ANALYSIS OF LOWER LIMBS EXPLOSIVE POWER IN VOLLEYBALL PLAYERS REPRESENTING DIFFERENT SPORTS LEVEL

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- force
- vertical jump height

Abstract:
Introduction: Power generated by muscles of the lower limbs strongly determines the vertical jump height, and this in turn may determine the effectiveness of the block, the spike, the topspin and floating serves, and thus can be crucial in achieving success in the game. The aim of the study was to analyze the power of the lower limbs and the vertical jump height in volleyball players, depending on the sports level and the volume of training loads. **Material and methods**: The study included 38 volleyball players. They were divided into two groups differing in the sports level and the volume of training loads. The power of the lower limbs, strength, velocity and vertical jump height was investigated using a three-dimensional accelerometer MyoTest Pro during the execution of CMJ test (counter movement jump). **Results**: There were no statistically significant differences in the parameters measured during the CMJ test between players representing different sports level. **Conclusions**: The research results do not confirm the existence of statistically significant differences in the vertical jump height, power and strength of the lower limbs between volleyball players of different sports level and the volume of training loads.

INTRODUCTION

The effectiveness of the player in volleyball depends on the combination of many factors. The researchers studied the effect on the effectiveness of a player such factors as: anxiety and self-confidence [Kais, Raudsepp 2004], mood [Newby, Simpson 1996], caffeinated energy drinks [Pérez-López et al. 2015], music during warm-up [Eliakim et al. 2007], technical and tactical abilities [Palao et al. 2007, Drikos et al. 2009, Afonso et al. 2010], physiological and anthropometric characteristics [Duncan et al. 2006, Stojanović et al. 2012]. These latter seem to be of key importance. Volleyball players usually present an above average height, slim figure and great fitness, especially in terms of strength, power and jumping ability [Gabbett, Georgieff 2007, Palao et al. 2014, Białoskórska et al. 2016]. These parameters are an essential part of the evaluation and selection of volleyball competitors and should be integrated and applied when planning annual training programs for volleyball players [Duncan et al. 2006]. Power generated by muscles of the lower limbs strongly determines the vertical jump height, and this in turn may determine the effectiveness of the block, the spike, the topspin and floating serves, and thus can be crucial in achieving success in the game [Forthomme et al. 2005, Markovic, Jaric 2007, Sheppard et al. 2008, Borràs et al. 2011, Buśko et al. 2013]. During a 5 set match a player performs from 65 to 136 jumps [Borràs et al. 2011]. On average, setters are the players with a higher number of jumps (136

jumps), followed by middle hitters (97 jumps), opposite hitters (88jumps), and side hitters (65jumps). The relationship between strength, power and sport performance of athletes has been documented by several investigators [Cronin et al. 2000, Stone et al. 2003]. The values of these parameters may change during the season due to specialized training loads [Marques et al. 2008, Milić et al. 2008, González-Ravé et al. 2011, Stojanović et al. 2012].

The aim of the study was to analyze the power of the lower limbs and the vertical jump height in volleyball players, depending on the sports level and the volume of training loads.

MATERIAL AND METHODS

The study included 38 volleyball players representing the academic teams of Wroclaw. The players were characterized by different sports level and different training loads. They were divided into two groups. The first was formed by 17 subjects currently playing in the second league teams - TEAM 1. These subjects were trained 6 times a week for two hours a day. In the second group there were 21 volleyball players who play exclusively in academic teams - TEAM 2. In this group workouts were carried out 2 times a week for 2 hours.

Table 1. Anthropometric characteristics of the subjects.

VARIABLE	TEAM 1 (n = 17)		TEAM 2 (n = 21)	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Age (years)	21.6	3.2	21.2	2.2
Body height (cm)	191.6	7.5	187.7	8.1
Body weight (kg)	85.6	8.3	81.3	8.8
BMI	23.1	1.4	23.2	2.0

The power of the lower limbs, strength, velocity and vertical jump height were investigated using a three-dimensional accelerometer MyoTest Pro v.1.3.2 during the execution of CMJ (counter movement jump) test. Reliability of this method was confirmed by Choukou et al. [Choukou et al. 2014]. The players were given instructions before taking the test and had an opportunity to have an experimental trial. The proper jumps were done in sports shoes on hard ground, after a previous dynamic warm-up. On a player's hips was fastened a belt with the accelerometer to which the body mass data was entered. The CMJ test consisted on performing five maximum counter movement jumps with hands on the pelvis. The cycle of the jumps was regulated by the sound emitted by the accelerometer.

Measurements were performed in the evening, during a training session in the competition period.

The following parameters were measured:

- power – P (W)
- concentric force – F_{con} (N)
- eccentric force – F_{ecc} (N)
- velocity – V (m/s)
- jump height – H (cm)

We analyzed the maximum and average values of these parameters.

