confirm the assumption that coordination, among other things, implies the precision of performing the task, *rhythmicity* (performing movable operations precisely at certain spatial and temporal intervals), *balance* (ability to maintain a stable position in dynamic motion structures), *reaction ability, kinesthetic differentiation* (use adequate amounts of power for a particular movement), *orientation in space* (ability to customize one's own body or part of body in space), the economyness of movement as well as the synchronization of movement in time. Therefore, because of the many varied, technically demanding, complicated and untypical movements in volleyball game, we can rightly talk about two key factors for success: specific coordination associated with ball handling skills and special volleyball precision.

In order to test the correlation of predictive variables of specific coordination ability of the female volleyball players with the level of playing/adding a ball with forearm[1], as a system of criterion variables, was conducted a research of transversal character.

Based on the results test of specific coordinating abilities, and the results test of the technique playing or adding a ball with forearms, the basic premise is that it will be possible to predict the level of precision of the female volleyball players.

So whatever it is, general, specific or situational coordination, the research has shown the essence of this ability: the proper relationship of established latent factors as parts of the whole, that give effective results.

METHOD

The sample consisted of 40 female volleyball players. The criteria for the selection of subjects are: (1) Subjects used as a sample were 14 to 16 years of age (± 6 months); (2) that they are active members of the volleyball teams from Republika Srpska; (3) that they actively train volleyball for at least 2 to 4 years; (4) that they actively participate in the realization of the training; (5) that training plan provides load of 5 per week for all subjects, with a duration 1 training 90-120 minutes; (6) that all subjects were underwent to a medical examination and they are healthy. Before starting the measurement, it is verified whether the accuracy of the instrument, and if necessary adjusted. According to the research tasks set, they are secured technical conditions to get the most accurate results. (1) measurement was done during the morning (8 AM to 14 PM); (2) instruments of standard manufacturing and they were controlled before and after the 10 subjects; (3) the subjects were tested in a sports hall that is sufficiently spacious and illuminated. The temperature is such that the subjects feel comfortable (according to the Rules of volleybal from 16° to 25°); (4) all measurements were performed by two or three measurer, and each of them carried out the same measurements; (5) the subjects were in the sports equipment and (6) the results measurement are read at the end of each task, and a person who registered it for control purposes, loudly was repeated the results before being enrolled in protocol of subjects.

[1] Later on in the text it is used the term ‘’bump’’.

Tests were selected from previously conducted research (Strahonja, Janković & Šnajder, 1982; Strahonja & Janković, 1988; Marelić, Đurković & Rešetar, 2007; Karalić, 2010; Stojanović, N., Stojanović, T., Stojanović, D., Herodek & Jurko, 2014).

Motor tests sample - Specific coordination abilities, Independent variables:

1. **One-hand juggling a ball through a hoop (ŽONG)**

   The aim: I's measured a skill of shooting a target. Task: A volleyball player stands in volleyball stance below the target, he tosses the ball with one hand, strikes the the fist (or with a taut palm) and trying to shoot the frame of the hoop. When the ball pass through the hoop or around hoop, he trying with the other hand to shoot the frame. Time of test performance is 20 seconds. If the subject accidentally drop a ball, takes another ball and continue the task. Final score: sum of the total number of hits.

2. **Test coordination by the volleyball net (KOOMRE)**

   The aim: I's measured a coordination ability of volleyball player. Task: A volleyball player stands in volleyball stance in front of the net. He jumped up and raised his hands to block (in jump raised fists above the upper edge of the net), lands and do collet to the back, on line of attack, he lay on his stomach, with the technique of rolling turned to 360 º back to stomach, then he turned itself to the net, and jumps to spike to hit the ball with the fist that the assistant keeps over the net. The stopwatch is turned off when the volleyball player hit the ball, that the assistant keeps over the net. Final score: to the achieved time edds by one second for every made mistakes (touch of net in the block, spike, awkwardly coasting and rolling).

3. **Test coordination in space (KOOPRO)**

   The aim: I's measured a coordination ability of volleyball player. Task: A volleyball player fit in volleyball stance position in front the left line of the square. Jump 3 times by this line to come to the next line, with three jumps with right and left foot run across the line so that with right foot reflects on the right and with the left foot the left side of the line, and coming to the end of his back turned with 6 jumps of backward came back to the fourth line then with 3 crossed steps pass over the fourth line. Final score: to the achieved time edds by one second for every made mistakes (larger or smaller number of jumps, rough distortion of direction in relation to the line.

4. **Hexagon test (HEKS)**

   The aim: I's measured a coordination ability of volleyball player and and agility. Task: A volleyball player stands in volleyball stance in the middle of hexagon. Volleyball player is turned with face toward to the line A, during a skipping over all lines. Then jump out over B, and go back to the middle. So skip all lines in the order C, D, E, F, A. Volleyball player must make three rounds, then the stopwatch stops. Final score: it takes the best time in three attempts.

Motor tests sample - Precision of plaing balls with "bump", dependent variables:

1. **Shooting the horizontal target with the "bump" (ČEHOR)**

   The aim: I's measured a shooting with 'bump" a target that is horizontally placed. Task: A volleyball player stands in volleyball stance upright in relation to the target at a distance of 3 m, takes the ball, tosses them and with 'bump" trying to shoot the middle of the ring. Final score: sum of the total number of points from 10 attempts.

2. **Shooting the target in the horizontal plane from position 2 (ČEPOZ2)**

   The aim: I's measured a shooting with 'bump" a target that is horizontally placed in position 2. Task: A volleyball player stands in volleyball stance in position 6, 1 m behind the line of attack. Horizontal target is set in the middle of position 2 (1.5m from the net and the right side of the lateral line). The feeder is in the middle of position 1 (3 m behind the line of attack, and the right side of the lateral the line). The feeder throws the balls in the direction of receiver who tried that with "bump" shoot the target in position 2. Final score: sum of the total number of points from 10 attempts.

3. **Shooting the vertcal target with "bump" (ČEVER)**

   The aim: I's measured a shooting with 'bump" a target that is vertically placed. Task: A volleyball player stands in volleyball stance upright in relation to the target at a distance of 3 m, takes the ball, tosses them and with 'bump" trying to shoot the middle of the ring. Final score: sum of the total number of points from 10 attempts.

In order to determine the nature of relationships and prediction efficiency of shooting horizontal and vertical target with "bump" on the basis of indicators specific coordination in volleyball, a multiple linear regression analysis was applied. From the domain of discriminative analysis, the ANOVA variance analysis was used to check the correlation level (one or more) on the variability of a given phenomenon.

RESULTS

Table 1. shows the descriptive statistics for a set of dependent and independent variables. According to the present parameter values, distribution of the results for the total sample volleyball players (n=40) is generally in the range of normality, which indicates the homogeneity of the sample of individuals, which provided further processing of data.

Table 1. Basic statistical parameters for a set of dependent and independent variables

	The basic statistical parameters					
	N	**Mean**	**Min.**	**Max.**	**Std.Dev.**	**KS**
ČEHOR	40	6.85	5.00	9.00	1.10	0.18
ČEVER	40	8.28	6.00	11.00	1.18	0.21
ČEPOZ2	40	7.00	5.00	10.00	1.30	0.42
ŽONG	40	9.73	7.00	15.00	1.99	0.47
KOOMRE	40	7.57	6.27	8.66	0.55	0.94
KOOPRO	40	9.54	8.92	10.70	0.42	0.52
HEKSA	40	25.18	24.12	26.71	0.51	0.55

In table 2 the value of multiple correlation coefficient between the dependent variable Shooting the horizontal target with the "bump" (ČEHOR) and system variables specific coordinative skills is **R =0.46** which points to significant correlation between the observed systems. The correlation is also statistically significant at **p = 0.001** (Table 2a). The results were obtained based on the degrees of freedom $\mathbf{df_1 = 2}$ and $\mathbf{df_2 = 37}$ and limit values for the F-test. For the statistically significant values accepted are those whose (limit) value of F-test was greater or equal to **3.23** at the significance level of **p = 0.05.** The resulting value of $\mathbf{R^2 = 0.1929}$ suggests that 19.29% of the total variability of the results of Shooting the horizontal target with the "bump" (ČEHOR) is determined by the variability of the independent variables system. The rest of 80.71% is not explained by regression model, so, it's influenced by some other unidentified (latent) factors, probably physiological, anthropomotor or psychological nature.

*Table 2. Results of multiple regression analysis for the dependent variable **Shooting the horizontal target with the "bump" (ČEHOR)***

Model	**Multiple R**	**Multiple R²**	**Adjusted R²**	**Std.Err. of Estimate**
1	0.460032	0.192915	0.129933	10.89724

Legend: Multiple R - coefficient of multiple correlations; Multiple R² - determination coefficients; Adjusted R ² - corrected coefficient of determination; Std.Err. Of Estimate - standard error of Estimate

Table 2a. Analysis of variance of the dependent variable ***Shooting the horizontal target with the "bump" (ČEHOR)***

ANOVA (Effect)		SS	df	MS	F	Sig.
ČEHOR	Regresson	553.78	2	138.44	5.587	**0.001**
	Residual	1239.06	37	24.78		
	Total	1792.84	39			

df1 = 2; df2 = 37; f = 3.23; P = 0.05

Legend: SS - Sq square; MS - values of regression and residual variance; Df - degree of freedom; F - F test; Sig. - realized level of significance;

From the set of variables of specific coordinative abilities (Table 2b) it was shown that the results of test Shooting the horizontal target with the "bump" (ČEHOR), used to estimate precision, can statistically significantly predict (**p = 0.042**) based on the results of the Test coordination in space (KOOPRO), used for evaluation of coordination, and whose beta coefficient is **Beta = -0.199**. The other variables of the specific coordination space have no statistical significance (Table 2b).

Table 2b. Beta Coefficients - Relative effect or importance of each independent variable

	Beta	Std.Err. – of Beta	B	Std.Err. – of B	t	p-level
ŽONG	0.02	0.10	0.03	0.15	0.23	0.82
KOMRE	0.122	0.097	0.219	0.174	1.260	0.210
KOOPRO	-0.199	0.097	-1.110	0.538	-2.062	**0.042**
HEKS	-0.023	0.094	-0.048	0.197	-0.244	0.808

Legend: Beta - coefficient of partial regression; Std.Err. - of Beta - standard partial regression coefficient error; T - the value of the Beta coefficient test; P-level - the significance of the Beta coefficient

In Table 3, the value of the multiple correlation coefficient between the dependent variables Shooting the vertcal target with "bump" (ČEVER) and the system of specific coordinating abilities variables is **R=0.37** which indicates a somewhat weaker correlation between the observed systems. The correlation is also statistically significant at **p = 0.000** (Table 3a). The obtained value **R^2 = 0.1485** indicates that 14.85% of the total variability of the results Shooting the vertcal target with "bump" (ČEVER) determined variability of the system of independent

variables. The rest of 85.15% is not explained by the regression model, so it's under the influence of some other anthropological characteristics or the ability of female volleyball players that are not the subject of this research.

Table 3. Results of multiple regression analysis for the dependent variable ***Shooting the vertcal target with "bump" (ČEVER)***

Model	Multiple R	Multiple R²	Adjusted R²	Std.Err. of Estimate
1	0.372196	0.148500	0.084814	1.736541

Table 3a. Analysis of variance of the dependent variable ***Shooting the vertcal target with "bump" (ČEVER)***

ANOVA (Effect)		SS	df	MS	F	Sig.
ČEVER	**Regresson**	1433.77	2	358.44	7.743	**0.000**
	Residual	2314.66	37	46.29		
	Total	3748.44	39			

It has also been shown that the test results of Shooting the vertcal target with "bump" (ČEVER) used to estimate precision, can statistically significantly predict (**p=0.007** and **p=0.002)**, based on the results of the Test coordination in volleyball net (KOOMRE) and Test coordination in space (KOOPRO). This is also confirmed by the Beta coefficient values for the mentioned independent variables (**Beta = 0.284** and **Beta = 0.293**). The other variables of the specific coordination space have no statistical significance (Table 3b).

Table 3b. Beta Coefficients - Relative effect or importance of each independent variable

	Beta	Std.Err. – of Beta	B	Std.Err. – of B	t	p-level
ŽONG	-0.046	0.106	0.023	0.052	-0.432	0.671
KOMRE	0.284	0.104	0.065	0.024	-2.735	**0.007**
KOOPRO	0.293	0.105	0.068	0.022	-2.633	**0.002**
HEKS	0.013	0.105	0.000	0.002	0.098	0.922

Table 4. Results of multiple regression analysis for the dependent variable ***Shooting the target in the horizontal plane from position 2 (ČEPOZ2)***

Model	Multiple R	Multiple R²	Adjusted R²	Std.Err. of Estimate
1	0.44061	0.20244	0.135576	11.045297

In Table 4, the value of the multiple correlation coefficient between the dependent variables Shooting the target in the horizontal plane from position 2 (ČEPOZ2) and a system of specific coordinating abilities variables is **R=0.44**, which points to the significant correlation of the observed systems. The correlation is also statistically significant at **p = 0.001** (Table 4a).
The obtained value **R² = 0.2024** points to the conclusion that 20.24% of the total variability of the result of the Shooting the target in the horizontal plane from position 2 (ČEPOZ2) is determined by the variability of the system of independent variables. The rest of 79.76% is not explained by the regression model, so it's under the influence of some other anthropological characteristics or the ability of the young female volleyball players.

Table 4a. Analysis of variance of the dependent variable ***Shooting the target in the horizontal plane from position 2 (ČEPOZ2)***

ANOVA (Effect)		SS	df	MS	F	Sig.
ČEPOZ2	Regresson	553.78	2	138.44	5.587	**0.001**
	Residual	1239.06	37	24.78		
	Total	1792.84	39			

In Table 4a, it has also been shown that the test results of Shooting the target in the horizontal plane from position 2 (ČEPOZ2) used to estimate precision, can statistically significantly predict (**p= 0.004** and **p=0.031**) based on the results of the One-hand juggling a ball through a hoop (ŽONG) **(Beta= -0.410)** and Test coordination in volleyball net (KOOMRE) **(Beta= 0.280)**. The other variables of the specific coordination space have no statistical significance.

Table 4b. Beta Coefficients - Relative effect or importance of each independent variable

	Beta	Std.Err. – of Beta	B	Std.Err. – of B	t	p-level
ŽONG	-0.410	0.159	-0.504	0.538	-3.143	**0.004**
KOMRE	0.280	0.164	0.368	0.455	2.257	**0.031**
KOOPRO	-0.158	0.188	0.199	0.158	0.571	0.571
HEKS	0.254	0.169	0.294	0.176	1.743	0.091

DISCUSSION

The basic motor skills as the basis for upgrading specific motor skills through a long-standing volleyball training process are important for success, because they to a large extent, determine game quality of each individual. Related to this, situational-motor skills that are a combination of motor and functional abilities with technical-tactical knowledge, are some kind of precondition for solving situations created in the game. So, reparation in the field of motor and functional abilities, technical-tactical knowledge, psychic (conative and cognitive) factors, but also the factor of sports luck, Are of utmost importance for success in sports as well as in volleyball. Diagnostics of the coordination structure began in the early 1980's (Hošek, 1976, Hošek-Momirović, 1981), continued and it lasts until today (Šimonek, 2006; Moriss, 2008; Bokan, 2009; Brodani & Šimonek, 2010; 2013; 2014; Gongey & Kerketta, 2016). Each new knowledge confirms an attribute of complex motor skills, and for that reason must be one of the indispensable motor skills that must find in each equation of the specification[2] of each sport. The breadth and veriety of the coordinative abilities prove its subdivision, so that, in the professional and scientific litetrature can find and forms like *speed coordination* (the ability to precisely

[2] Multidimensionality of which depends the success of the game, hypothetically, is possible to actually write it down in the form of linear equations (Elsner,1990): **U= Ak1+Mk2+Fk3+Mik4+Ik5+Kk6+Sk7+Zsk8+Zfk9+PTk10+... Ekn. U**-success in a volleyball game, **K1, k2,** ..., **kn -** coefficient of influence of the associated factors (weights), **A-**anthropometric characteristics of the volleyball player, **M-**motor skills of the volleyball player**, F-**functional abilities of the volleyball player, **Mi-**motor skills of volleyball player, **I -** the intellectual (cognitive) ability of the volleyball player**,** the **K-**conative characteristics of the volleyball player, the **S-, the Zs-**health of the volleyball player, the **Zf-**influence of external factors (on the competition), the **PT-**training training course**,** the **E-**error). The success factors in sport are defined hierarchically, which means that at the beginning of a series are the most important factors or dimensions, and finally those that are less important. The equation is hypothetical if to the hierarchical structure of the factors of success has been based on the subjective assessment of their importance (Milanović, 2013).

perform the desired movement in a short time), *rhythmic coordination* (ability to perform the desired task in a continuous or discontinuous rhythm), fast learning of motor tasks, *spatial-temporal orientation* (the ability to control more objects in space and time, the need for so-called "peripheral" vision), and *timeliness*. So, coordination is an indisputable essential motor ability that participates in every movement and so in these tests, but the results require an answer to the question: which latent factors are actually determine the coordination abilities volleyball players in research and thus assumed primacy in the realization of the set tasks?

