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Original research article

LUMBAR AND ABDOMINAL MUSCLE ISOMETRIC POTENTIAL IN VOLLEYBALL CADETS*

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Abstract. *The aim of this study was to analyze the possible differences in spinal lumbar and abdominal muscle isometric potential of prospective male and female volleyball players, the cadet selection of Serbia, aged 14 ± 6 months. The sample included 42 participants with a mean height of 177.38 cm (SD ± 6.36), and mean weight 56.02 kg (SD ± 7, 28), 15 male and 27 female participants. Isometric muscle potential assessment was conducted using four standardized motor movement tasks. In addition to the descriptive statistics used, as basic statistics, the t-test for independent samples was used to compare the mean values of parameters measured in two different groups of athletes – volleyball players (girls – boys). The descriptive indicators of the sample suggest greater values of deep spinal muscle isometric potential among the boys in all the studied variables. The results obtained by the t-test of independent samples indicate that a statistically significant difference exists between the mean results in the variables of trunk flexor static contractions and trunk extensor static contractions, at the 0.001 level. For the other two variables, the values indicate that the difference between genders is not significant but accidental.*

Key words: *muscle strength, trunk, volleyball players.*

INTRODUCTION

The structure of motor requests which are characteristic for a volleyball game consists of frequent changes of direction, numerous jumps, spike jumps, etc. The above-mentioned characteristics require adequate preparation and high performance in terms of sporting

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techniques and specific physical preparation. In the area of motor movement, there are three basic forms of muscle strain expression, i.e. manifestation of muscular energy (potential): isometric muscle potential, ballistic muscle potential and repetitive muscle potential.

Isometric muscle potential is expressed through the static mode that is reflected in the ability to endure and maximally maintain muscle strength while there is no movement, and muscle belly approximation. Typical motor activities for this mode of expressing strength are various types of endurance, balance, standstill, holding movement or great load positions. The mechanisms of strength manifestation, especially isometric muscle potential, are primarily related to morpho-functional characteristics of the muscle: the amount of employed muscles, the size of their cross-sections, the structure of their fibers at the muscle cell excitation, impulse transfer speed through the synapse etc. as well as biochemical and metabolic processes in the employed muscle and the presence of energy resources in them (Mikić, 2000; Stojiljković, 2003).

This type of muscle potential is present during static posture of the body or any part of it. When we first mention this, one usually thinks of the postural muscles that are responsible for the proper functioning of the locomotor system as well as other parts of the body, especially the lumbar and abdominal regions. In the postural muscles of the back, red (slow-twitch) muscle fibers dominate. The diameter of the muscle fibers is slightly smaller, with smaller sarkoplasm but with greater efficiency for oxygen, which allows them to work longer without fatigue. These muscles mainly work under anaerobic conditions. There is an assumption that the endurance of postural muscles is directly related to the density of red muscle fibers in the lumbar region and that the lack of static strength and ability to resist fatigue is a risk factor for the occurrence of various changes in that part of the spinal column. However, this assumption is presumably still in the domain of research (Bogduk, 2005).

During the process of growth and development, the spinal column is one of the points of the locomotor system that is sensitive to the effects of external factors, and there are frequent cases of power reduction of abdominal and back muscles. Data on anthropometric characteristics and the endurance of the muscles of the lower back and abdomen are the subject of many studies that dealt with the influence of certain factors (Salminen, Okansen, Maki, & Pentti, 1992; Balague, Dutoit, & Waldburger, 1988), external factors (Balague et al., 1995; Viry, Creveuil, & Marcelli, 1999; Watson, et al., 2002), as well as the status of the spinal cord (Dejanović & Živković, 2008).

The general consensus is that a statistically significant correlation has been noticed between anthropometric characteristics and the isometric endurance of the lumbar and abdominal muscles in the studied population (Dejanović, et al., 2008). There is much scientific and empirical evidence supporting the claim that there are differences between the body size of athletes involved in various sports and games and the events within the same sport. The age, height and body size of the athletes at the national and international level are significant from several aspects, and a significant linear connection between back muscles strength and body height of the participants was determined.