Results from conducted research were depicted in a form of mean and standard deviation. Distribution of data was verified due to Shapiro-Wilk test. In order to compare the results obtained in the two groups the *t*-test for independent samples was performed. Statistically significant differences were found when $p \leq 0.05$. Statistical analysis was performed using the computer program Statistica 10.0 (StatSoft).

RESULTS

The results obtained by the volleyball players of both groups during the execution of five maximum vertical jumps (CMJ) are shown in Table 2.

Table 2. The mean values (± SD) of parameters measured during the CMJ test in both groups; *max* - maximum value in five jumps; *mean* - mean value of five jumps; *p* - level of statistical significance for the *t*-test for independent samples.

Variable	TEAM 1	TEAM 2	*t*	*p*
P max (W)	56.6 ± 16.1	59.3 ± 13.3	0.55361	0.583267
P mean (W)	48.8 ± 11.3	50.6 ± 12.6	0.43804	0.663977
F_{con} *max (N)*	25.2 ± 2.9	25.6 ± 2.5	0.38799	0.700310
F_{con} *mean (N)*	23.6 ± 2.5	23.8 ± 2.2	0.33867	0.736823
F_{ecc} *max (N)*	20.5 ± 3.1	19.9 ± 3.8	-0.52285	0.604284
F_{ecc} *mean (N)*	19.2 ± 2.6	17.7 ± 2.9	-1.66801	0.103991
V max (m/s)	300.5 ± 112.9	291.6 ± 47.3	-0.32603	0.746291
V mean (m/s)	261.2 ± 52.4	262.6 ± 51.7	0.08107	0.935836
H max (cm)	45.7 ± 4.1	47.9 ± 7.3	1.11842	0.270796
H mean (cm)	44.9 ± 4.3	46.3 ± 7.0	0.72710	0.471866

Statistical significance considered at $p \leq 0.05$.

Comparing the mean values of parameters measured during the CMJ test in volleyball players representing different sports level, there were no statistically significant differences (Table 2). Players who participated in the training units only in the academic teams (TEAM 2) achieved a slightly higher values of P max (59.3 ± 13.3 W vs 56.6 ± 16.1 W) and P mean (50.6 ± 12.6 W vs 48.8 ± 11.3 W). On the other hand, the subjects playing in the second-league teams (TEAM 1) slightly dominated in terms of eccentric strength, especially F_{ecc} mean (19.2 ± 2.6 N vs 17.7 ± 2.9 N), although, also in this case the differences were not statistically significant. Concentric strength, velocity and vertical jump height in both groups achieved very similar values.

DISCUSSION

The aim of the study was to answer the question whether athletes competing at different sports level and undergo different training loads will also be diverse in terms of biomechanical parameters, such as: power, strength, velocity and jump height, obtained during the CMJ test. It may seem quite obvious that a higher level of competition and a larger training loads should also result in a greater power developed by the lower limbs and a higher vertical jump height. The results of this study do not support this hypothesis, because there were no statistically significant differences between groups in the measured parameters.

Gabbett and Georgieff [Gabbett, Georgieff 2007] studied the diversity in terms of physiological and anthropometric characteristics of volleyball players representing different sports level. They compared with each other athletes competing at international (national team), state and regional level. They found that the vertical jump height was significantly higher in the national team and the state teams compared to the regional teams, in both the men and women group. The differences between the results of Gabbett and Georgieff and our results may be due to the fact that in our study participated volleyball players of the senior groups, while Gabbett and Georgieff studied juniors, i.e. those whose muscular power increases much faster than in senior group.

The maximum values of vertical jump height obtained in our study (TEAM 1: 45.7 ± 4.1 cm; TEAM 2: 47.9 ± 7.3 cm) are similar to those recorded by Vanrenterghem'a et al. in professional volleyball players (46 ± 3 cm) [Vanrenterghem et al. 2004]. The authors, however, did not explain in what level of competition the subjects participated. Borràs et al.

evaluated the physical state of volleyball players competing at the international level, comparing their jump heights during 3 different seasons to determine reference values for the next drafted athletes and other volleyball teams [Borràs et al. 2011]. In subsequent years, the players achieved the following results of vertical jump height in the CMJ test: 2006 - 46.5 ± 3.5 cm; 2007 - 47.3 ± 5.7 cm; 2008 – 49.7 ± 4.6 cm. The differences between successive seasons were not statistically significant. Despite the fact that players obtained relatively better jump performances in 2008, the team achieved the best competitive result in 2007, when they won the European Championship. According to the authors, this proves the importance of the technique, individual and collective tactics, team strategy, and opponent analysis during a game.

Drikos et al. mentioned two elements that statistically have the greatest impact on winning the game: the serving and attack efficiency ratio [Drikos et al. 2009]. As you can see there are many variables determining the success in volleyball, and the power of lower limbs muscles and jumping ability are just some of them.

CONCLUSIONS

The results do not confirm the existence of statistically significant differences in vertical jump height, power and strength of lower limbs between volleyball players of different sports level and the volume of training loads.

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