What can be observed on the basis of the results is a fact that, based on specific coordination, is a significant statistical prediction of performing motor tests. Nearly the same conclusions came from authors of earlier research (Šabotić, 2004; Tahiraj, 2007; Babin, Bavčević & Vlahović, 2013; Schaal, Ransdell, Simonson & Gao, 2013; Stojanović, at all. 2014.) However, apart from the fact that coordination has a high birth rate ($h^2 = 0.80$) (Pistotnik, 2003) and established correlations in performance, attention is drawn to the fact that performance, with a higher proportion, really determined to some other unidentified (latent) factors or capabilities of young female volleyball players. In the first place they are expressed a two abilities within coordination which are already to a great extent independent, hese are **agility** and **balance** whose interaction has been confirmed by Ortega, Ruiz, Castillo & Sjostrom (2008) and Pradhan (2016). Except agility and balance, the results of this research have shown that coordination of female volleyball players have an indirect impact on strength, speed, endurance, flexibility and the ability to react fast As its integral parts, which was proved in researchs Kansala (2008), Lidiora & Ziva (2010) and Gangeya & Kerkette (2016), exploring, among other things, the success factors in volleyball game.

The significant characteristic of the motor tests of this research is that all the tests involved the manipulation of certain subject/prop. In particular, we are talking about ball. On this type of skills affected: a sense of the shape of the object, sense of its size and weight, elasticity and inertia (Poljšak, 1980). The next factor to be taken into account is the functional nature, and refers to the mobility of the joints, strengthening the muscles that flex the fingers and hands, the forearm during the ball pass and strengthening the muscles that are provided by adding the ball. The ball requires movement, dynamics, skill, agility, precision, speed and intelligence, and sometimes strength (Poljšak, 1980). All these are latent character factors, which can be justified by the high percentage of the total variability in the results for all three tests of the system

dependent variables. Then, one should remember that one situation in the game never repeated twice in the same way so that volleyballs are forced to react in a very short time, regardless of whether they are at the phase of the attack or defense. From this, as important factors in the realization of tests imposed a simultaneous movement of the ball and body (synchronization), control of the desired direction, movement of the ball and body, and the need for excellent visual perception (Iveković, 2013). Perhaps the clearest answer to the question of correlation latent factors to the performance of tasks and their synergy with manifest abilities (female volleyball players), was given by R. V. Roussev (1998)[3]:

Picture 1. System of coordinating abilities of athletes (R.V. Rousev, 1998).

System of coordinating abilities of athletes				
LEVEL 1 **Ability to regulate the behavior of muscle fibers.**	**LEVEL 2** **Ability to regulate muscular strain**	**LEVEL 3** **Ability to regulate movements of body parts**	**LEVEL 4** **Ability to move the whole body**	**LEVEL 5** **Ability to regulate moving objects**
Regulation of muscle fibers isometry	Regulation of muscle fibers isometry	Position control during contact	Regulation of body balance	Manual stabilization regulation
regulation of muscule fibers straining	Regulation of muscle auxotonia	Kinesthetic motor control	Body rotation regulation	Tactile manipulation regulation
		Time motoric regulation	Visual regulation of locomotion	Visual regulation of manipulation
		Regulation of motiric imitation		
		Acustuc motoric regulation		

CONCLUSION

Young volleyballs have shown that their coordinating abilities during the performance of the task Shooting the horizontal target with the "bump" (ČEHOR) are statistically significant.
In the test Shooting the vertcal target with "bump" (ČEVER) significant was two types of coordination, coordination in space and coordination on the volleyballnet, while in the third test, Shooting the target in the horizontal plane from position 2 (ČEPOZ2) was shown as a significant coordination on the volleyball net and the one-handed juggling of the ball through the hoop (ŽONG). Taken into consideration that the significance and complexity of coordination in this and similar transferational research is evident, the first conclusion is that latent factors, which

[3]Download from: Ragulj, N. (2004). Kineziologija znanost o pokretu. [PTT]. www. marul.ffst.hr/~nrogulj/predavanje.

have determined the coordination abilities of the young female volleyball players can act independently, but also on each other.

We believe that many agree that volleyball technique, in that sense, requires specific coordination. A large number of technical and tactical elements that are applied in the game and a great variability to use them, volleyball game ranks as sports that require specific coordination. Such formulation of specific coordination was defined, among others, by Bompa (1985, 1999). The situational coordination is even more complex than specific and is being upgraded to it. It could be described as the ability of a successful, meaningful and unpredictable motor response in 'conflict' competitive situations (Metikoš, Milanović, Prot, Jukić & Marković, 2003). So whatever it is, general, specific or situational coordination, the research has shown the essence of this ability: the proper relationship of established latent factors as parts of the whole, that give effective results. If we add preconditions as: close connection with volleyball technique, then the ability to solve complex, unforeseen motor tasks (intelligence), the acquisition of kinesthetic sense, a good estimate of spatial parameters, (systematic training), acquired motor skills (motor experience), and the level of development Other motor skills (speed, strength, endurance, flexibility, etc.), the second conclusion is that coordination is important motor skills and that without it one can not expect efficient performance given the technical and tactical structure in volleyball game. Volleyball is one of the most dynamic sports games with a constant change of typical and atypical situations, which players must quickly observe, analyze and adequately respond to them. Related to this, in the training process should strive as much as possible the approval of motor skills necessary for success in volleyball. A higher level of handling with technical-tactical elements, requires a higher level of motor preparation. Only such preparation contributes to a better, easier and economical application of complex movements in competitive conditions. In order to achieve a more efficient performance of the technical activities of the volleyball player, it is necessary a optimal motoric achievemen, respectively, certain "inventories" of acquired motor skills. If these "inventories" of acquired motor skills are larger, above all of the general coordination, thus will be easier to dominate with new movements and the level of development of specific coordination will be higher (Marinković, 2011). All this leads us to the third important conclusion of this research: coordination, no doubt, must have a purpose. It must be functional, that is, should be manifest in order to efficiently realize the set tasks.

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ANALYSIS OF THE EFFECTS OF SIX-MONTH STEP AEROBICS PROGRAMME WITH FEMALE STUDENTS WHO TRAIN AND FEMALE STUDENTS WHO DO NOT HAVE ORGANISED PHYSICAL TRAINING

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SUMMARY

In a sample of 100 female students at the College of Nursing Studies of the University of Bihać, a six-months-long experiment was conducted with the aim of determining the differences between two groups, namely the one that practiced step aerobics twice a week and the other, control group, which had no organized physical training. The research topic is a longitudinal study on a sample of female students, through the prism of researching the efficiency of Step aerobics programme in the evaluation of selected anthropological characteristics, as well as through the process of valorization of this programme's effect on the anthropological status of female students compared to students who did not have an organized physical training. Based on t-test and discriminant analysis, it has been concluded that there are statistically significant differences between these two groups of students. The results show that there has been a change in the students of the experimental group in the initial and final measurement, which also reflected on the differences between the experimental and control groups. A single discriminant function that has very high statistical significance has been isolated. Based on these results, it can be confirmed that there was an improvement of results of morphological characteristics in female students, although they practiced only twice a week. It turned out that there was also a redistribution of body composition on account of improving the volume at the expense of adipose tissue.

Keywords: step aerobics, morphological characteristics

INTRODUCTION

Aerobics is a unique sport phenomenon and it is among the sports which emerged in the last 25 years. It originated in America and began to spread from the late 1970s and was intended for all age groups, (women at first) and later to all others. With aerobic exercise, we aim to increase the abilities that are defined as aerobic fitness in modern sport (Sharkey, 1991) in terms of aerobic power and aerobic capacity as an indicator of the ability of taking, transporting and utilizing oxygen. Mastering certain motoric programmes plays very important role in aerobics. Nowadays, it is known that the management of movements implies constant "communication" between the CNS and the peripheral system to perform the movement, and it corrects the movement together with peripheral inlet, whereby CNS plans, programmes and sends command to limbs (Mirkov, 2011). In aerobics, there is an infinite number of elements of movement and their combinations (Zagorc, 1996). Most of previous research dealing with functional, motoric and morphological characteristics of female students (Skender, 2002), as well as the impact of certain aerobics programmes (Đug &Mikić, 2007), are mostly about the positive impact of transformational programmes on a sample of subjects aged 19-21 years. Based on the presented results at the beginning and the end of the conducted fitness programme, i. e. step aerobics, over a period of two months with a frequency of 2 times a week, and on the basis of the importance of the changes which were tested with T-test, they concluded that the applied programme of step aerobics produced significant partial changes–effects– in a group of 21 students, when it comes to applied anthropometric variables. In a study, (Oreb, Blarežina & Gošnik-Oreb, 1997) determined that after the implementation of the three-month aerobic dance programme within the Physical Education classes lasting two hours a week, there is an exceptional utility of aerobic dance especially in improving rhythm, movement frequency, explosive strength and coordination. Another study (Đug, Mikić & Mačković, 2008) determined the level of tranformation processes of morphological characteristics as a result of the six-month programmed fitness among the students of first and second year, who attended the optional classes of fitness at the University of Tuzla. The research included 199 students at the age of 19-21. The TBC-total body condition fitness programme, which was conducted with another group of subjects, produced significant partial effects, namely the weight reduction and the reduction of subcutaneous adipose tissue, which is one of the main tasks of this fitness programme. Body structure (physique) is estimated so that the electrical signal passes more easily through the body parts that contain water (blood, urine, muscles) because they have better conductivity than through bones or adipose tissue. The greater the amount of non-adipose tissue, the greater conductivity and less resistance. Combining bioelectrical impedance with other factors such as height, weight, and age, we get information about the structure of body weight. (Nešić, Ostojić, Đokić & Šeper, 2012). With this research, we tried to determine the effects of the Step aerobics programme, with the aim of transforming some anthropological characteristics in female students at the subsidiary faculty of the University of Bihać.

The subject of this research can be defined essentially as a longitudinal study on the population of female students, through the prism of researching the efficiency of Step aerobics programme in the evaluation of selected anthropological characteristics, as well as through the process of valorization of this programme's effect on the anthropological status of female students compared to students who did not have an organized physical training.

The main goal of this research is to determine the effects of a six-month Step aerobics programme in some anthropological characteristics among students of the University of Bihać.

The secondary goal is to analyze the differences of effects of a six-month Step aerobics programme in some anthropological characteristics among female students of the University of Bihać and female students who did not have an organized physical exercise.

METHODS

The sample comprised of 100 students of the University of Bihać divided into two groups, one experimental and one control group. The experimental group (E), which followed the model of step aerobics, consisted of 50 students, and the control group (K) which was not subjected to an organized exercise programme, consisted of 50 students.
In studying anthropological characteristics of both groups' subjects, we used two batteries of tests to assess the following anthropological characteristics:

- AGE- Chronological Age
- AVIS- Body height– measured with Martin's anthropometer. A subject is on a firm, horizontal ground in an upright position. The head of the subject should be in such a position that the Frankfurt plane is horizontal. The subject straightens his/her back as far as possible, and puts feet together. The examiner stands on the subject's left side and makes sure that the anthropometer is placed directly along the back of the body and vertically, and then drops a metal ring – slider so that the horizontal plate reaches the patient's head. We read the result on the scale at the top part of triangular slot on the slider. The result is read with an accuracy of 0.1 cm.
- AMAS- Body mass is measured with a scale placed on a horizontal, solid surface. The subject stands barefoot and calm at the middle of the scale, until the figure is formed on the scale. The result is read with an accuracy of 0.1 kg.
- BMI- Body mass index – (estimated body weight) the ratio of height and weight
- BMR- Basal metabolic rate – the total energy that is released from the body to maintain the normal function of the motionless body such as respiration and circulation. (1kcal = 4.184 kJ)
- RESISTANCE- Impedance measures present physical resistance to electrical current. Muscle acts as a conductor of electricity, and adipose tissue acts as a resistor.
- FAT % - a percentage of fat
- FAT MASS- a total mass of fat (kg, lb) in a body
- FFM-fat free mass. A mass of released fat composed of muscles, bones, tissue, water and other fat-free mass in the body.
- TBW - total body water. The total mass of water in the body is the amount of water expressed in lb, kg, or st.lb, which is found in the body. TBW makes from 50% to 70% of total body weight.

The sample of variables for assessing body composition were measured using body composition monitor model TANITA BC-540 has been used to measure body composition. This device, in the form of portable scales, uses installed software to measure the bioelectric impedance and body weight, and then, based on the measured data and the entered parameters (gender, age, body height) calculates the percentage of fat content in the structure of body composition, muscle mass in kilograms, a percentage of water in body structure, so called physical rating (on a scale 1-9), basal metabolic rate (BMR) in kilocalories and joules, metabolic age and weight of bones.

In data processing, only three variables (the percentage of fat, muscle mass and percentage of water) are taken into consideration as the most important for research.

The sample of variables for evaluation of morphological characteristics: (Skender, 2008.)

AOBGRU – chest width
AOBNAD - scope of the upper arm
AOBTRB - scope of the stomach
AOBNAT - scope of the upper thigh
ANABTR - abdominal skinfold
ANABNAD - upper arm skinfold
ANAB - back skinfold

The following measuring instruments were used to anthropometric characteristics: Martin's anthropometer with precision scale of 0.1 cm, 1500-milimeter-long Centimeter tape, caliper.
Measurements of morphological characteristics are measured according to the IBP (International Biological Program). The measurements were performed using a centimeter tape. Skin folds were measured with calipers. The measurements were performed in the morning in the initial and final measurements. The measurements were performed by the same measurer to reduce potential errors in the measurement to a minimum.
The measurement results were analyzed by the statistical programme SPSS 17. After checking the normality of distribution, it has been determined that the data have a normal distribution, and T-test and discriminant analysis have been made.
The subjects in the experimental group practiced Step aerobics programme which was full of aerobic exercises for at least 60 minutes, twice a week over a period of six months. The structure of movements in Step aerobics refers to the constant changes of rhythm and tempo as well as changes in energy consumption by using a stepper.
The subjects who practiced STEP aerobics programme performed the movements which consisted of numerous jumps, leaps, steps and turns which are connected into one entity in the form of choreography that looks like a modern dance, and after each choreography, they conducted shaping exercises that are performed for individual muscle groups.

RESULTS

Table 1. Descriptive statistics of all variables on initial measurement in both groups of respondents

grupe	Varijable	N	Mean	SD	KS test
E	AVISTJ	50	164,50	5,79	0,23
	AMASTJ	50	59.64	10,29	0,58
	BMI	50	21.78	3,83	0,19
	BMR	50	6049.68	426,42	0,26
	OTPOR	50	597.32	69,92	0,31
	FAT%	50	15.53	7,46	0,87
	FAT MASS	50	44.09	3,25	0,40
	FFM	50	32.28	2,37	0,36
	TBW	50	84.97	6,48	0,39
	AOBGRU	50	24.48	2,91	0,54
	AOBNAD	50	74.37	8,34	0,28
	AOBTRB	50	50.80	4,71	0,65
	AOBNAT	50	1,76	0,61	0,91

	ANABTR	50	1,58	0,48	0,32
	ANABNAD	50	1,20	0,52	0,12
	ANABLE	50	1,20	0,52	0,45
K	AVISTJ	50	164,32	5,06	0,28
	AMASTJ	50	61,17	10,05	0,65
	BMI	50	21,84	5,47	0,91
	BMR	50	6085,76	414,62	0,32
	OTPOR	50	572,38	106,82	0,12
	FAT%	50	16,19	7,68	0,45
	FAT MASS	50	44,38	3,57	0,87
	FFM	50	32,48	2,60	0,40
	TBW	50	84,73	6,42	0,36
	AOBGRU	50	24,70	2,89	0,39
	AOBNAD	50	75,32	7,58	0,65
	AOBTRB	50	50,95	5,20	0,91
	AOBNAT	50	1,85	0,55	0,32
	ANABTR	50	1,57	0,47	0,12
	ANABNAD	50	1,28	0,59	0,45
	ANABLE	50	1,28	0,59	0,57

Table 2. Descriptive statistics of all variables on the final measurement in both groups of respondents

grupe	Varijable	N	Mean	SD	KS test
E	AVISTJ	50	165,54	5,79	0,65
	AMASTJ	50	59,81	10,88	0,91
	BMI	50	20,60	4,21	0,32
	BMR	50	5917,00	452,63	0,12
	OTPOR	50	559,00	56,84	0,45
	FAT%	50	22,95	7,85	0,57
	FAT MASS	50	44,15	3,48	0,12
	FFM	50	32,35	2,55	0,45
	TBW	50	86,10	6,89	0,28
	AOBGRU	50	25,20	3,26	0,65
	AOBNAD	50	68,00	6,86	0,91
	AOBTRB	50	52,45	5,13	0,32
	AOBNAT	50	1,54	0,64	0,12
	ANABTR	50	1,54	0,64	0,45
	ANABNAD	50	1,28	0,47	0,87
	ANABLE	50	1,27	0,59	0,28
K	AVISTJ	50	164,32	5,06	0,65
	AMASTJ	50	61,79	9,90	0,91
	BMI	50	22,97	3,80	0,32
	BMR	50	6109,46	407,30	0,12
	OTPOR	50	543,06	64,53	0,45
	FAT%	50	25,32	6,69	0,12
	FAT MASS	50	45,65	3,53	0,45
	FFM	50	33,42	2,58	0,28
	TBW	50	88,74	6,27	0,65
	AOBGRU	50	26,48	3,34	0,91
	AOBNAD	50	72,40	7,56	0,32
	AOBTRB	50	54,26	5,23	0,12
	AOBNAT	50	1,76	0,58	0,45

	ANABTR	50	1,76	0,58	0,87
	ANABNAD	50	1,28	0,47	0,28
	ANABLE	50	1,27	0,59	0,65

As part of this analysis, we determined statistical significances of differences of applied variables before and after the realization of the STEP programme. Table 3 shows the values of T- test of the dependent sample for determining statistical significance in morphologic characteristics and body composition. For a better understanding of the table, variables are marked in the different time points by adding the suffix I for the initial measurement at the end and the suffix F for the final measurement.