Height, weight and other anthropometric characteristics are essential for success in certain sports. In some sports, less height and weight are necessary to achieve maximum results, while in others increased height and weight are necessary for excellent results. For success in basketball, height is of great importance. Volleyball players need to be tall, with well-developed muscles, for they must show the required physical properties of the rally (Parizkova, 1991; Mafulli, 1992). Soccer players have been determined to belong to a

group in which morphological characteristics show considerable variability, so the logical conclusion is that the previously mentioned characteristics are not of great importance for success. In the area of mobility, it was determined that football players are characterized by high frequency and speed of movement as well as by a high level of coordination. By determining the differences in morphological space of the above mentioned athletes, data was obtained that statistically significant differences between selected soccer and volleyball players exist in the measured morphological characteristics (Nejić, Stanković, & Joksimović, 2009).

Given that the game of volleyball requires a certain level of individual anthropological characteristics of young volleyball players to successfully act on situational conditions, and that the interdisciplinary approach in scientific study is the principal methodological orientation, the subject matter of study in the field of sports is anthropological status. As there are specificities of certain sports that originate from differences in their competitive structure, so is there a constant need for the continued theoretical research and practical testing of these specificities. In volleyball, this means testing some anthropological abilities and characteristics.

The goal of this research is to test what the current practice has shown. When it comes to male and female players, whether to a greater or lesser degree, there are some differences in body size and specific motor abilities, and whether the efficiency of test realization is indirectly and directly affected by many factors, not only from the motor area, but the area of complete anthropological status of volleyball players. Therefore, the aim of this study was to determine the possible differences between the isometric potential of the lumbar and abdominal regions of the spinal column among the cadet male and female volleyball team of Serbia.

THE METHOD

The experimental procedure

A transversal study was carried out on the representative sample of prospective male and female volleyball players of the cadet selection at the level of entire Serbia, aged 14 ± 6 months. The cadet selection of Serbia was conducted by the Trainer Organization as part of the Volleyball Federation of Serbia.

The sample of participants

The sample of participants included 42 volleyball players of mean height 177.38 cm (SD ± 6,36), and mean weight 56,02 kg (SD ± 7.28), 15 male and 27 female participants. Their descriptive characteristics are presented in Table 1. All of the participants gave their consent in writing after they had been informed of the testing protocol.

Procedures

Isometric muscle potential assessment was conducted using four standardized motor movement tasks, covering the following areas: static contraction of the flexors of the torso (FLEKS), static contraction of the extensors of the torso (EKSTE), static contraction of the left flexor of the torso (STKOL), and static contraction of the right flexor of the torso

(STKOD) (Mikić, 2000). Of the anthropometric parameters, body height and weight were used, and the measurement carried out in accordance with the guidelines of the International Biological Programme (Weiner, & Lourie, 1969). The instruments were of standard production and were calibrated before measuring.

The tests for assessing the isometric strength of the flexor, lateral flexor and extensor forces of the participants were carried out in the prone position on the side, with the participant lying on their forearm (the lateral flexors), lying down on the stomach with the body outside the area of support (extension of the torso) and seated position with the angle between the torso and thigh at 90 degrees, and the angle between the leg and thigh at 90 degrees (Mikić, 2000).

Warm-Up Protocol

All of the participants gave written consent after being informed of the test protocol. The study protocol was approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Nis, according to the revised Declaration of Helsinki. The participants were tested by the author of this work in a sports hall. During the test, the air temperature ranged from 22° C to 25° C. Testing began at 10 am and finished at 1 pm. Tests of standard anthropometry (height, body weight) were carried out first, and the players were instructed on how to conduct the further testing of muscle groups.

The tests that isolate these muscle groups are very difficult to construct, but the next group of tests represent the best solution. The fact that each has a statistical significance of 0.98 speaks in favor of them (McGill, Childs, & Liebenson, 1999). One muscle group per day was tested, or one test per day, so the participant would be rested and results more valid and objective. Before the testing, the participant first took part in a warm-up protocol for a period of up to 15 minutes, as the authors McGill et al. (1999) proposed, in order to activate the muscles, to obtain more valid and objective results and prevent possible injury to the muscle. Each participant performed a standard 15-minute warm-up consisting of general movements and dynamic and static stretching.

Test of static left and right torso lateral flexor muscle endurance-variables (m. Obliquus Externus et Interims Abdominis, m. Quadratus lumborum) STKOL *and* STKOD

The participant takes the prone position, leaning on the side of the forearm. Their legs are stretched in a slight step forward position, so that the upper leg is positioned slightly forward. The body needs to be stretched without any sort of bending. The other, free arm is positioned on the opposite shoulder. Measuring is stopped when proper posture is distorted, i.e. when the participant touches the ground with their hand. Time is measured in seconds with an accuracy of 0.10 sec.

Test of static torso flexor muscle (m. Rectus Abdominis, m. Psoas, M. Illiacus) - variable FLEKS

The participant leans back on the bench that is at an angle of 50 degrees in relation to the plane. One of the measuring assistants fixes the participant's feet on the ground so that the knees are angled at 90 degrees to the ground. The participant fixes their hands to the chest, crossed. The other assistant holds the bench and in agreement with the third one, who measures the time, slips the bench 10 cm away from the participant's back. Measuring stops when proper posture is distorted, i.e. when the participant touches the bench with any part of his body. Time is measured in seconds with an accuracy of 0.10 sec.

Test of static torso extensor muscle endurance (m. *Erector Spinae) - variable* EKSTE

The participant takes the position on a bench or the vaulting box, relying on their hips and legs that were fixed by a second measuring assistant. The arms are fixed on the chest, crossed, hands touching the shoulders. Measuring stops when proper posture is distorted, i.e. when the participant is no longer able to hold the horizontal position. Time is measured in seconds with an accuracy of 0.10 sec.

Statistical analyses

For statistical analysis, the Statistical Package for the Social Sciences SPSS was used (v18.0, SPSS Inc., Chicago, IL) in order to achieve clear interpretation of the obtained results. In accordance with the set aim, the basic descriptive statistics were used, along with the t-test for independent samples, used to compare the mean values of the measured characteristics of two different groups of athletes – volleyball players (girls - boys).

RESULTS

Table 1 Descriptive statistics of the players

Height (cm)	Weight (kg)	STKOL (min)	STKOD (min)	FLEKS (min)	EKSTE (min)
177.38±6.36	56.02±7.28	1.21±0.56	1.37±0.72	1.95±0.85	2.26±0.98

Results presented as AS ± SD.

Legend: FLEKS – Static torso flexor muscle contraction in min., EKSTE – Static torso extensor muscle contraction in min., STKOL – Static left torso lateral flexor muscle contraction in min., STKOD – Static right torso lateral flexor muscle contraction min.

Table 2 The mean value and standard deviation of the studied motor variables analyzed in relation to gender

	STKOL(min)	STKOD (min)	FLEKS (min)	EKSTE (min)
Boys	1.40±0.30	1.55±0.59	2.39±0.87	2.86±0.72
Girls	1.10±0.64	1.26±0.76	1.69±0.74	1.93±0.95

Results presented as AS ± SD.

Legend: FLEKS – Static torso flexor muscle contraction in min., EKSTE – Static torso extensor muscle contraction in min., STKOL – Static left torso lateral flexor muscle contraction in min., STKOD – Static right torso lateral flexor muscle contraction min.

According to the mean, minimum and maximum results in all tests for the assessment of the spinal lumbar and abdominal region isometric potential, we can state the following:

The isometric torso flexor potential (FLEKS) for boys is higher than for girls, which is shown by the mean value [2.39±0.87>1.69±0.74]. The torso extensor (EKSTE) also shows the same results, that the mean value for the girls is smaller than for the boys [1.93±0.95<2.86±0.72].

The mean value of static right torso flexor contractions (STKOD) show slightly better results for the boys when compared to the girls [1.55±0.59>1.26±0.76], as well as for the mean value of the static left torso flexor contractions (STKOL), which also shows better results for the boys [1.40±0.30>1.10±0.64].