The analysis of Table 3 revealed statistically significant changes in the following variables of morphological characteristics: impedance, fat free mass, total body water, volume of the chest, volume of the upper arm, volume of the stomach, upper thigh and skin fold back.

Table 3.T-test in the area of morphological characteristics and body composition of the experimental group E2 in the initial and final measurement

	Mean	Std. Deviatic	Std. Error Mean	95% Confidence Inte		t	df	Sig. (tail)
				Upper	Lower			
AMASI - AMASF	-,64898	2,38049	,34007	-1,33274	,03478	-1,908	48	,062
BMII - BMIF	-1,1280	4,42512	,62581	-2,38560	,12960	-1,802	49	,078
BMRI - BMRF	-23,700	99,9435	14,13415	-52,10363	4,70363	-1,677	49	,100
OTPORI- OTPORF	29,320(	91,2170	12,90004	3,39640	55,24360	2,273	49	,027
FATPROI - FATPROF	,67000	3,72626	,52697	-,38899	1,72899	1,271	49	,210
FATMASI-FATMASF	-,10200	2,65756	,37584	-,85727	,65327	-,271	49	,787
FFMI-FFMF	-1,2660	1,17606	,16632	-1,60023	-,93177	-7,612	49	,000
TBWI - TBWF	-,93600	,85589	,12104	-1,17924	-,69276	-7,733	49	,000
AOBGRUI - AOBGRUF	-4,0100	4,40682	,62322	-5,26241	-2,75759	-6,434	49	,000
AOBNADI - AOBNADF	-1,7720	1,40117	,19816	-2,17021	-1,37379	-8,942	49	,000
AOBTRBI-AOBTRBF	2,9160(	6,80952	,96301	,98076	4,85124	3,028	49	,004
AOBNATI-AOBNATF	-3,3100	3,17749	,44936	-4,21303	-2,40697	-7,366	49	,000
ANABTRI-ANABTRF	,08800	,46979	,06644	-,04551	,22151	1,325	49	,191
ANABNADI - ANABNADF	-,03360	,33154	,04689	-,12782	,06062	-,717	49	,477

ANABLEI-ANABLEF	,15040	,45446	,06427	,02124	,27956	2,340	49	,023

Table 4. T-test in the area of morphological characteristics and body composition of the experimental and control group Initial measurement

	Mean	Std. Dev	Std. Err Mean	95% Confid Inte. of the Dif.		t	df	Sig. (2-tai)
AMAS	-2,0606	8,09297	1,40881	-4,9302	,80904	-1,463	32	,153
BMI	-1,12800	4,42512	,62581	-2,3856	,12960	-1,802	49	,078
BMR	-23,70000	99,94350	14,13415	-52,103	4,7036	-1,677	49	,100
OTPOR	1,73939	9,14730	1,59234	-1,504	4,9828	1,092	32	,283
FATPRO	,67000	3,72626	,52697	-,38899	1,7289	1,271	49	,210
FATMAS	-,10200	2,65756	,37584	-,85727	,65327	-,271	49	,787
FFM	-1,12800	4,42512	,62581	-2,3856	,12960	-1,802	49	,078
TBW	-23,70000	99,94350	14,13415	-52,103	4,7036	-1,677	49	,100
AOBGRU	1,17879	4,23916	,73794	-,324	2,6819	1,597	32	,120
AOBNAD	1,73939	9,14730	1,59234	-1,504	4,9828	1,092	32	,283
AOBTRB	1,17879	4,23916	,73794	-,324	2,6819	1,597	32	,120
AOBNAT	-2,0606	8,09297	1,40881	-4,9302	,80904	-1,463	32	,153
ANABTR	-1,12800	4,42512	,62581	-2,3856	,12960	-1,802	49	,078
ANABNAD	,21121	,89753	,15624	-,1070	,5294	1,352	32	,186
ANABLE	-,04152	,74377	,12947	-,3052	,2222	-,321	32	,751
AMAS	-,10200	2,65756	,37584	-,85727	,65327	-,271	49	,787

Table 5 shows the differences between the experimental and control groups in the morphological characteristics and body composition. The values of the differences in the following variables have been determined: body weight, body mass index, basal metabolic rate, resistance, fat percentage, total weight of fat mass (in kg, lb) in a body, fat free mass, total body water, back skinfold, scope of the upper thigh, and abdomenal scope.

The difference in morphological dimension of body weight is especially significant, with statistically significant difference of 0.5%. If we analyze the variables of the body structure, the total weight of fat mass (in kg, lb) in a body and fat free mass, we see that they also showed statistically significant differences in these groups of subjects, especially because they are a part of body mass, as well as subcutaneous adipose tissue.

Table 5. T-test in the area of morphological characteristics and body composition of experimental and control groups

	Mean	Std. Dev	Std. Err Mean	95% Confid Inte. of the Dif.		t	df	Sig. (2-tai)
AMASI - AMASF	-2,0606	8,09297	1,40881	-4,9302	,80904	-1,463	32	,153
BMII - BMIF	6,34242	12,38901	2,15665	1,9494	10,735	2,941	32	,006
BMRI - BMRF	2,89697	4,26889	,74312	1,3832	4,4106	3,898	32	,000
OTPORI- OTPORF	253,181	522,873	91,02064	67,778	438,58	2,782	32	,009
FATPROI - FATPROF	-35,121	91,64598	15,95352	-67,61	-2,624	-2,201	32	,035
FATMASI-FATMASF	4,80303	8,99908	1,56654	1,6121	7,9939	3,066	32	,004
FFMI-FFMF	4,60606	8,40992	1,46398	1,6240	7,5880	3,146	32	,004
TBWI - TBWF	1,77576	4,62264	,80470	,1366	3,4148	2,207	32	,035
AOBGRUI - AOBGRUF	1,30000	3,39273	,59060	,0969	2,5030	2,201	32	,035
AOBNADI - AOBNADF	1,73939	9,14730	1,59234	-1,504	4,9828	1,092	32	,283
AOBTRBI-AOBTRBF	1,17879	4,23916	,73794	-,324	2,6819	1,597	32	,120
AOBNATI-AOBNATF	5,02727	10,84811	1,88841	1,180	8,8738	2,662	32	,012
ANABTRI-ANABTRF	2,79091	6,54529	1,13939	,470	5,1117	2,449	32	,020
ANABNADI - ANABNADI	,21121	,89753	,15624	-,1070	,5294	1,352	32	,186
ANABLEI-ANABLEF	-,04152	,74377	,12947	-,3052	,2222	-,321	32	,751
AMASI - AMASF	,20939	,57657	,10037	,0049	,4138	2,086	32	,045

In this subsection, we have analysed the quantitative morphological changes in the experimental group E (a group that practiced STEP aerobics) after completing six-month programme. Analysis of Table 3 shows that this area underwent quantitative changes. There has been a formation of an

important discriminative function of height, .776 which indicates very high statistical significance of 0.01%, a very high coefficient of significance.

Table 6. The significance of isolated discriminant functions of morphological characteristics and body composition in the experimental group's initial and final measurements

Function	Eigenvalue	% of Varia	Cumulative %	Canonical Correlation	Wilks' Lamb	Chi-squar	df	Sig.
1	1,513(a)	100,0	100,0	,776	,398	86,163	9	,000

Table 7. The structure of discriminant function

	1
AOBNAT	,255
AOBGRU	,253
AOBNAD	,227
OTPORI(a)	-,205
AOBTRB	-,155
FFM(a)	,145
TBW	,145
ANABLE	-,116
AVIS(a)	-,085
FATPRO(a)	-,059
ANABNAD(a)	,052
ANABTR(a)	,042
FATMAS(a)	-,034
AMAS	,031
BMR(a)	,027
BMI(a)	,005

Table 8. Centroids of groups

group	Function
	1

1,00	-1,246
2,00	1,246

This subsection analyzes the quantitative changes of morphological characteristics between the experimental group E and the control group K after completing the programme, keeping in mind that the experimental group completed a six-month programme of step aerobics while the control group did not have an organized physical exercise. The analysis of Table 9 indicates that morphological area in most subjects has undergone significant quantitative changes, as it was expected. We see that there has been the formation of an important function .633 which indicates the correlation between the set of data from which we conducted discriminant analysis and the discriminant function. The statistical significance of this canonical correlation is 0.01%, indicating a very high bond.

Table 9**.** The significance of isolated discriminant functions

Function	Eigenvalue	% of Var	Cumulative	Canonical Correlation	Wilks' La	Chi-squ	df	Sig.
1	,754(a)	100,0	100,0	,656	,570	41,578	14	,000

Table 10.The structure of discriminant function

	Function
	1
BMI	-,441
FATMAS(a)	-,434
FATPROC	-,428
AMAS	-,422
BMR	-,404
AOBTRB	-,348
FFM	-,341
TBW(a)	-,339
AOBNAT	-,307
OTPOR	,281

ANABLE	-,269
ANABTR	-,215
AOBNAD	-,185
AOBGRU	-,172
ANABNAT	,118
AVIS	,073

Table 11.Centroids of groups

group	Function
	1
1,00	-,697
2,00	1,056

DISCUSSION

Considering the research results for the experimental group, it can be said that statistically significant differences have been achieved under the influence of the STEP programme, which is evident from Table 3 and 5. The achieved differences are significant in 8 variables of morphological characteristics and body composition. The analysis of Table 7 (the structure of discriminant function) shows that the tests of AOBNAT, AOBGRU and AOBNAD have the biggest contribution to the discriminant function. The subjects who practiced STEP aerobics programme in the experimental group performed the movements which consisted of numerous jumps, leaps, steps and turns which are connected into one entity in the form of choreography that looks like a modern dance, and after each choreography, they conducted shaping exercises that are performed for individual muscle groups. The effects of step workout are: strengthening the leg muscles and lower back, muscle tension and increasing the vitality of the entire organism. After analyzing the programme, we see that the subjects practiced for one hour 2 times a week. For these reasons, there have been significant changes of this morphological manifestation and the results of this discriminant function showed that the step programme statistically had a significant effect on improving the dimension of body volume, namely chest width, scope of upper thigh, and scope of upper arm. In Table 8 that shows the centroids of groups, it can be seen

there is a clear polarization of results in the initial and final measurements, as well as in the previous group, only in lower intensity.

We can conclude that the programme has significantly influenced the redistribution of fat, voluminosity and scope of the skeleton, adiposity among the female students of the experimental group. The reason can be found in the programme performed by the students of the experimental group. The programme of Step aerobics that has been conducted twice a week for six months was full of aerobic exercise which lasted at least 60 minutes. The structure of the movement in Step aerobics refers to the constant changes of rhythm and tempo as well as changes in energy consumption by using a stepper. The subjects who practiced STEP aerobics programme performed the movements which consisted of numerous jumps, leaps, steps and turns which are connected into one entity in the form of choreography that looks like a modern dance, and after each choreography, they conducted shaping exercises that are performed for individual muscle groups. The effects of step workout are: strengthening the leg muscles and lower back, muscle tension and increasing the vitality of the entire organism.

Table 5 indicated there are statistically significant differences between the two groups (experimental and control). The discriminant analysis revealed one discriminant function that has a very high statistical significance.

The analysis of Table 10 which shows the structure of discriminant function, indicates that the variables AMASTJ, AOBTRB, AOBNAT, ANABLE i ANABTR gave the greatest contribution to discriminative function.

This is because movements in Step aerobics programme performed by the subjects in this experimental group significantly strained muscles of lower limbs, among other things, and the results are reflected in the back skinfold and abdominal skinfold. The movements performed in step aerobics significantly strain the muscles of the abdomen as in the various movements of vertical or horizontal climbing, stomach muscles play an important role and are continuously active. Of course the programme reflected on mass reduction in the experimental group, which is a direct result of the Step aerobics programme. This is to confirm that the Step aerobics programme, as aerobic exercise, significantly influenced on the reduction of mass and

subcutaneous fat, as well as abdominal scope in the experimental group, which is the goal of aerobics. This observation is confirmed by the group centroids that show the difference in gender and large distance between groups. The control group did not have any organized programme, but we could not influence or control their free time completely. Yet, the results of discriminant analysis showed that these four variables made the greatest discrimination between these two groups.

Based on the results obtained in this study, we can confirm that the step aerobics had a very significant effect on the improvement of morphological characteristics among students of the University of Bihać. Although they practiced only twice a week, it turned out that a significant effect has been achieved in the majority of variables of the morphological area, and that the redistribution of body composition was performed with the aim of improving the volume at the expense of adipose tissue. The results in motor skills would probably show significantly better results, but unfortunately we did not research that in this paper.

CONCLUSION

Results we obtained in the research applied to a sample of 100 subjects of the student population at the University of Bihać speak in favor of the fact that step aerobics is very suitable form of activity and sport appropriate to this age. T-test indicated the difference between arithmetic means of the experimental and control groups in almost all the characteristics of morphological traits and body composition. The results of discriminant analysis indicate that one discriminant function of very high significance singled out. Also, analyzing the disparities between the initial and final measurements in the experimental group, it became apparent that the programme has caused significant statistical changes in the domain of most morphological characteristics and some variables of body structures. This speaks in favor of a claim that there has been a redistribution in body composition in favor of the creation of muscles in relation to the amount of fat, which was caused by the programme full of aerobic exercise, various kinds of jumps, leaps and steps. This study confirmed that step aerobics is a very important sport that should be practiced in student age.

Female students are burdened with lectures, classes and studying, which certainly reflects negatively on their morphological characteristics, and thus on the structure of the body composition, as well as on other anthropological characteristics.

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SECURITY REQUIREMENTS AT THE OLYMPIC GAMES

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SUMMARY

The subject of this paper is related to the security requirements at the Olympic Games. The Olympic Games are the biggest global sporting event that brings together athletes and spectators from over 200 countries worldwide. The phenomenological aspects of sports - social, political and economic factors are some of the reasons for their planetary popularity. Unfortunately, major events have always attracted the attention of terrorists, various organizations and individuals, who in them saw an opportunity to inhumanely turn the attention to themselves for the sake of objectives that are not associated with sports but rather with politics and other issues. For these reasons the safety requirements of the Olympic Games are very important, and they are among other things one of the primary tasks of the organization of each Olympic Games. The objective of this paper is to emphasize the need and importance of the utilization of security measures during the Olympic Games. In addition to the general safety of all participants and spectators, one should take into account the protection of athletes against injury. For the purpose of providing security for athletes, coaches, managers, delegations, referees, audience and special VIP guests, hosts of the Games take special measures with the help of international assistance. By analyzing commitment of the host cities' Organizational Committees in the 21st century in the field of security, the results of the paper suggest the necessity of the implementation of security measures during the Olympic Games in order to prevent their misuse by negative elements.

Keywords: security measures, terrorism, Olympic Games.

INTRODUCTION

The Olympic Games have since their creation represented a sporting event that except for sports has had another very important dimension - security. Although the modern Olympic Games were created on the principles of the ancient Olympic Games, today, after 120 years since their restoration, we can begin to recognize their similarities and differences by looking at them from the security aspect. Due to the large number of wars among Greek cities, which resulted in a large number of wounded and dead, which also led to the impoverishment of the cities, on the advice of the oracle of Delphi the *ekeheria* or sacred truce was established. The agreement that

was signed on a metal disk by three Greek kings became the basis of the sacred truce among the Greek cities during the Games. In addition to the cessation of wars, this agreement also involved the inviolability of Olympia and immunity of all spectators. Thanks to the sacred truce, all competitors, official representatives of the Greek states and other citizens came, stayed and safely returned to their cities, without fearing something might happen to them on the way. At the beginning of the Games the sacred truce lasted for one month and was later extended to three months and respected by all Greeks as the undisputed law. In addition to extending the duration of the truce, its effect spread to the entire region around Olympia so that the whole of Elis was declared the Holy Land. This included a ban on access to all armed men, as well as all wars.

The truce was upheld for 12 consecutive centuries of the Olympic Games with rare exceptions. Penalties for violators of the truce were very strict. Although the sacred truce did not allow bringing weapons into the Sanctuary during the Games, in 364 B.C. there was a case of a fight in Olympia during the Games (Xenophon, 1988). In an attempt to regain the rule over the Sanctuary, the Eleatics even fought at Altis against Pisano. Later, those Olympic Games did not count like they ever took place.

This useful prophecy used the peace dimension of sports, its ability to transform human aggressiveness into a peaceful competition and at the same time give a chance to the enemies to meet, to fight together and get to know each other in peace at the same stadium. There was also a "real-political" dimension: the best athletes were usually warriors, and therefore it was not possible for them to participate in the Games unless they temporarily stopped fighting. In addition, both athletes and ordinary spectators were forced to travel to Olympia mainly by land (Šiljak, 2013).