Table 3 The t-test significance of differences between the boys and girls in relation to the studied variables

	Levene's Test for Equality of Variances		t-test for Equality of Means					
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Stkol	17.12	0.0	1.68	40	0.10	0.29	–0.05	0.65
Stkod	0.81	0.37	1.28	40	0.20	0.29	–0.16	0.75
Fleks	0.50	0.48	2.73	40	**0.00***	0.69	0.18	1.21
Ekste	3.32	0.07	3.28	40	**0.00***	0.93	0.35	1.50

*Difference significant at $p \leq 0.05$.

By means of the T-test for independent samples, the test results for spinal lumbar and abdominal isometric potential among male and female volleyball players was compared. A statistically significant difference was determined between the mean results for the variables of static torso flexor contractions (FLEKS) and static torso extensor contractions (EKSTE) at the 0.001 level. The mean value of this difference is 0.69 and 0.93. The lower level of the interval with a probability of 95% is 0.18 and 0.35, and for the upper is 1.21 and 1.50, and they contain the accurate amount of this difference.

The other two variables of 0.10 and 0.20 values indicate that the difference between the genders is not significant, but accidental.

DISCUSSION

The descriptive indicators of the research sample indicate the greater values of spinal lumbar and abdominal isometric potential for the boys in all the studied variables when compared to the girls.

By means of the T-test for independent samples, the testing results were compared and a statistically significant difference was determined between their mean results for the variables of static torso flexor contractions (FLEKS) and static torso extensor contractions (EKSTE), at the 0.001 level. The other two variables indicate that the difference between the genders is not significant, but accidental. The authors also point out these and similar research results. The results for the isometric endurance of the lumbar and abdominal muscles indicate several statistically significant multiple correlations between the anthropometric characteristics and durability of the lumbar extensors. The multiple correlations of the anthropometric characteristics and abdominal muscle endurance were not statistically significant (Živković & Dejanović, 2008). The research results obtained from 98 cricket players from various universities in India could be cited. They suggest that back strength has a positive correlation with leg strength, but not with the other anthropometric characteristics. The results differ from most studies dealing with the relations between anthropometric characteristics and deep spinal muscles isometric endurance (Koley, Khajuria, & Melton, 2010).

Nikolaidis, Ziv, Arnon, & Lidor (2012), by means of data analysis, reached three main discoveries. They indicated the existence of differences in the physiological

characteristics between three age categories of adolescents and senior Greek female volleyball players. The participants were divided into 3 age groups – younger than 14, 14-18, as well as over 18. The authors indicate the great need for the coach to use this information in designing training, strength and conditioning programs.

The aim of another study was to test the reliability of the parameters and characteristics of muscle strength among both genders. Fifteen males and fifteen females participated in this study. The authors concluded that maximum strength for men is higher than for women for all the applied load (Demura, Shinichi, Miyaguchi, & Kazuyoshi, 2009).

Noyes, Barber, Sue, Smith, & Campbell (2011) determined whether specific training can lead to improvements in neuromuscular indices in thirty-four high school volleyball players aged 14.5 ± 1.0 years. The authors concluded that the implemented program significantly improved the strength of the lower extremities, vertical jumping ability and abdominal strength. They also suggested that such a program could be implemented among the high school volleyball player population.

On testing the physiological and anthropometric characteristics of one hundred fifty-three junior volleyball players who compete at elite, semi-elite and novice levels, it was determined that male players were taller, heavier, leaner, and had more height, better speed, agility, and muscle strength than female players. These results provide data and include standards for junior volleyball players who compete in the elite, semi-elite and novice levels. Given the improvement of muscle strength in the lower extremities, agility and increased level of game play, and given the importance of these characteristics in competitive games, coaches should work on these characteristics to improve the very game of young male players (Gabbett & Georgieff, 2007).

In determining the status and development of the motor abilities of the pioneer and cadet male population selection of Serbia in the period from 1996 to 2004, based on a sample of 353 male players it was concluded that in this period the generations from 2003 and 2004 had significantly better results in the area of explosive strength. These data clearly indicate that the level of this ability increased significantly in the period since 1996 to 2004. The assumption behind this increase is that the requirements of national teams contributed to better work in the development of explosive strength of the club selections, and more demanding criteria of selection for the national team of Serbia (Stojanović, Nešić, & Karalić, 2008).