However, the human factor as the cause of all the events is the same as three millennia ago. The disputed referee decisions, the use of doping substances in order to win at all costs and amateurism that has grown in professionalism are present at today's Olympic Games,[1] political boycotts, terrorism, commercialization. These negative situations which the IOC encountered produced its positive reaction in order to preserve the Olympic spirit of the Games; thus very strict security measures are being implemented during the organization of the Games. As a result, a large number of volunteers were included as aid, the Olympic movement for peace was founded in the tradition of the ancient *ekeheria*, a solidarity fund was established to help athletes, cooperation with the Anti-Doping Agency was realized, and so on (Šiljak, 2013).

The problem of this paper relates to the security of the Games that the organizers face. Security is a very broad term, considering that it can start from the security of the individual to the security of the entire nation or a global sporting event. The development of modern technology

[1] One of the five principles based on which the Olympic Games were established in 1894 was that only amateurs could participate in the Games. The interpretation of this principle has in the Olympic history led to unfortunate and unpopular decisions by referees. Modernization of the Games has influenced its change and since 1988 professional athletes have the right to take part in the Games.

provides such equipment for the OC which is based on the latest technology to secure the whole event from unwanted incidents.

The subject of this paper is related to the security requirements at the Olympic Games, the biggest global sporting event. Over the last 120 years of the modern Olympic Games, supporting events have dictated an increase of security measures and consequently an increase in security requirements. The objective of this paper is to emphasize the need to apply security measures during the Olympic Games and prevent their misuse by negative elements.

Modern Olympics and Security

In addition to its positive side, globalization also has a negative side. Sports, unfortunately, cannot be separated from the impact of economic and political factors, either directly or indirectly and commercialization, professionalism, bidding to host the Olympic Games are all indicators.

Security at the Olympic Games in the beginning of their hosting related mostly to the very actors of the Games; today it has become a much more complex field that entire teams of scientists are dealing with.

World War I prevented the 6th Olympic Games from happening, which were supposed to be held in Berlin in 1916. The organization of the 12th Olympic Games, scheduled for 1940, was entrusted to Tokyo, and after the Second Japanese-Chinese War broke out it was assigned to Helsinki. This competition, was, however, canceled due to World War II, and so were the following Games, which were supposed to be hosted in London in 1944. Due to the safety of participants and spectators, during the 20th century the Games were canceled three times, while the ancient Greeks stopped their wars because of the Games. Nowadays, the IOC is working very hard to revive the institution of the Olympic truce with a very-difficult-to-achieve aim of the cessation of hostilities during all future Olympic Games, as well as after their completion with the final outcome - a peaceful settlement of differences.

With examples of unfortunate events at the Olympic Games in Munich in 1972, Atlanta, 1996, and Athens, 2004, three different ways of jeopardizing security of the Olympic Games can be seen. The Munich Games held from 26 August to 11 September 1972 were the largest held at the time, but they will forever be remembered for the tragic event on 5 September when terrorists, members of the Palestinian organization "Black September", invaded the Olympic Village, and killed two Israeli representatives, and took nine as hostages (figure 1). After an unsuccessful rescue attempt at the Munich airport all hostages were killed, as well as five terrorists and one German police officer. There was a 34-hour interruption of the Games, but after the memorial services to the fallen athletes the Games continued as per the decision of the IOC, with the support of Israeli officials, but with no athletes from that country.

Fig.1 - Palestinian terrorists in Munich in 1972

The act of an organized terrorist attack on Israeli athletes in 1972 in Munich stunned the whole world, and since that day the Games have never been the same. Many countries have during crises like the Cold War boycotted the Olymp ic Games, while the police and even the army guarded athletes as if they were the most senior political representatives. That's what to a certain extent has managed to prevent any further terrorist attempts at prestigious sporting events.

When a 20-kg bomb exploded at the Olympic Park in 1996 in Atlanta two persons were killed and 111 wounded (Fig. 2). These two lessons are very instructive, especially for the host countries of the Olympic Games. Underestimating such events in the coming period could further aggravate and complicate the security of the Olympic Games.

Fig. 2- The victims of the bombing in Atlanta in 1996

A specific attack against a competitor happened in Athens in 2004. During the marathon race, seven kilometers before the finish line, the then-leading Brazilian Vanderlei de Lima was attacked by a spectator, who was later found to be an Irish priest, at a moment when he had an advantage of 48 seconds compared to its closest competitor, and his rhythm was completely interrupted (figure 3). His opponents took advantage of the situation and Italian Stefano Baldini won the gold medal, while Lima came in third. IOC subsequently handed the "Pierre de Coubertin" award to the Brazilian athlete.

Fig. 3 - The attack on Vanderlei de Lima during the marathon

Although the terrorist attack during the Games in Munich in 1972 was a turning point in the security of this sporting event, a global connection of all security agencies in order to secure the entire event came as late as 2004 and the Athens Olympic Games. However, despite the relatively good security measures in Athens, the previous example indicates that failure is always possible. The Olympic Games have moved the boundaries of sports in many aspects and so caused a clash of different interests, which is the most important argument for emphasizing the issue of security of the Games. Security and sports are two essential elements of every person's life. A man has always aspired to a healthy body and spirit as well as security as a prerequisite to achieve it.

Terrorism today, as a threat to the entire world, including the Olympics, is certainly considered a priority risk, before which all the world's security agencies are teaming up to ensure its prevention. The responsibility of the organizers and the Organizing Committee of the host city is huge and spreads to the whole country, and as such is considered one of their most difficult tasks. However, there are other risks that should be prevented that belong to the field of security management, which is the safety of athletes during the competition. This includes safe sporting facilities, equipment, etc., in relation to the risk of injury of the athletes. If the Winter Olympic Games can be considered safe in terms of terrorist attacks, they can be considered even more dangerous for the lives of the athletes due to their specific sporting tracks and disciplines. Competitions in winter sports border on extreme in terms of difficult trails. A fatal accident that occurred in Vancouver at the Winter Olympics in 2010 confirms this fact. Nodar Kumaritashvili, a Georgian luger, died on the track during training (Fig. 4). The Games had to go on, but the question remains whether the organizers, in order to make the trail more attractive, forgot about its safety.

Fig. 4 - Nodar Kumaritashvili immediately after the fatal fall

Russian skier Maria Komissarova suffered a spinal injury after which she was no longer able to walk during the last Winter Olympic Games held in Sochi in 2014. At the Games in Sochi there was the large number of injuries, however, the IOC's official report was the same as from the previous Games in Calgary (http://www.olympic.org/news/ioc-injury-illness-surveillance-study-protecting-the-athletes-health/225531). It is alleged that the special IOC medical commission followed all competitors during the Games and recorded all injuries. Their further investigation, as well as that of the scientists in the field of medicine should find solutions for safer conditions for competitors. The question is whether doctors can influence a less attractive but a safer trail which, as such, does not please the organizers because it doesn't attract enough attention.

At the Olympic Games 8 athletes have so far lost their lives during the competition (4 at Winter Games and 4 at Summer Games). Outside the competition 14 athletes have lost their lives in various accidents, and out of those 14, 11 were killed in Munich in 1972. There is information about the fallen spectators at the Olympic Games that is not accurate. In Mexico in 1968 a large number of Mexican students who were protesting during the Games were killed; in Atlanta in 1996 a bomb attack killed 2 and injured 111 people, while in London in 2012 two deaths were recorded where a bus ran into a cyclist as it was transporting teams to venues (http://en.wikipedia.org/wiki/Olympic_deaths).

Organization of the Games

Management of a sporting event is complex because it is necessary to follow the event from the beginning till the end. Olympic Games Management must include all elements of management - from planning and organization to management and control, for the successful implementation. Questions of health care and safety at the same time taking into account the potential financial risks are discussed in the framework of a risk management project. In preparing this sporting event the organizer tends to eliminate or reduce to a minimum the events or activities that may disturb the participants of the event (athletes, spectators or officials).

Operational activities related to the organization of the competition include supplying the facility with the necessary equipment, as well as providing all other conditions and operational activities necessary for the successful development of a sporting event: the venue, sports equipment, the

exact schedule of planned activities, sponsorship, security, crowd control, media and promotional activities, and more.

From an organizational point of view, the Olympic Games represent a major undertaking and challenge for the International Olympic Committee, Organizational Committees, as well as the host city and country. The organization of the Olympic Games is a complex and dynamic process that is constantly changing. Current problems of organization, i.e., management of the Games in general grab the attention of professional and sporting public, and can be found in the sphere of interests of "ordinary" viewers. The organization of the Olympic Games is entrusted by the IOC to the National Olympic Committee of the country of the host city and the host city itself. For this purpose, the NOC has a duty to establish the Organising Committee of the Olympic Games, which from the moment it is constituted reports directly to the Executive Board of the IOC. The Organising Committee of the Olympic Games has the status of a legal entity in the country of the host city. The executive body of the Organizing Committee of the Olympic Games includes: a member of the IOC, the President and the Secretary General of the NOC and at least one member appointed by the host city. It may also include representatives of public authorities and other leading figures. The Organising Committee of the Olympic Games must act in accordance with the Olympic Charter.

Management of the Olympic Games means that future Organising Committees of the Olympic Games start with the candidacy of their city to be the Olympics host city and end by handing in the report to the IOC in the aftermath of the Games (Škaro, 2012). The same author structures the Olympic Games into phases:

- Idea and feasibility
- Competition for project acceptance
- Construction and preparation for the Games
- Hosting the Olympic Games, and
- Closing the Games and using the Olympic legacy.

With the aim of bringing together all competitors, officials and other staff of teams in one place, the Organizing Committee of the Olympic Games must provide the Olympic Village for a period determined by the Executive Board of the IOC. The Olympic Village shall meet all requirements set forth by the Executive Board of the IOC, such as, for example, quotas for the accommodation of delegations of countries.

The Organising Committee of the Olympic Games must provide adequate housing and business premises if certain events occur at a location that is not in the host city of the Games, in accordance with the requirements of the Executive Board of the IOC. Also, it is its duty to organize different events of the cultural program during the entire duration of the Olympic Village. Before its implementation, the cultural program must be submitted for approval to the Executive Board of the IOC.

In order for, above all, the contestants and then coaches and other members of the delegation to take part in the Olympic Games, they have to respect the Olympic Charter, including the eligibility requirements set forth by the IOC, as well as specific rules of the International Federation.

While organizing the Olympic Games practice has shown that the planned budget for their organization has always been exceeded. Bearing in mind the fact that the number of potential threats to the security of the Games has increased, the cost of their organization has been increasing as well. It is difficult to establish or to get to the official data on how much of that budget is spent on the security segment of the Games, especially if one takes into account the fact that safety concerns not only the participants, but also other persons and objects. Fig. 5 shows the tabulation of resources spent for the organization of the Games in selected examples.

YEAR	HOST CITY	BUDGET
1992	Barcelona	$9.3 billion
2002	Salt Lake City	$1.2 billion
2004	Athens	$9 billion
2010	Vancouver	$2.3 billion
2012	London	$14.6 billion
2014	Sochi	$51 billion

Fig. 5 - Tabulation of resources spent for the organization of the Games

If we compare the Games from Salt Lake City and Vancouver, we notice that for the organization of those in Vancouver they spent twice the amount of money. Given that due to the geographical location, natural resources, the number of competitors and visitors the Winter and Summer Olympic Games have not in any way ever been compared, we cannot ignore the fact that until the Olympic Games in Sochi in 2014, figures were in favor of the Summer Olympics. For the overall organization of the Games Russia spent $51 billion and thus surpassed all previous costs for the organization of the Games since their beginning to the present. The Russian Federal Security Service engaged four times the number of members of security during the Games than at the Games in London in 2012. In addition, they applied a multiple security system with comprehensive monitoring measures including drones, reconnaissance robots for explosives detection, super-fast boats and submarines that use sonar to detect potential threats coming from the sea (Marković, Draganović & Radošević, 2014). There is only an assumption how much money went for security, but an example for it can be the cost of the Organizing Committee for the Games in London in 2012 that in addition to the total sum of $14.6 billion amounted to approximately $1 billion.

In addition to a multi-layered state security body, an Israeli security company is hired for the next Olympic Games to be held in Rio de Janeiro in 2016 at a cost of $ 2.2 billion. Luiz

Fernando Correa is the security director of the team of the Organizing Committee of the host, and he coordinated the same tasks during the Pan American Games in Rio in 2007.

Security Requirements at the Olympic Games

The Organising Committees of the Olympic Games in cooperation with the IOC plan and make documents against which the current preparations for the Olympic Games are conducted, as well as their very implementation.

These official documents are planned in accordance with the place of hosting the Olympic Games and as such contain specific provisions relating to security during the Games. In order to establish the best possible readiness against adverse events, guidelines or priorities will be set up which are considered for possible crisis situations.

On the basis of such document for the Olympic Games held in 2012 in London the security requirements were focused on the following threats:

- terrorism,
- serious crime
- domestic extremism and public disorder, and
- natural disasters.

The document which refers to security for the forthcoming Olympic Games that will be held in Rio de Janeiro in 2016 has seen an increased number of security threat requirements - or has maybe presented them in more detail, namely:

- civil disobedience
- crime
- technological risks
- traffic
- natural disasters
- other disasters
- terrorism
- major traffic accidents, and
- airspace control.

The security team for the Games in London most definitely exercised control of both the airspace and other traffic areas, but it has also singled out four main threats, of which terrorism is the first in significance. It is obvious that the location and environment dictate the priority, and for the upcoming Games civil disobedience and crime are considered a greater threat. The noted examples are the very indicators that general security requirements may be present as well as those specific to every region individually.

In Rio de Janeiro there are ongoing security projects related to the upcoming Games, which relate to: improving supervisory skills, improving the system of training of police forces,

increasing engagement of civilian police, improving the training of civilian police officers, improving operational management in civilian police, increasing the involvement of the military police, improving criminogenic prevention, and so on. Obviously, such serious projects involve coordination with the intelligence services.

CONCLUSION

Security during the Olympic Games is nowadays a global project of the Organizing Committee of the Olympic Games, the IOC, the security structures at all levels of the country of the city that is the host of the Olympic Games, as well as the involvement of a large number of world security agencies. The risk can never be eliminated completely, but the potential threats must be identified and understood so they can be mitigated or prevented. Security requirements are not the same for all Olympic Games and they depend on several factors, of which the very location of the Games has the largest role in their planning. Although terrorism is not at the top spot as a threat in the strategy of the forthcoming Olympic Games, it is still considered a global threat to all past Games. Modern technology in the function of intelligence and communications systems, in addition to the above measures so far has confirmed its important role in the effort of the organizers of the Olympic Games to host as safe an event as possible, while further improvement is still needed.

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THE USAGE OF TESTS OF ENDURANCE DURING THE WORK WITH THE STUDENTS OF FACULTY OF SECURITY SCIENCES

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Original scientific paper

Summary

The research was conducted on a sample of 27 male students of the first year of the Faculty of Security Studies in order to determine the value of the functional capabilities of the students of the Faculty of Security Sciences achieved during the Cooper test and the Beep test, in order to consider the possibility of applying the Beep test in the process of assessing the functional capabilities of students when conducting the selection process for admission to the faculty. Using the appropriate statistical procedure, it was found that there is no statistically significant connection of variables for the evaluation of morphological characteristics with the results achieved on the Beep test and the Cooper test, as well as that there is no statistically significant connection of variables for the assessment of morphological characteristics with the obtained results of maximum oxygen consumption on the Beep test and Cooper test. Also, it was found that there is no a difference in maximum oxygen consumption between the tests that were applied. Considering variability of the load that is characteristic of the Beep test and the similarities with specific activities characteristic for the performance of elements and their connections in the teaching process of the SFO (Special Physical Education Program), the authors suggest that the Beep test should be included in the tests that are used to determine the functional capabilities of the candidates when conducting the selection process for admission candidates for education at the Faculty of Security Sciences. The gathered information can also be used to make and optimize the plan and program of the SFO, as well as to create homogeneous groups in order to achieve efficient learning outcomes.

Keywords: *students, Cooper test, Beep test, selection*

INTRODUCTION

The term "teaching" in Special Physical Education Program (later in the text referred to as SFO) represents the process of planned and systematic transfer and adoption of special thematic areas adjusted to students of the Faculty of Security Sciences that are relevant for the future performance of their professional duties and responsibilities, and it includes many components. The basic ones are: acquiring knowledge, forming skills, forming habits and increasing their knowledge, skills and habits. The performance and practical use of techniques from the Special Physical Education Program (SFO) is conditioned by both high technical and motor abilities and functional and mental abilities, as well as by appropriate anthropometric predispositions. In order to realize the teaching process

and assure the active participation of the students in the program of SFO, in addition to the motor skills such as strength, speed, flexibility, coordination, agility, precision and balance, very important skill is also endurance. Endurance is the ability of an individual to maintain his working ability over a longer period of time, so each individual needs to develop an optimal level of functional abilities, where mixed aerobic-anaerobic energy processes dominate, and they are characterized by simple and complex movements. Pelemis et al. (2011) state that the physiological basis of physical working capacity is the functional ability of the organism to increase the level of metabolic processes in accordance with the demands of the physical effort that the organism is exposed to, and metabolic processes mean the transformation of chemical energy into muscular contraction. According to Milosevic, the level of development of functional characteristics determines the speed of force development, the speed of movement and long-term operation without visible signs of fatigue, and without significantly reducing its efficiency, and it depends on the energy reserves and the functional quality of the energy chain that ensures the supply of muscle with energy for the work from adenosyntrifosfat. (Milošević, M., & Milošević, M. 2013). Vučić (2016) in his thesis states that aerobic ability represents the ability of an organism to produce, using aerobic metabolic processes (oxidative degradation of carbohydrates and free fatty acids), the energy necessary for physical work and is associated with activities in which all the necessary energy for muscle work is provided from oxidative metabolic processes. The size of the aerobic capacity depends of the functional state of all organic and metabolic systems involved in the transport of oxygen and the usage of it in making energy necessary for work. The basic physiological indicators of the aerobic functional abilities of the organism are the values of maximum oxygen consumption ($V0_2$ max) which implies the highest amount of oxygen the organism can spend in one minute (Matković & Ružičić 2009), and they are expressed in absolute (l / min) or relative units (ml / kg / min). Skinner & McLellan (1980) state that oxygen consumption in the aerobic threshold achieves a stable value which is the same as the intensity of work from moderate physical activity, and then the concentration of lactic acid in the working muscle and blood above the resting level increases, but the balance between accumulation and decomposition of lactate is still possible, and then a stable state of oxygen consumption and a stable concentration of lactic acid in the blood occurs.

Limited number of lessons intended for learning and improving the planned SFO program requires a constant search for new resources and methods, which means a greater level of science and its implementation, both in the learning process and in the process of student development. The program of the SFO is characterized by polystructural acyclic movements, which makes it very complex and intense, since its performance requires the frequent use of phosphagenic sources of energy. The program requires the complete control of aggression and movement in static and dynamic conditions that are reflected in the level of performance of techniques that is achieved, such as movements, shocks, blocks, lugs, cleansing and throwing, in as short period of time as possible. Although most of the SFO program contents are taking place under anaerobic conditions (movements are performed in the shortest time unit), there is the possibility of performing such motor programs that require significantly more time, and, therefore, different conditions (aerobic-anaerobic) in which motor programs would be realized. Of course, this involves activity in which there is increased oxygen consumption and depends mostly on the energy capacity of the organism which should provide sufficient number of repetitions of specific motor programs. High level of energy capacities gives opportunity, not only for long-term work and accepting the specific motor programs from the SFO, but also the possibility to use them practically. That means that high intensity is required for the efficient realization, and the intensity may last even for a few minutes. This is especially noticeable in

new and unforeseen situations, where it is necessary to reprogram the previously formed motor program, and that requires increased mental and physical activity. This is why a future security worker must achieve a high level of physical, technical, tactical, psychological and integral preparedness in performing his professional duty. Of course, this is a very difficult and complex task that takes the right amount of time in which the optimal number of repetitions of simple and complex situations is possible. Unfortunately, the optimum number of repetitions in the available training time, which would allow the automation of the elements of the technique and their connections, is simply not possible. It is considered that a high level of specific endurance would enable students to have more repetitions even in the limited training time, and that would significantly influence the acceptance of those motor programs. High level of all aspects of physiological abilities, as well as the high level of specific technical abilities, would enable future security workers to use the program from the SFO successfully. Blagojević, Dopsaj & Vučković (2006), based on previous studies, state that it is necessary that the aerobic capabilities of police officers are developed at the level of maximum oxygen consumption between 48 and 50 ml / kg / min, in order to perform standard police work efficiently. The same authors (2016) state that police officers with a higher level of general endurance, i.e. with a higher level of development of the aerobic energy system have a statistically significant easier compensation of the stressful situation and, in situations of specific fatigue, they recover from stress faster. It is obvious that the physical abilities of individuals must be at the appropriate level in order to successfully perform security tasks, and this is one of the reasons why there is more and more attention to the selection of candidates enrolling at the faculty. Considering the fact that students of the Faculty of Security Sciences (FBN) were subjected to tests of motor and functional abilities when enrolling in school, it is possible to say that after selecting candidates, they belong to a homogeneous group, which is why the idea for research came out precisely from the need to examine the impact of morphological characteristics in estimation of functional abilities and value of maximum oxygen consumption (VO_2max). Although it is known that the "actual" maximum oxygen consumption is best assessed in the laboratory, due to the high cost and impracticality of organizing it, the authors decided to evaluate functional abilities in field conditions. The assessment of aerobic abilities was based on the results of the maximum oxygen consumption achieved on the Cooper and Beep tests of the maximum multistage loading by 20 meters return run, which is also the subject of this research. During the selection of the candidates who wanted to enroll at the Faculty of Security Sciences, when assessing the functional, metabolic processes, a Cooper test is planned, since it implies continuity (by its time determination), while the Beep test of the maximum multistage loading by 20 meters return run is characterized by discontinuity, i.e. by the acceleration and deceleration of movement, which also characterizes the performance of motor programs from the SFO.

The research was conducted in order to determine the possibility of predicting the values of functional capabilities achieved during the performance of the Cooper test, based on the values of the functional capabilities achieved during the performance of the Beep test, for the purpose of considering the possibility of using the Beep test of the maximum multistage loading by 20 meters return run in the selection of candidates and assessing functional abilities during the implementation of the selection process for admission to education.

METHODS

The research lasted for seven days, during which the data was collected and classificated, and also statisticaly analysed. The sample of examinees consisted of 27 male students of the first year of the Faculty of Security Studies in Banja Luka, age 19 ± 0.6 years, which were clinically healthy, without visible physical defects or morphological aberrations. The basic anthropomorphological indicators of the tested sample were: TV 183.11 ± 5.12 cm, TM 81.25 ± 8.02 kg and ITM 22.35 ± 1.96. In order to determine the starting point for the selection of candidates and the realization of the classes for students (in order to obtain data on their basic morphological predispositions) it was necessary to determine whether, on the basis of somatic status, the results of the tests of functional abilities can be predicted, in order to avoid any kind of discrimination of candidates and participants. To determine morphological characteristics, the following variables were analyzed: body mass (TM), body height (TV) and body mass index (ITM). Those variables were included because they are indications that there are some eating disorders that lead to obesity or malnutrition, which may affect motor abilities and performance of the tests (and on the tests). The morphological characteristics were determined the day before the first test was performed using an anthropometer by Martin (body height) and the Body Composition Analyzer of the brand Tanita, model BC – 418 (body weight and ITM). Variables which were used for determining the level of functional abilities of the examinees were tests for assessing the level of endurance: Cooper test and Beep test of the maximum multistage loading by 20 meters return run (who's authors are Leger & Lambert 1982**)**, since those are two field tests used for assessing the functional abilities and the tests that were most commonly used in the practice so far. Both tests were realised according to the standard procedure on the athletic track, during the time period of seven days, so the Cooper test was conducted on the first day, and after five days (during which the examinees were disengaged from mandatory physical activity) the Beep test was used. The estimate of the maximum oxygen consumption for the Cooper test was determined on the basis of the formula for estimating the maximum oxygen consumption (given by Sudarov in 2007), which is: VO_2max (ml / kg / min) = (Running distance (m) - 504.9) / 44.73. The estimate of the maximum oxygen consumption for the Beep test was determined by adding the run-off level of the Beep test to the "beep calculator", which is calculated on the basis of the algorithm (Legel and Gadoury, 1989), where VO2max (ml / kg / min) = 18.043461 + (0.3689295 x TS) + (-0.000349 x TS x TS), and TS stands for the total number of intervals. Statistical evaluation of data was conducted on Pentium 4 PC, using the application statistical program SPSS (version 20.00). The basic measures of central tendency and measures of the dispersion of results were determined using the arithmetic mean (Mean) and standard deviation (Std. Deviation). In order to test the regularity of the data distribution, the Kolmogorov-Smirnov test was used, while correlation analysis was used to determine the correlation between variables of morphological characteristics and results, and the regression analysis was used for the prediction of results achieved in tests that were based on morphological characteristics. The correlation between the results of the Beep test and the Kuper test was determined by the correlation analysis.

RESULTS

Table 1. Descriptive statistics of the Beep test and variables used for estimating morphological characteristics

Variables	N	Min	Max	Mean	S D	KS test
AVIT	27	170,00	193,00	183,11	5,12	0,856
ATET	27	60,00	89,00	81,25	8,02	0,992
ITM	27	18,87	26,26	22,35	1,96	0,999
VO_2 BEEP	27	36,40	53,70	44,37	4,48	0,849
BEEP	27	980	2040	1453,33	276,68	0,903

Legend: N – number of examinees; Min. – minimal result; Max. – maximum result; Mean – arithmetic mean; Std. Deviation – standard deviation; KS (p) – value of probability of Kolmogorov – Smirnov test; AVIT – body height, ATET – body weight, ITM – body mass index, VO2 BEEP – maximum oxygen consumption achieved on the Beep test; BEEP – number of meters of running earned on the Beep test.

Table 1 shows the descriptive values of the variables used for estimating morphological characteristics and variables used for estimating the maximum oxygen consumption and the results of the number of meters running earned on the Beep test. It was determined that the distribution of the results was well grouped and that there were no significant deviations from the mean values of the results, which is also indicated by the value of the KS test. During the analysis of the differences between the minimum and maximum results, the highest ranking value was shown by the Beep test variable (BEEP), and the lowest value of the ranking is the maximum oxygen consumption of the Beep test (VO_2 B). In the Beep test, the highest score achieved by the examinees was 2,040 meters and the least was 980 meters, with a range of 1,060 meters between the minimum and the maximum score. During the analysis of the maximum consumption of oxygen in the Beep test, it was discovered that the subjects achieved a maximum value of 53.70 (ml / kg / min) and a minimum of 36.40 (ml / kg / min), with a range of 17.3 (ml / kg / min).

Table 2. Regression analysis of VO_2max Beep test and variables used for estimation of morphological characteristics

Model	R	R Square	Adjusted R Square	Std. Error
1	,231[a]	,053	-,070	4,64143

a. Predictors (Constans) AVIT, ATET, ITM
b. Dependent variable VO_2 BEEP

Table 3. Results of VO_2max on the Beep test based on morphological characteristics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	142,758	400,102		,357	,724
	AVIT	-,490	2,197	-,611	-,223	,826
	ATET	,476	2,714	,860	,175	,862
	ITM	-1,989	9,025	-,832	-,220	,827

a. Dependent Variable: VO_2 BEEP

Based on the regression analysis (Table 2), it is noticeable that the connection of morphology measures with the result of the maximum oxygen consumption achieved on the Beep test (VO_2 max) is r = 0.231 or 23%, while the rest of 77% is unexplained or influenced by other factors. When the analysis of the prediction of the results of the maximum oxygen consumption for the Beep test, that was based on the variable for the assessment of morphological characteristics (Table 3) was completed, it was visible that a statistically significant prediction about the results of maximal oxygen consumption on the Beep test (based on the applied variables for the assessment of morphological characteristics) was not determined.

Table 4. Regression analysis of the Beep test and variables used for the evaluation of morphological characteristics

Model	R	R Square	Adjusted R Square	Std. Error
1	,225[a]	,051	-,073	286,636

a. Predictors (Constans) AVIT, ATET, ITM
b. Dependent varijable BEEP

Tabela 5. Results of the Beep test (meters crossed) based on morphological characteristics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7849,050	24708,714		,318	,754
	AVIT	-32,127	135,673	-,650	-,237	,815
	ATET	31,783	167,615	,931	,190	,851
	ITM	-129,790	557,367	-,880	-,233	,818

a. Dependent Variable: BEEP

After analyzing the results of the regression analysis (Tables 4 and 5), it was observed that the correlation of morphological characteristics with the result achieved on the Beep test (meters crossed) is r = 0.225 or 22.5%, while the rest of 77.5% remained unexplained or under the influence of other factors. When the analysis of the prediction of the Beep test results (meters crossed) based on variables for estimating morphological characteristics was conducted, a

statistically significant prediction of the Beep test result (meters crossed) based on the applied variables for estimating morphological characteristics was not determined.

Table 6. Correlation of the predictor variables with the results of the Beep test (VO_2 mac and meters crossed)

		AVIT	ATET	ITM
BEEP	Pearson Correlation	-,150	-,220	-,179
	Sig. (2-tailed)	,456	,271	,371
	N	27	27	27
VO2 BEEP	Pearson Correlation	-,151	-,226	-,187
	Sig. (2-tailed)	,451	,256	,351
	N	27	27	27

BEEP – beep test, VO_2 BEEP – maximum oxygen consumption on the beep test

Based on the results of the correlation analysis (Table 6), it is clear that there is no statistically significant association of variables for estimating morphological characteristics with the result achieved on the Beep test and the maximum consumption of oxygen on the Beep test.

Table 7. Descriptive statistics of the Cooper test and variables used for the assessment of morphological characteristics

Variables	N	Min	Max	Mean	S D	KS test
AVIT	27	170,00	193,00	183,11	5,12	0,856
ATET	27	60,00	89,00	81,25	8,02	0,992
ITM	27	18,87	26,26	22,59	1,96	0,999
KUPER	27	2550	3100	2761,85	152,59	0,582
VO2 KUPER	27	45,40	57,60	50,10	3,38	0,563

Legend: N – number of examinees; Min. – minimal result; Max. – maximum result; Mean – arithmetic mean; Std. Deviation – standard deviation; KS (p) – value of probability of Kolmogorov-Smirnov test; AVIT – body height, ATET - body weight, ITM – body mass index, VO_2 KUPER – maximum oxygen consumption achieved on the Cooper test; KUPER – number of meters of running earned on the Cooper test.

Table 7 shows the descriptive values of the variables used for estimating morphological characteristics and variables used for estimating the maximum oxygen consumption and the results of the number of meters of running earned on the Cooper test. It was observed that the most part of distribution of results is fairly well grouped and that there are no significant deviations from the mean values of the results. The results distribution scores for the applied variables were tested using the Kolmogorov – Smyrnov test, and it is obvious that the obtained values were significantly above 0.00, which indicates that the hypothesis about the normal distribution of results should be accepted. After analyzing the results of the Cooper test, it is obvious that the highest score achieved by the examinees was 3,100 meters and the minimum score was 2,550 meters, with a range of 550 meters between the minimum and the maximum score. Analysis of the maximum oxygen consumption at the Cooper test shows that examinees achieved a maximum value of 57.60 (ml / kg / min) and a minimum of 45.40 (ml / kg / min) with a range of 12.2 (ml / kg / Min).

Table 8. Regression analysis of maximum oxygen consumption at the Cooper test and variables used for estimating morphological characteristics

Model	R	R Square	Adjusted R Square	Std. Error
1	,288[a]	,083	-,037	3,44911

a. Predictors (Constans) AVIT, ATET, ITM
b. Dependent varijable VO2 KUPER

Table 9. The results of maximum oxygen consumption on the Copper test based on variables used for estimating morphological characteristics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-331,758	297,321		-1,116	,276
	AVIT	2,124	1,633	3,512	1,301	,206
	ATET	-2,635	2,017	-6,308	-1,306	,204
	ITM	8,532	6,707	4,725	1,272	,216

a. Dependent Variable: VO_2 KUPER

Based on the results of the regression analysis (Table 8), it was concluded that the correlation between the variables for estimating morphological characteristics and the result of the maximum oxygen consumption achieved on the Cooper test is r = 0.288 or 28.8%, while the rest of 71.2% is unclear or influenced by other factors. After the analysis of the prediction of the results of the maximum oxygen consumption at the Cooper test based on the variables for the assessment of morphological characteristics (Table 9), it was concluded that a statistically significant prediction of the results of maximum oxygen consumption at the Cooper test (based on the variables used for the evaluation of morphological characteristics) was not determined.

Table 10. The regression analysis of the Cooper test and variables used for the evaluation of morphological characteristics

Model	R	R Square	Adjusted R Square	Std. Erro
1	,289[a]	,084	-,036	155,294

a. Predictors (Constans) AVIT, ATET, ITM
b. Dependent varijable KUPER

Table 11. Results of the Cooper test (meters crossed) based on the variables used for the evaluation of morphological characteristics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-14570,704	13386,688		-1,088	,288
	AVIT	96,407	73,505	3,539	1,312	,203
	ATET	-119,541	90,811	-6,352	-1,316	,201
	ITM	387,066	301,970	4,758	1,282	,213

a. Dependent Variable: KUPER

After analyzing the results of the regression analysis (Table 10), it was obvious that the correlation of the variables used for estimating morphological characteristics with the result achieved on the Cooper test (meters crossed) is r = 0.289 or 28.9%, while the rest of 71.1% is unexplained or influenced by other factors. After the analysis of the prediction of the results of the Cooper test (Table 11) based on the variables used for the assessment of morphological characteristics, it was concluded that there was not statistically significant prediction of the results of the Cooper test based on variables used for assessing morphological characteristics.