The physical abilities and characteristics of adolescent volleyball players were tested on twenty-nine adolescents, aged 12-17. The results indicate that age, experience, body mass, strength and balance are the key to physical abilities and characteristics of adolescent girls who play volleyball. Potentially, this type of information will allow coaches and athletes to identify possibilities specific for age categories and the evaluation of players who are still in development (Melrose, Spaniol, Bohling, & Bonnette, 2007).

Based on a study sample of 40 selected females, their morphological structure and functional abilities were determined. It can be concluded that, except for height, for selection we require a high capacity for jumping and explosive strength not only of the muscles of the lower and upper extremities but back muscles as well (Mladenović-Ćirić & Đurašković, 2008).

In order to determine the impact of year-long systematic physical exercise on physical fitness, the content of which included the game of volleyball, the fitness of the students of the Pedagogic Academy in Sombor - Serbia was studied, at the start of the first year and the end of the school year. The following were tested: speed, agility, explosive strength,

coordination, repetitive force and static force. The results showed that the fitness of the students, except speed, influenced by regular practice, the content of which was volleyball, remained at the starting level (Rodić, 1996).

On a sample of 50 male and 55 female volleyball players, aged fourteen, summer camp participant candidates for the Serbian national team, a study with the aim of a comparative analysis of some anthropometric measures and motor abilities was carried out. The results indicate that the differences in all the variables are statistically significant in favor of the male players, except for the hyperextension variable, where the female players had better results (Stojanović, Nikolić, Đurašković, & Milkić, 2005).

PRACTICAL APPLICATIONS

Based on the previous analysis, we can conclude that male players are stronger, heavier, have more height, better speed and agility than female players. The results of this study regarding static contraction of the right and left lateral flexors of the torso show the lack of statistical significance between male and female cadet volleyball players. This offers support for greater involvement of the large muscle groups among male volleyball players in relation to female volleyball players, and the need for inclusion of these data in the training process. In addition, coaches need to improve these characteristics of volleyball players of this particular age group, in order to improve the play of the individual, team and later, the game itself.

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IZOMETRIJSKI POTENCIJAL DUBOKIH MIŠIĆA KIČMENOG STUBA KOD ODBOJKAŠA KADETSKOG UZRASTA

Cilj rada je istraživanje eventualnih razlika između izometrijskog potencijala lumbalne i abdominalne regije kičmenog stuba perspektivnih odbojkaša i odbojkašica, članova Kadetske selekcije Srbije, starosti do 14 god. ± 6 meseci. Uzorak ispitanika je obuhvatio 42 ispitanika koji su imali prosečnu visinu od 177,38 cm (SD ± 6,36), a prosečna težina 56,02 kg (SD ± 7,28), od čega 15 muškog pola i 27 ispitanika ženskog pola. Procena mišićnog izometrijskog potencijala sprovedena je pomoću četiri standardizovana motorička kretna zadatka. Od statistickih metoda primenjena je osnovna deskriptivna statistika, kao bazična statistika, a upotrebljen je t-test za nezavisne uzorke, radi poređenje srednje vrednosti obeležja merenog u dve različite grupe sportista - odbojkaša (devojčice - dečaci). Deskriptivni pokazatelji na istraživanom uzorku ukazuju na veće vrednosti izometrijskog potencijala dubokih mišića kičmenog stuba kod dečaka u svim istraživanim varijablama. T-testom nezavisnih uzoraka upoređeni su rezultati ispitivanja i utvrđena je statistički značajna razlika između njihovih prosečnih rezultata u varijablama statičke kontrakcije pregibača trupa i statičke kontrakcije opružača trupa, na nivou 0,001. Kod druge dve varijable vrednosti ukazuju da razlika između polova nije značajna, već slučajna.

Ključne reči: *snaga mišića, trup, odbojkaši, kadeti.*