Table 12. Correlation of the variables used for the evaluation of the morphological characteristics and the results of the Cooper test

		AVIT	ATET	ITM
KUPER	Pearson Correlation	-,017	-,114	-,122
	Sig. (2-tailed)	,933	,573	,546
	N	27	27	27
VO2 KUPER	Pearson Correlation	-,018	-,114	-,121
	Sig. (2-tailed)	,927	,571	,548
	N	27	27	27

The analysis of the correlation shows that there is not any statistically significant correlation of morphological characteristics with the result achieved at the Cooper test (VO_2 max and meters crossed). Previous analyzes also show that these characteristics do not have a statistically significant correlation with the results obtained on the Beep test and the Cooper test.

Table 13. Correlation of the results of the Cooper (KUPER) test with the results of the Beep test

		KUPER	VO_2 KUPER
BEEP	Pearson Correlation	,645	,736
	Sig. (2-tailed)	,000	,000
	N	27	27
VO_2 BEEP	Pearson Correlation	,688	,712
	Sig. (2-tailed)	,000	,000
	N	27	27

Table 13 shows that a high correlation between the Beep test and the Cooper test was obtained and it shows maximum oxygen consumption achieved on the Beep test and the Cooper test. It also shows that there was high correlation between the Beep test and the maximum oxygen consumption at the Cooper test, and the maximum oxygen consumption achieved on the Beep test and the maximum oxygen consumption achieved on the Cooper test. These results indicate that it is possible to use one test instead of the other, depending on the testing conditions and the requirements.

DISCUSSION

Based on the value of the results of the anthropometric characteristics of the students shown in Table 1, we can conclude that the average height of the sample of 183.11 cm along with the body mass of 81.25 kg indicates the normal body mass index (22.59) of the study sample. Considering the fact that the sample of the study were students who were subjected to the selection process during the process of enrollment to faculty, we can consider that these values define the normal body mass and are turned to a non-fat component with a far greater percentage of muscle mass than the subcutaneous fat tissue. The values of the central and dispersion parameters for evaluation of the results achieved on the Beep test and the maximum oxigen consumption during the performance of the Beep test show a normal distribution and are indicators of the current physical capability of the students of the Faculty of Security Sciences. The results shown in Tables 2 and 3 are proof that there is no statistically significant qualitative correlation between predictor and criterion variables, which results in the impossibility of predicting the results of maximum oxygen consumption at the Beep test based on the applied variables used for estimating morphological characteristics. Almost identical results were shown in Tables 4 and 5, with the results achieved on the Beep test and the possibility of predicting the results achieved based on variables used for estimating morphological characteristics. After comparing the mean value of the results our students' obtained on the Beep test to the predicted mean values of the results of Australian police services who use the Beep test to check the functional abilities of their officers (South Australia Police 9.04, Air Service Australia 9.60, Royal Air Force 9.10, Western Australia Police 10.1, British Army 10.2 and Royal Marines 13.00), we found that the results of our students are below the predicted average, which indicates that the functional capabilities of our students assumed for the successful performance of official tasks are not at a satisfactory level, while comparison of the mean value of the results of the maximum oxygen consumption of our students achieved on the Beep test with the mean values of the results predicted for that age shows that our students achieved an average result, and, based on that, we can conclude that the aerobic-anaerobic abilities of our students are at an average level. Table 6 shows the results of the correlation analysis of the obtained results and the results of the maximum oxygen consumption on the Beep test with variables used for estimating morphological characteristics. Relatively low level of correlation coefficients confirms the match of the results of the regression analysis of the criteria in the current prediction space. The values of the Pirson correlation coefficient show that the highest correlation between the achieved result (poor negative correlation) and the results of the maximum oxygen consumption on the Beep test was obtained with the variable of weight, which indicates that subjects with lower body weight achieved better results and, therefore, a higher level of maximum oxygen consumption. However, although this study did not show that longitudinal dimensionality affects the results of tests used for estimating maximum oxygen consumption, some previous researches gave certain results related to this problem. According to Jakovljević, Ljubojević, Karalić, Gerdijan & Vukić (2014), the influence of anthropometric characteristics on the conditional parameters of the footballers was researched (Wong, Chamari, Dellal & Wisloff, 2009), which proved that there was a statistically significant correlation between body height and the results on the Beep test (p = 0 , 26), as well as between body height and maximum oxygen consumption on the Beep test (p

= 0.35). The results of the correlation between the variables used for the evaluation of morphological characteristics and the results obtained at the Cooper test and the results of the correlation between the variables used for estimating the morphological characteristics with the maximum oxygen consumption at the Cooper test are shown in Tables 7, 8, 9, 10 and 11. The same as with the previous results, we can conclude that there is no statistically significant correlation between the predictor and the criterion variables, which also results in the impossibility of predicting the results achieved on the Cooper test and the results of the maximum oxygen consumption on the Cooper test. These results can be explained by the fact that this is a selected sample of subjects whose morphological characteristics values move within the normal distribution. It should be mentioned that Mitrovic and his associates (2015) conducted a survey in which they examined the correlation between the state of physical nutrition and the level of aerobic fitness of members of special police units. The authors had a sample of 72 male examinees of the average age of 34.2 ± 5.2 years, an average working life of 12.5 ± 4.9 years and an average body mass index of 27.59 kg / m2, examining the correlation between the body mass index and maximum running at 3000 meters as one of the variants of the Cooper test. The conclusion of the research was that there are statistically significant differences between selected and trained police officers between the state of nutrition and the speed of running in the aerobic energy strain regime, in the opposite proportional direction. This correlation is explained at the level of 33.4% of the total variance, which leads to the conclusion that a higher level of body nutrition indicates a statistically significant level of aerobic performance. The results of the correlation analysis of the obtained results and the results of the maximum oxygen consumption at the Cooper test with variables used for estimating the morphological characteristics are shown in Table 12. Based on Pirson's coefficient of correlation, obtained results are almost identical as in Table 6. If we compare the results of our students with the values that are expected by the criteria for the same age on the Cooper test, we can see that the state of competence of our students is good. In order to have a more complete picture of the functional abilities of our students, it is necessary to go through the studies of the abilities listed above that were conducted on a similar sample of examinees. If we compare mean values of the results of our respondents achieved on the Cooper test with the average values of the results achieved by students of the eleventh generation of the The Academy of Criminalistic and Police studies from Belgrade (Blagojević, Dopsaj & Vučković 2006), we can see that the results our students achieved are approximate to the results of the students of the eleventh generation of The Academy of Criminalistic and Police studies from Belgrade. Table 13 shows the correlation of the results of the Beep test and the Cooper test and the correlation of the results of the Beep test with the maximum oxygen consumption at the Cooper test. The table shows that there is a very high correlation between the results of the Beep test with the results of the Cooper test and the maximum oxygen consumption at the Cooper test, as well as that there is a very high correlation between the maximum oxygen consumption on the Beep test with the results of the Cooper test and the maximum oxygen consumption at the Cooper test.

For efforts that last longer period of time, the main determining factor is not only the maximum oxygen consumption that the respondent can achieve on testing, but it is also very important to determine on which level the maximum aerobic capacity can be used. The higher the level of training is, the greater is the percentage of possible aerobic capacity utilization, which indicates that the examinee who is able to execute oxygen consumption at a higher level will be more capable. In the Cooper test, motivation has an extremely important role and is one very important factor of success. We simply can not ignore the fact that the test is relatively strenuous and long lasting, so objective indicators of the condition can only be expected with highly motivated individuals. It should also be stressed that the Cooper test is, practically, possible to run only on the athletic track, because in other measured areas the examinees get so far apart that, after a few minutes, the examiner is not able to track all the examees and record their score after a 12-minute period expires. The Beep test is one of the most popular test procedures that is currently used in the assessment of aerobic endurance (Leger & Boucher,

1980; Leger & Lambert, 1982; Leger, Mercier, Gadoury, & Lambert, 1988). Because of the fact that the test is performed in a way that the speed of the run is defined by the sound signal coming from a CD, computer or other audio output, it is impossible to achieve the wrong result on the Beep test, due to the excessive running intensity or the underestimation of your own abilities. The test is normally performed indoors, but it can also be performed in an open space. However, precisely this feature (that the Beep test can be performed indoors) is a significant comparative advantage over other aerobic endurance tests. The biggest advantage of this test is the fact that it is possible to test a larger group of examinees in a small area at the same time, where the experience of the examinee has no impact on the test, while minimal changes in running speed enable examinees to estimate the required intensity of work very precisely. Even though most of the SFO program content is taking place under anaerobic conditions (movements are performed in the shortest time unit possible), we should not forget the possibility of performing such motor programs that require more time, and (due to that fact) other conditions (aerobic – Anaerobic) in which motor programs will be realized. This, of course, involves activity in which there is increased oxygen consumption and it mainly depends on the energy capacity of the organism, which should provide sufficient repetition of specific motor programs. High level of energy capacities gives the opportunity not only for long-term work and development of specific motor programs from the SFO, but also the possibility of their practical usage. Therefore, if we want our students to fully accept specific motor programs and the possibility of their practical usage, they must have appropriate energy abilities in the process of learning and improvement, which would enable them both optimal work intensity and optimal number of repetitions. Obtained informations can be used to make and optimize the SFO plan and program, while creating homogeneous groups in the classroom, which would ensure continououity of learning and improvement, as well as in the selection of candidates for enrollment at the FSS.

CONCLUSION

The research was conducted in order to determine the influence of morphological characteristics on the results of the Beep test and the Cooper test and the maximum oxygen consumption on the Beep test and Cooper test, in order to confirm the influence of the defined variables as justified variables in the diagnostic field tests, and to observe the state of the functional students' abilities on the basis of the value of the Beep test and Cooper test, but also the maximum consumption of oxygen on the Beep test and Cooper test. After the obtained results and their processing by the appropriate statistical procedure, it was concluded that there is no statistically significant association of variables used for the evaluation of morphological characteristics with the results achieved on the Beep test and Cooper test, and that there is no statistically significant connection of the variables used for the evaluation of morphological characteristics with the results of maximum oxygen consumption on the Beep test and Cooper test. Furthermore, it was determined that there is no a difference in the maximum oxygen consumption between the tests that were applied, which can be explained by the specific characteristics of the applied tests. Based on the results obtained after this research and due to the characteristics of the Beep test and the Cooper test, as well as due to the possiblity of measuring them in different conditions, the authors suggest that the functional capabilities of the candidates in the process of selecting candidates for admission to the Faculty of Security Sciences should be tested by the Beep test. Having this in mind, it is necessary to have another (similar) research to determine, with more precise measurements, how long and in what operating mode each individual can be efficient, not only in acquiring teaching contents, but also for programming and controlling training procedures in the field of SFO.

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DEVELOPMENTAL CHARACTERISTICS OF PRESCHOOL AGED GIRLS FROM DIFFERENT URBAN AREAS

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Short scientific paper

SUMMARY

Human growth and development are under the influence of both genetic and environmental factors. Longitudinal and transversal dimensions of skeleton are, to a large extent, genetically determined contrary to circular dimensions, body weight and skin fold. The aim of this research was to determine developmental differences between the girls from Vranje and Užice. This research was conducted in kindergartens of Vranje and Užice. The sample comprised 136 girls, 72 of whom were 5 (+ eight months) years of age from Užice, and 64 of whom were 5 (+ seven months) years of age from Vranje. We used standardized instruments to measure the anthropometric characteristics, according to the methodology recommended by the International Biological Program (Weiner & Lourie, 1981). The average height of the girls from Vranje is 118, 6±5, 37 cm, and of the girls from Užice 119, 4±5, 46 cm. The girls from Užice were taller than those from Vranje, but the difference in height is not statistically significant. The results have shown that there is statistically significant difference in leg length. The average leg length of the girls from Vranje is 63,2±4,55cm, and those from Užice 64,7±3,96 cm. The girls from Vranje have greater pelvic width than the girls from Užice, which is statistically significant. We have not observed statistically significant differences concerning other measured anthropometric variables.

Key words: developmental characteristics, girls, preschool age, urban environment.

INTRODUCTION

The basic task of preschool institutions is to provide an optimum contribution to the physical growth and development of children, the development of their motor and functional abilities, as well as to provide the necessary conditions for living and being creative within a community (Bala, Popović & Madić, 2005).

Through the study of morphological characteristics we obtain primary information on the human somatic status which is determined by anthropometric dimensions. The question is, under which circumstances are these dimensions additionally developed (for example, physical activity or other ecosocial factors. Anthropometric characteristics differ in terms of gender, age, and genetic-ecosocial conditions (Gajev, 2009).

The growth and development of children is greatly influenced by genetic and environmental factors of the surroundings in which they develop and grow. External factors are important for achieving the genetic maximum of a polygenetic growth pattern. The influence of external factors (the environment) at the preschool age is greater when compared to the subsequent periods of growth and development. Of the external factors, the social status of parents is of great influence for the optimum growth and development of the child. Spontaneous and organized forms of physical activity at the preschool age are important, both from a motor, but also cognitive and functional aspect of development. In this phase it is important for physical activity to be of the appropriate intensity, suited to the age and physical abilities of the child, both in terms of calendar and biological age (Đurašković, 2009).

At this age the annual growth in terms height growth and other anthropometric indicators of children is not that pronounced, and so we could say that the child is in a relatively stable phase of growth and development (Đorđić, Bala, Popović & Sabo, 2006). Physical growth and development to a certain extent can also depend on the environment in which they takes place Here we include whether rural or urban environments, higher and lower altitudes (Nikolić & Paranosić 1980). Healthy life habits are formed during the preschool and young school age, and growth and development take place in relatively stable stages, unlike the pubescent phase. With the aim of the objective evaluation of growth and development, we rely on a method of standards used to compare the obtained anthropometric parameters with the same indicators of participants of the same age and gender (Mišigoj-Duraković, 2008). It is necessary to also take into consideration the fact that a child is not a "small man" and for that reason has its own growth pattern of morphological and functional-physiological characteristics. Information on the growth of children in terms of their height and body mass is often used to evaluate their health status and their BMI, as well as to evaluate the tempo of their growth and development (Božić-Krstić, Rakić & Pavlica, 2003).
This research has as its aim to determine the differences in the anthropometric characteristics of preschool children from the urban environments of Vranje and Užice.

METHODS

The overall sample consisted of 136 girls, 72 of whom had an average age of 5 years and 8 months from Užice, and 64 participants with an average age of 5 years and 7 months from Vranje. All of the participants attended the same preschool and were healthy during the measuring of their anthropometric characteristics.
The evaluation of anthropometric characteristics included measures of longitudinal, transversal and circular dimensionality of the skeleton, as well as subcutaneous fatty tissue. The following measures were taken:

I – To evaluate the longitudinal dimensionality of the skeleton:
1. body height (BH),
2. leg length (LL),
3. arm length (AL),

II – To evaluate the transversal dimensionality of the skeleton:
4. shoulder width (SW),
5. pelvic width (PW),
6. hip width (HW),

III – To evaluate the circular dimensionality of the skeleton:
7. body mass (BM),
8. body mass index (BMI),
9. average thorax volume (ATV),
10. upper arm circumference (UAC),
11. lower leg circumference (LLC),

IV – To evaluate subcutaneous fatty tissue:
12. upper arm skin fold (UASF),
13. back skin fold (BSF) and
14. abdominal skin fold (ASF).

The measuring of all these morphological parameters was carried out in accordance with the International Biological Program (Weiner & Lourie, 1981).

RESULTS

Tables 1. and 2. show the descriptive statistical parameters of the preschool girls from Užice and Vranje. Following their analysis, based on the value of the arithmetic means and minimum and maximum score, we can conclude that the results of all the morphological measurements had normal distribution, except the back skin fold and abdominal skin fold for both sets of girls.

Table 1. The basic statistical parameters of the anthropometric characteristics of preschool-aged girls from Užice

Varijable	N	AM	MIN	MAX	SD
AGE	72	5.8	5.0	7.0	0.67
BH	72	119.4	107.0	132.5	5.46
LL	72	64.7	56.0	73.5	3.96
AL	72	51.3	44.8	57.7	2.99
SW	72	26.6	23.8	30.5	1.42
PW	72	19.1	16.0	23.0	1.39
HW	72	20.8	17.2	27.7	1.77
BM	72	22.9	16.0	35.0	4.02
BMI	72	16.02	11.70	21.63	2.02
ATV	72	58.5	50.6	71.0	4.26
UAC	72	17.8	14.4	22.6	1.78
LLC	72	36.2	26.3	54.0	4.43
UASF	72	12.1	6.2	21.2	3.64
BSF	72	7.5	3.6	19.0	3.60
ASF	72	8.0	3.0	23.4	4.70

Legend: N – number of participants; AM – arithmetic means; MIN – minimum value; MAX – maximum value; SD – standard deviation.

Table 2. The basic statistical parameters of anthropometric characteristics of preschool girls from Vranje

Varijable	N	AM	MIN	MAX	SD
AGE	64	5.7	5.0	7.0	0.50
BH	64	118.6	109.8	131.6	5.37
LL	64	63.3	52.2	73.5	4.54
AL	64	51.5	42.5	61.8	3.10
SW	64	26.7	23.6	31.2	1.60
PW	64	19.6	16.9	22.9	1.42
HW	64	21.1	18.9	25.5	1.45
BM	64	22.8	17.0	32.0	4.13
BMI	64	16.15	12.76	22.32	2.25
ATV	64	58.8	50.2	70.5	4.70
UAC	64	17.9	15.0	23.2	1.96
LLC	64	36.9	31.0	47.0	4.28
UASF	64	12.8	6.0	20.6	3.92
BSF	64	8.3	3.0	19.4	3.92
ASF	64	9.2	3.0	24.0	4.69

Legend: N – the number of participants; AM – arithmetic means; MIN – minimum value; MAX – maximum value; SD – standard deviation.

By analyzing the differences (Table 3) of the mean values of the anthropometric characteristics of preschool girls from Užice and Vranje, which belong to different urban environments, we can conclude that in all the measured characteristics there are no statistically significant differences, except for leg length, which is statistically significantly

greater for the girls from Užice (p=0.049), and pelvic width, which is statistically significantly greater than for the group of girls from Vranje (p=0.012). By studying the numeric differences between the female participants of these two urban environments, a difference can be noted. The girls from Užice had somewhat greater values for height and leg length, had narrow hips and pelvic bones, had somewhat smaller circular measurements and subcutaneous fatty tissue in comparison to the girls from Vranje. Based on these data, we can conclude that the girls from Užice were taller and have a gracile build (are the mesomorphic-ectomorphic type), and the girls from Vranje were somewhat shorter and had the characteristics of endomorphic build (according to Sheldon).

Table 3. The difference between the arithmetic means and anthropometric characteristics of preschool girls from Užice and Vranje

Varijable	Preschool Užice		Preschool Vranje		t	p
	AM	**SD**	**AM**	**SD**		
AGE	5.8	0.67	5.7	0.56	1.634	0.104
BH	119.4	5.46	118.6	5.37	0.874	0.383
LL	**64.7**	3.96	63.2	4.55	1.984	**0.049***
AL	51.3	2.99	51.4	2.81	-0.081	0.935
SW	26.6	1.42	26.7	1.56	-0.250	0.802
PW	19.1	1.39	**19.7**	1.41	-2.524	**0.012***
HW	20.8	1.77	21.1	1.45	-0.927	0.355
BM	22.9	4.02	22.8	4.10	0.180	0.857
BMI	16.02	2.02	16.18	2.37	-0.414	0.679
ATV	58.5	4.26	58.9	4.68	-0.544	0.586
UAC	17.8	1.78	17.9	1.94	-0.445	0.656
LLC	36.2	4.43	36.7	4.21	-0.713	0.476
UASF	12.1	3.64	12.7	3.91	-0.969	0.333
BSF	7.5	3.60	8.3	4.12	-1.176	0.241
ASF	8.0	4.70	9.2	5.01	-1.405	0.162

Legend: AS – arithmetic means; SD – standard deviation; t – value of the student t-test; p – significance coefficient of the differences in arithmetic means; * - a statistically significant difference at the $p < 0.05$ level

DISCUSSION

By analyzing the means (Table 1), the arm length (51.3 cm) of the preschool girls from Užice ranges within the normal values for that age, but their body height (119.4 cm) and leg length (64.7 cm) are somewhat greater than the norm (Gerver & DE bruin, 1996) and the values recorded in studies which dealt with the development characteristics of girls of this age (Bala, 2009; Mišigoj-Duraković, 2008; Đurašković, 2009). In the case of transversal measurements, we can also conclude that they range within the values which are considered normal for this age, considering the values reported in previous studies. It is clear that there is a significant difference between our data and the values for pelvic width reported by Gerver & DE bruin (1996), with the values reported in our study being somewhat greater. However, this can be considered the effect of acceleration over a period of almost twenty years. Body mass and the body mass index range within the normal values for the level of nourishment of girls this age, as do the circular measurements (thorax volume, upper arm volume and upper leg volume). The values of the subcutaneous fatty tissue are somewhat greater than those determined in the aforementioned studies, which leads us to the conclusion that girls aged 5 to 7 from Užice have a somewhat greater body height, but smaller percentage of muscle mass in relation to the body fat component, considering that their body mass index is within the normal range, and in accordance with the nourishment criterion (Cole**,** Bellizi, Flegal &

Deitz, 2000). By analyzing the means (Table 2), the body height (119.4 cm), arm length (51.3 cm) and leg length (64.7 cm) of the preschool girls from Vranje range within the normal values for that age group (Gerver & DE bruin, 1996) and the research results which dealt with the developmental characteristics of girls of this age group (Bala, 2004; Mišigoj-Duraković, 2008; Popović, 2008; Đurašković, 2009). In the case of transversal measurements, we can also conclude that they range within the normal values for that age, compared to the values reported in previous studies, except for the values of hip width (21.1 cm), which is somewhat greater than the normal value for that age. Body mass and the body mass index range within the normal values of the level of nourishment for girls this age, as do the circular measurements (thorax volume, upper arm and upper leg volume). The values of subcutaneous fatty tissue are slightly greater than those determined in the aforementioned studies, which leads us to the conclusion that girls aged 5 to 7 from Vranje have normal body height, but a reduced percentage of muscle mass in relation to the overall mass component, considering that their body mass index is within the normal, and in accordance with the nourishment criteria (Cole**,** Bellizi, Flegal i Deitz, 2000). The growth and development of humans is influenced by internal and external factors. Of all the internal factors, the genetic one has the greatest influence. However, this influence is not identical for all latent body dimensions. The longitudinal dimensionality of the skeleton is to the greatest extent under the influence of inherited genetic material, and it ranges from 85 to 98%, depending on the author (Malacko, 1985; Kolarov, 2005; Đurašković, 2009). According to Nikolić & Paranosić (1980) physical growth and development to a certain extent can also depend on the environment in which it is taking place, and this includes the rural and urban environment, higher and lower altitude levels, climatic conditions and so on.

The study we carried out included a sample which corresponded to the previous samples, and consisted of preschool children aged 5±1, all from the urban environments of Užice (411 ma) and Vranje (480 ma), which can be found at approximately equal altitudes. It was determined that height and the analyzed longitudinal and transversal dimensions of the body are within the ranges of normal growth and development for the analyzed period of development (Gerver & DE bruin, 1996; Mišigoj-Duraković, 2008), with the addition that the girls from Užice are somewhat taller and have longer legs in comparison to girls from Vranje, and that the latter group of girls had somewhat higher values for hip and pelvic width. These differences can probably be explained by the physical identity of the populations from western and easter Serbia, guided by the knowledge that western Serbia is an area of the predominantly dinarian type (according to Vladimir Dvorniković, as cited in Popović), while in eastern Serbia we find the slovene (nordic) anthropological type (according to Jovan Cvijić, as cited in Bogdanović). The dinarian anthropological type has the characteristics of high, gracile individuals, with a conspicuously longer lower body, while the slavic (nordic) type is characterized by shorter stature and a longer upper body part.

CONCLUSION

By comparing the anthropometric characteristics of preschool girls aged five to seven from two urban environments which can be found at the same altitude, but in different parts of Serbia, Užice in the western part and Vranje in the eastern part, we can conclude that the girls from western Serbia are somewhat taller, and have longer legs in comparison to the girls from the eastern part, which have a wider pelvis and hips. The girls from Užice belong to the mesomorphic-ectomorphic type, while the girls from Vranje are somewhat shorter and have the characteristics of the endomorphic build.

This conclusion can be explained by the previous data collected on the different physical characteristics of the population of western and eastern Serbia, which confirm that the dinarian anthropological type is dominant in western Serbia, and the slavic (nordic) anthropological type is dominant in eastern Serbia. Under the assumption that the influence of the other internal and external factors on the growth and development of children was the same for both samples, we can conclude that the physical identity of certain anthropological types has a significant influence on the growth and development of children.

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SPORT PARTICIPATION AFTER INJURY OF ANTERIOR CRUCIATE LIGAMENT

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Professional paper

SUMMARY

One of the most common problems involving the knee joint is an anterior cruciate ligament injury or ACL tear. Of the four major knee ligaments of the knee, an ACL injury or rupture is the most debilitating knee ligament injury. Ligament injuries in the knee joint often lead to premature end of sport career in athletes. Treatment following ACL rupture can be operative or conservative. In both cases, main goal of patient is to reach the best functional level, without risk of re-injury or degenerative changes in knee joint. Return to high level of sport performance is the indicator of successfull treatment. Rehabilitation represents crucial part of threatment. Knowledge on healing processes and knee biomechanics after injury and recostruction, along with physiologial aspects of training processess, is very importmant for the construction of training programs. Current rehabilitation programs use immediate trainings, i.e. exercises for the increasement of range of motion. In most cases, rehabilitation programs are being created relative to time which is needed for the returnment to certain sport activities. In this article, we would like to provide an overview of the current strategies for sport participation and rehabilitation after ACL injury. Operation, along with completed rehabilitation program, which is sport-specific, should lead to functional stability of knee joint. Furthermore, adequate muscle strength and performance can be presented as main criterias for the returning to sport activities. Another factors, such as additional injuries, sociological and psychological barieres, can also influence the returnement to sport activities. Therefore, they should be considered durring rehabilitation process and evaluation of the treatment.

Keywords: physiotherapy,recovery, injuries, sport medicine, rehabilitation

INTRODUCTION

Elite athletes are exposed to greater risk of anterior cruciate ligament (ACL) injuries (Roos, Ornell, Gardsell et al., 1995; Bjordal, Arnly, Hannestad et al., 1997). Furthermore, risk of injury is greater among (Roos, Ornell, Gardsell et al., 1995; Bjordal, Arnly, Hannestad et al., 1997; Myklebust, Maehlum, Engebretsen et al., 1997*;* Hewett, Lindenfeld, Riccobene et al., 1999).

Injury of ACL lead to static and functional instability, which provoke changes in mouvement patterns (Berchuck, Andriacchi, Bach et al., 1990*;* Beard, Dodd, Trundle et al., 1994*;* Kvist & Gillquist, 2001) and increase risk of suffering from osteoarthritis (Gillquist & Messner, 1999).

In most cases, ACL injuries lead to premature end of sport career (Roos, Ornell, Gardsell et al., 1995; Bjordal, Arnly, Hannestad et al., 1997). Study of (Roos, Ornell, Gardsell et al., 1995) showed that only 30% of football players were active 3 years after ACL injury.

Durring operation, after ACL injury, ruptured ligament is being replaced with graft in order to reduce anterior translation of tibia in sagital plane. The main purpose of recostrunction is to restore knee function, without any pain and degenerative changes in relation to operation.

It is not neccessare to operate all athletes with ACL rupture. Most common criteria are age of the athlete, additional injuries of ligaments and menisci, functional and sport requirement in relation to knee, as well as readiness and willigness of the athlete to participate actively in post-operative rehabilitation.

1. Knee joint

The knee joint is one of the strongest and most important joints in the human body. It allows the lower leg to move relative to the thigh while supporting the body's weight. Movements at the knee joint are essential to many everyday activities, including walking, running, sitting and standing.

Knee joint consists of three bones, thigh bone (*femur*), kneecap (*patella*) and tibia. Tendons connect the knee bones to the leg muscles that move the knee joint. Ligaments join the knee bones and provide stability to the knee. Morphologicaly it can be said that knee is composed of patelofemoral and femorotibial joint, with two sections, external and internal.

Knee joint is protected with well inerved articulated tunica, which proximaly extends from articular surface of femur for patella (*facies patellaris femoris*) and forms suprapatellar knee pocket (Fulkerson & Hungerford, 1990).

1.1. Anterior cruciate ligament

Anterior cruciate ligament is interarticular and extrasynovial articular structure. It originates from a wide base on the anterior aspect of the tibia and inserts into the lateral condyle of the femur on its posteromedial aspect (Micheo, Hernandez & Seda, 2010). It has two bundles, anteromedial and posterolateral bundle (Norwood & Cross, 1979).

Anterior cruciate ligament is the main brake of tibial anterior translation and secundar line of defence on forces of great intensity which work towards the formation of valgus and varus deformities (Ninković, 2011).

All ligaments, including ACL, have just like tendons, structure which is generated , i.e. formed by forces which act on them. Tendons and ligaments have the ability of morphological adaptation due to changes in their mechanical surrounding which may arise from injuries, illnesses or inadequate training.

Anatomy of the ACL has great significance in the rehabilitation and reconstruction process. An appropriate reconstruction and comprehensive recovery would eventually enable the reconstructed ACL to mimic its original anatomy as much as possible, leading to improved functionality (Markatos, Kaseta, Lallos, Korres & Efstathopoulos, 2013).

2. Treatment after ACL injury and safe returning to sport activities

The main reason why is it so important to carry out rehabilitation after ACL injury is acquirement of good functional stability and bast possible level of functionallity, as well as reducement of risk for re-injury. Training programs are focused on healthy and on injured leg, then on muscles of hip and trunk which are crucial for whole body stabilisation.

Functional stability of knee joint depends on mutual influence of passive structures and dynamical systems. It is also dependent on coordination and proprioception. Deficit of

muscle strength (Muellner, Alacamlioglu, Nikolić et al., 1998; Osteras, Augestad & Tondel, 1998; Risberg, Holm, Tjomsland et al., 1999a; Risberg, Holm, Steen et al., 1999b; Mikkelsen, Werner & Eriksson, 2000; Henriksson, Rockborn i Good 2002; Keays, Bullock-Saxton, Newcombe et al., 2003) and proprioception (Friden, Roberts, Ageberg et al., 2001) can be seen after ACL injury.

2.1. Neuromuscular training

The main purpose of neuromuscular training is to improve the ability of neural system to generate optimal and much faster muscle contraction, then to improve coordination and balance, as well as re-learning of certain skills and mouvement patterns (Risberg, Mork, Jenssen et al., 2001). The importance of neuromuscular training has been showed in following prospect controlled studies where the incidence of ACL injuries was much lower in athletes who undergo proprioceptive training (Caraffa, Cerulli, Projetti et al., 1996; Hewett, Lindenfeld, Riccobene et al., 1999).

Closed chain kynetics exercises had become very popular and they are very offten recomanded in rehabilitation after ACL injury because it is belived that they are much safer than the other exercises (Shelbourne i Nitz, 1990; Palmitier, An, Scott et al., 1991; Bynum, Barrack i Alexander 1995; Panni, Milano, Tartarone et al., 2001; Henriksson, Rockborn i Good 2002; Pinczewski, Deehan, Salmon et al., 2002; ; Jansson, Linko, Sandelin et al., 2003).

However, there is no enough evidence to support this statement (Beynnon & Johnson, 1996; Fitzgerald, Axe & Snyder-Mackler, 2000; Morrissey, Hudson, Drechsler et al., 2000; Mikkelsen, Werner i Eriksson 2000).

2.2. Range of motion

Most of the authors began with training for improvement of Range of motion immediate after operation. Early post-operative mobilisation of knee joint eliminates adverse effects of imobilisation on graft stifness and consecutive muscle strenght. Braces limitates range of motion and in some cases prevent antero-posterior translation. When braces were used in the first 6 weeks after surgery, there were no beneficial effects on knee joint (Nielsen & Yde 1991; Feller, Bartlett, Chapman et al., 1997; Kartus, Stener, Kohler et al., 1997; Muellner, Alacamlioglu, Nikolić et al., 1998; Möller, Forssblad, Hansson et al., 2001).

2.3. Full weight-bearing on injured leg

In 21 of 34 reviewed articles, full weight-bearing on injured leg was allowed immediately after surgery, depending on pain, swelling in the injured knee joint and on degree of extension loss.

Effects of early weight-bearing on knee laxity still has not been tasted in details. Study of (Tyler, McHugh, Gleim et al., 1998) compared patients who immediately after surgery began with full weight-bearing activities with patients who started doing that 2 weeks after surgery. After 7 months of following they didn't find any differences among these two groups of patients.

3. When to return to light and contact activities?

Decision on weather to return to sport-specific activities or not is in most casses emirically based. Unnecessarily delaying the return to unrestricted activities is undesirable, but so is a premature return because it can lead to graf injury.

In the reviewed studies, patients were usaually allowed to return to light activities such as running at 2-3 months after surgery and to contact sports after 6 months. It is

necessary to test musle strenght i level of performances 6 months after surgery because most of athletes return to sport at this period of time.

According to IKDC (*International Knee Documentation Committee*) lesss than a 10% deficit at the one-leg jump test imlies to normal knee function. Of course, these limits must be considered together with other criteria for returning to sports such as asymptomatic knee (no pain or effusion, full range of motion), associated injuries and psychologial factors (Morrey, Stuart, Smith et al., 1999*;* Risberg, Holm, Steen et al., 1999a*;* Shelbourne & Davis, 1999*;* Ross, Irrgang, Denegar et al., 2002).

From previous statements we can conclude that an athlete should only return to sports practices with the approval and under the supervision of their health care provider. When available, it is desireable that athletes work closely with their team's certified athletic trainer.

4. Recommendations for return to sports

One of the main indications for the reconstruction of ACL is that patient is being alowed to return to spot activities (Webb, Corry, Clingeleffer et al., 1998). Beside that, rate of return to a high level of athletic activity has been a critical indicator of the seccesss of ACL reconstruction (Deehan, Salmon, Webb et al., 2000).

However, the question has been raised whether the only effect of ACL reconstruction in some individuals is ,, to give the patient enough security to reach the goal of going back to strenuous sports, and then ruining the knee?" (Gillquist & Messner, 1999).

In order to safely return to sport activities, athletes must complete rehabilitation program which is in accordiance with following requirements, presented in figure 1 of this article.

Figure 2. Factors and criteria that influence a safe return to sports

<table>
<tr><td rowspan="4">REHABILITATION</td><td>Muscle strength and performance
Evaluated by isokinetic test and one leg hop test <10-15% deficit</td><td rowspan="3">SAFE RETURN TO SPORTS</td><td>Social i.e. family, pregnancy, finished college, etc.</td><td rowspan="4">OTHER FACTORS</td></tr>
<tr><td>No pain or effusion full ROM
Evaluated by: clinical examination</td><td>Psychological factors i.e. motivation, scholarship, fear of re-injury, etc.</td></tr>
<tr><td>Functional knee stability
Evaluated by: clinical examination and objective measurements ex motion analysis</td><td>Static knee stability
Evaluated by: clinical examination and objective measures ex KT-1000</td><td>Associated injuries i.e. menisci, cartilage, other ligaments, etc.</td></tr>
<tr><td colspan="3">SURGERY</td></tr>
</table>

CONCLUSION

The trend in rehabilitation after ACL injury is healing towards accelerated programmes with an early return to sports. In addition, return to sport activities in considered as a valid indicator of successful treatment. However, both the question of whether the return to sport can be safe and the reason why the patient does not return to sports mus be taken into consideration.

The goal of reconstruction is to improve stability but even after ACL reconstruction, sagittal translation may be increased. Furthermore, this is not correlated to knee function or a return to sports. Many patients can participate in sports despite a large difference in sagittal transla tion or a torn ACL, emphasising the importance of functional stability and good muscle function.

Based on current knowledge and patient compliance, some criteria should be fulfilled before allowing the patient to return to sports. These are a completed rehabilitation with adequate muscle strength and performance and as a result, knee functional stability. Surgery should result in a stable knee evaluated by static measures of sagittal translation. Other factors, such as associated injuries and social and psychological hindrances may influence the return to sports.

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SPECIFIC TRAINING ADJUSTMENTS FOR YOUNG DISCUS THROWERS AS A PREREQUISITE FOR ACHIEVING ELITE PERFORMANCE

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Professional paper

SUMMARY

The aim of this paper is to demonstrate a model of specific discus thrower training adjustments, as well as depicting the most important characteristics of achieving elite performance. The most important aspects of the training programme have been taken into account, specifically those applied by discus throwers who have achieved significant improvements in their season. The improvement is indicated in the result of 58, 34 m (within the year 2016) compared with the result of 47,72m achieved in 2015, with the disc weight of 1,5 kg in the category U 18, representing a significant difference of 10,62 m. The result was achieved at the European Athletic Championship in the youth category. The attained result is likewise a personal best, and has been achieved during the finals of European Championship as perceived.

Key words: discus throw, elite performance, training programme

INTRODUCTION

The speed of result improvement in athletic throwing events is preconditioned by the application of scientific research. Achieving superior sport performance is a direct result of athlete's adjustment to the various types and methods of training (Bompa, 2001). During the competition, to be exact during the most important competition, an athlete is to achieve top results which requires a sequence of cumulative activities to be performed so as to deliver maximum sport performance at the most important annual competition. During this last

development phase, a child goes through a transition from youth to an adulthood (Andrijašević 2010). The discus throw is an athletic event, by which contestants go through a long competition period. Al Oerter, an American disc thrower, is an example of an athlete who has succeeded in attaining a long and prosperous career, with a result of 69,46m achieved when he was 43 years of age. If a disc thrower is to maintain a high level of performance during his lifetime, it is necessary to design a qualitative and thorough preparation. Disc throwers who achieve good results as junior contestants but later are unable to achieve not as nearly expected results, are not a rare case. In that sense, it is not unlikely that we have "skipped some steps" in the long-run planning and programming, nor the fact that the training started earlier than is intended for the adult athletes – seniors (early specialisation). Maintaining a high level of physical fitness enables a development of better expertise in later stages. Of course, one needs to take into account the modern tendency for reducing the age of sport readiness. The subject whose parameters are applied in this paper are those of a disc thrower who has during his first year (out of two) won a fourth place at the European Athletic Championship in the U 18 category in Tbilisi (GEO), achieving a result of 58,34m, and who is likewise a member of the national team of Bosnia and Herzegovina in the event of discus throw and shot put in the pioneers and youth category.

DISCUSSION

In the previous year the best result of 47,72m in the event of 1,5 kg discus throw was achieved during the Balkan Alethic Championship for the youth category. The best result of 58,34m for the season (2016) was as well a personal best. During the semi-finals the achieved result and a personal best was 57,14m (up to that moment the personal best 56,04m was attained at Croatian Open Throwing Championship in Split). The overall seasonal improvement of 10,62m is an assumption for a successful performance (medal – winning) for the following year at the World Championship in Kenya. An important attribute of athlete performance is the ability to tolerate different levels of frustration which emerge prior, during and after the competition (Bowerman, Freeman & Gambeta, 2012). Top performance has been planned for the European Championship in Tbilisi (Georgia), where it was ultimately achieved, as well as for the following season competition, which is World Championship in Nairobi (Kenya). Taking into consideration that the subjects in this season are one year older contestants (the three top rated), and also

considering their peers and upcoming results, expectations are realistic that a medal will be won at the World Championship.

Considering that an athlete has entered into a specialization phase and can handle greater training and competition demands, exercises which aim at elite performance development have been carefully introduced (Bompa, 2001). During training planning, which is a main task of every coach, special attention has been placed to a disc throwing technique and primary movement exercises which athletes use during their technical performances. Diet is based on taking natural base products and attaining nutrition from healthy sources.

Based on the analysis of the motor ability tests, taken in 2015, prior to the beginning of the season, as well as the analysis of previous trainings, it has been concluded that disc thrower during his current development period has exhibited lower level of some general and specific motor abilities.

Table 1 Motor test results for 2015 and 2016, as well as the plan for 2017

Test	2015	2016	difference 2016/17	Plan for 2017	Elite senior disc throwers (modal characteristics)
Power snatch (strength)	65kg	80kg	15kg	95kg	135-140kg
Deep Squat	135kg	160kg	25kg	180kg	270-280kg
Bench Press	110kg	120kg	10kg	140kg	240-260kg
Double-leg triple jump	635cm	705cm	70cm	810cm	10,00-10,50
30m sprint – flying start	4,58s	4,33s	- 0,25s	4,10s	
3kg static shot put, like discus throw	21,45m	26,60m	5,15m	32,50m	45m
5kg shot put, over the head	13,67	17,10m	3,43m	21,00m	21-22m (7,26kg)
1,5kg static discus throw	37,20m	46,55m	9,35m	53,50m	
2kg discus throw from rotation	40,03m	48,28m	8,25m	54,00m	68-72m
1,5kg discus throw from rotation	**47,72m**	**58,34m**	**10,62m**	**65,00m**	

Diagram 1. Test results for general strength assessment in 2015 and 2017, as well as the plan for 2017

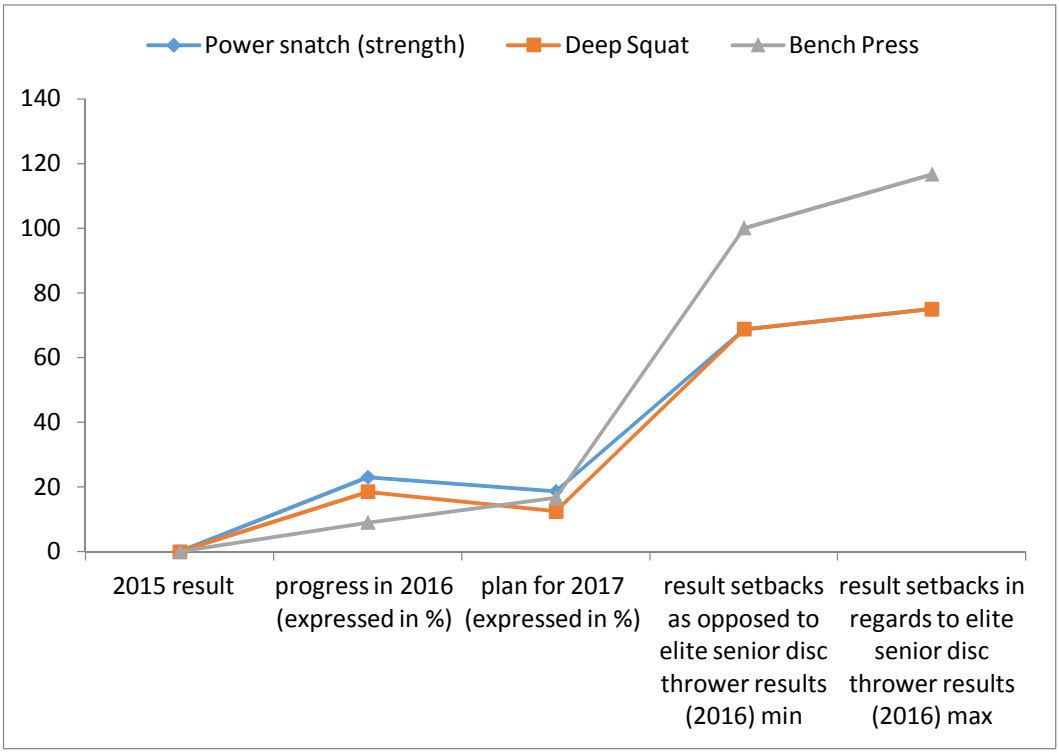


Diagram 2. Test results for explosive strength assessments in 2015 and 2016, as well as the plan for 2017

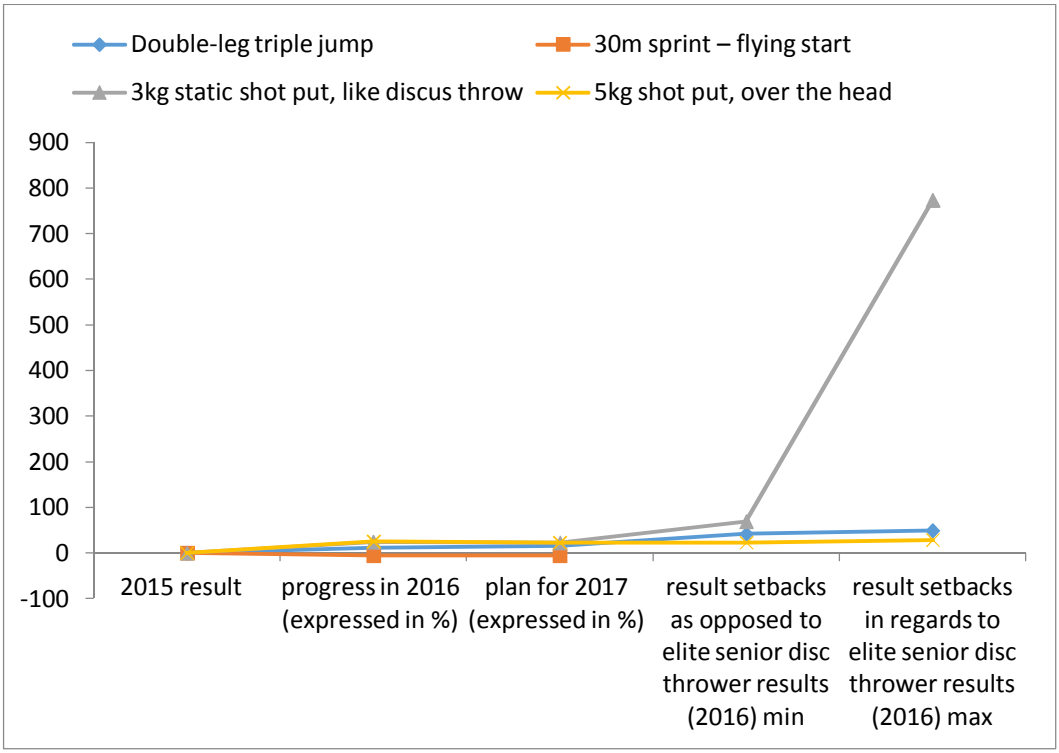
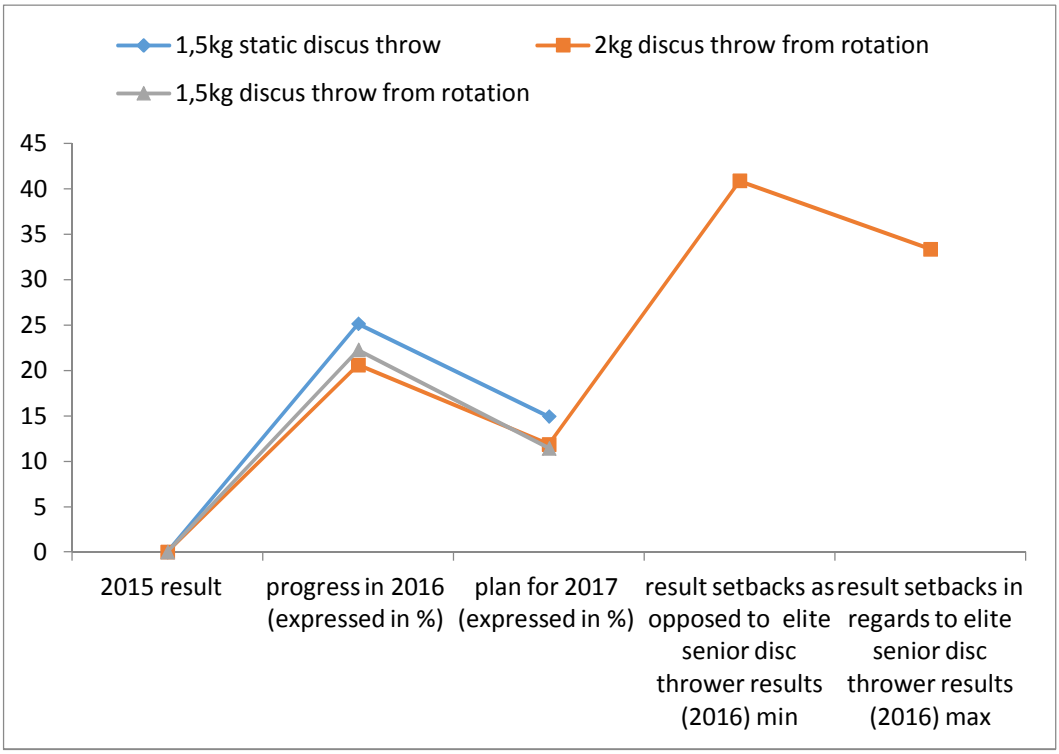


Diagram 3. Results achieved for the discus throw event (indicator of sport performance) in 2015 and 2016, as well as the plan for 2017



The deficits exhibited in the motor ability tests (static triple jump, sprint 30m) often limit the technical performance. During this period, athletes should have a high level of technical performance, which should be insisted upon if one is to use motor abilities to its maximum. A good indicator of a high level technique is the difference between static throwing and throwing from rotation. The greater the difference, the thrower can exhibit greater velocity during release. The disk thrower category U18 is able to throw 1,5 kg disc. In trainings, apart from using the prescribed weight of 1,5 kg, one can use lighter (1kg, 1,25 kg), or heavier training tools (1,75 kg, 2 kg). Coach's creativity and skill is reflected in composing the appropriate throwing distribution for different training tools throughout the entire year, as well as planning the numbers and lengths.

During the competition period the following activities have taken place:

- the number of overall throws was reduced (different throwing techniques, such as shot put in front, over, into the air, etc.), but the number of shots in half-rotation and full rotation was increased;

- Throwing intensity was gradually increased for the last 10 days right before the start of the competition when the intensity was lowered from 90 – 95 % to 70-80%;
- Training sessions with the application of weights have for the last month been assigned to specific disc thrower exercises (extended arms stretching on the bench, body twist with shoulder weights, plate side bends). The most applied exercises were those of explosive character (snatch, clean, half squat jumps, bend jumps), initiated from the knees or from the middle of thighs with a minimum requirement of keeping the weights steady after the lift;
- for the last month 2kg disc throw was excluded, while the smaller weight was included instead (1,25kg) 2 times per week, and 1,75 kg once a week. Competition weight was applied twice a week.
- the number of exercises for stretching specific musculoskeletal segments which partake in throwing activities were increased;

U18 Category is a youth category for contestants of 16 and 17 years of age.

Even though the training itself is taking on the characteristics of a senior contestants' training, one must honour the specificities of a young body so as not to lead to stagnant results. During the specialisation phase, as a phase of sport development, the focus has been placed on selected sport training. Foundations laid out during the specialization phase will enable a better performance for the elite phase (Bompa, 2001).

CONCLUSION

Based on the analysis of results achieved in 2015 and 2016, one can state that significant improvement in disc throwing results have been achieved. The results attained were during the most important competitions in a season, which is due to optimum dosage of intensity and volume during the season, as well as specific adaptations made for the planned sport performance. There is still enough place for further improvement in results, because not all condition training capacities have been applied. Great number of parameters do not satisfy the modal characteristics laid down in some tests, which should represent one of the tasks for the improvement of bad performance. Prerequisite for further throwing improvement is constant technique development and increasing general and specific abilities. By the end of "sport

education", many athletes who have developed solid foundations and wish to achieve top results in a specific sport, will be able to specialize in it. (Bompa, 2005).

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