THE RELATIONSHIP BETWEEN ISOKINETIC STRENGTH AND JUMP PERFORMANCE IN ELITE FEMALE VOLLEYBALL PLAYERS

Serdar Uslu[1], Ensar Abazović[2], Denis Čaušević[2], Indira Mahmutović[3], Barak Riza[4]

[1]*Physical Education and Sport Teacher Department, Sport Science Faculty, Gazi University, Turkey*
[2]*Faculty of Sport and Pyhsical Education, University of Sarajevo, BiH*
[3]*Faculty of Educational Sciences, University of Sarajevo, BiH*
[4]*Spor Toto SC Ankara, Turkey*

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Abstract

The purpose of this study was to evaluate the relationship between knee extensor and flexor muscles strength and vertical jump in professional female volleyball players. Forty-one female volleyball players participated in this study. Isokinetic PT and was measured at 60°/s, whilst CMJ performance using a force plate. The participants were later divided to WG (weaker group - PT/BW<2) and SG (stronger group - PT/BW>2). Isokinetic concentric knee extension and flexion PT was significantly correlated with CMJ performance. However, higher correlation coefficients were obtained at the non-dominant leg. No significant differences were found but mere trend favoring non-dominant leg muscles in the weaker group. Strong positive correlation exists between isokinetic knee PT and CMJ height in professional female volleyball players. When divided and compared to WG and SG the results indicate weaker players tend to modify their technique individually and towards unilaterality as so they could maximize their performance.

***Key words**: Isokinetic peak torque, vertical jump performance, correlation*

Introduction

In many sports, the short bursts of high intensity power production plays a major role in performance. Team sport activities are comprised of varying explosive movements like forward and backward shuffles, runs at different intensities and sustained forceful contractions to control ball against defensive pressure (Kalinski, Norkowski, Kerner, & Tkaczuk, 2002; Kin-Isler, Ariburun, Ozkan, Aytar, & Tandogan, 2008). It can be suggested therefore, that anaerobic performance and the ability to perform high-intensity actions are crucial in this type of sport (Bangsbo, Iaia, & Krustrup, 2008). Anaerobic performance is composed of anaerobic power and capacity. Anaerobic power reflects the ability to use the phosphagenic system and anaerobic capacity reflects the ability to derive energy from a combination of anaerobic glycolysis and the phosphagen system. Anaerobic performance depends on many factors, such as body composition, age, sex, muscle fiber composition, muscle cross sectional area, strength and training (Castagna, Impellizzeri, Rampinini, D'Ottavio, & Manzi, 2008; Kin-Isler et al., 2008).
Muscular strength is another factor that is generally accepted to have a great influence on athletic performance (Özkan, Kayihan, Kaya, & Öz, 2014). Power has been accepted as a crucial component of anaerobic (Arslan, 2005) and sprint performance (Alemdaroğlu, 2012). Power, speed and agility are abilities that make an important contribution to efficient movement with and without the ball, thus play an important role in volleyball technique and tactics (Erculj, Blas, & Bracic, 2010). The level of these abilities, that is, the motor potential, is most often measured using various motor tests with and without the ball (Colli, Faina, Gallozi, Lupo, & Marini, 1987). In volleyball practice, field tests are the most suitable and applicable because they are implemented in conditions similar to those of training or competition (Alemdaroğlu, 2012; Erculj et al., 2010). For instance, (Dawson, Ackland, Roberts, & Lawrence, 1991) supported the notion that the magnitude of force generated during dynamic muscle contractions is related to the amount of speed an athlete can produce during a sprint performance. In addition, (Young, Mc Lean, & Ardagna, 1995) reported that dynamic leg strength was one of the major factors explaining the anaerobic power. And also, by increasing the available force of muscular contraction in appropriate muscles or muscle groups, acceleration and speed in skills critical such as turning, sprinting, jumping, and changing pace may improve (Cometti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001).
Volleyball is an intermittent, high-intensity physical activity that requires well-developed aerobic and anaerobic fitness and is considered a physically demanding sport, which requires a high degree of technical skill, strength, agility, sprinting ability and endurance (is positively associated with recovery during repeated high-intensity bouts) from a physiological standpoint, volleyball traditionally has been described as a high power, predominantly anaerobic sport. Due to the rules of the game and structure of matches, volleyball athletes experience

repetitive bouts of intense activities, but also have an opportunity to recover between bouts. The 'work period', defined as the total time during the match in which the ball is in play is typically slightly shorter than the 'recovery or rest period' which may be defined as the total time during the match in which the ball is not in play. In practical terms, the work period represents the time spent contesting each point, while the recovery period represents the time between points. Volleyball athletes must therefore be capable of generating energy rapidly and also must be capable of recovering rapidly in anticipation of the next point. Consequently, both the aerobic and anaerobic systems must be well developed to enable the volleyball athlete to perform maximally (Reeser & Bahr, 2017). On the other hand, volleyball is a sport in evolution, after the rule changes have altered tactical strategy and this has in turn motivated strength and conditioning specialists to update and adjust muscle strength and conditioning protocols specifically for the modern volleyball athlete. Modern volleyball players require a greater amount of muscle strength, quickness and agility than ever before in the history of sport. Players at all positions are highly active during match play, and thus require optimal performance in addition to strong overall conditioning. Critical to development of these abilities is the trainability of higher level of muscle strength (Bompa & Buzzichelli, 2018).

Volleyball required multidirectional movements and jumping. A typical match is built around short, explosive burst of movement and relatively long periods that allow athletes to fully recover. Rallies in volleyball last between 3 and 45 seconds. Depending on their position, athletes are rarely required to move more than 5 to 15 feet (1,5-5 m) in any direction (Developing agility and quickness). As it is currently played, volleyball is a game in which success depend on large measure on the athleticism of the participants. In particular, the ability to jump high, quickly and explosively is essential to most of the skills, including spiking, blocking, jump serving and even setting (Hawley, 2008) such as dribbles, sprints, forward and backward shuffles, runs at different intensities and sustained forceful contractions to control the ball against defensive pressure and low intensity activities (Uslu, 2013). Therefore, the purpose of this study was to evaluate the relationship between knee extensor and flexor muscles strength and vertical jump in professional female volleyball players.

Materials and methods

Subjects and Experimental Approach

Forty-one female volleyball players participated in this study voluntarily. The mean age was 20,37 ± 4.2 yrs; mean body height 183,3 ±8,5 cm; mean body mass 72,2± 12,9 kg. The subjects were informed about the possible risks and benefits of the study and gave their informed consent to participate in this study. The study was conducted over a 1-week period, during which the players did not participate in any other training or matches. On the first day, anthropometric measurements, vertical jump measurements were performed respectively. On the second day, players underwent isokinetic leg strength tests.

Procedures

Anthropometric Measurements

Subjects reported to the laboratory at 8:00 a.m. First, body height (cm) and body weight (kg) measurements were taken for each subject. The body height of the volleyball players was measured by a stadiometer with an accuracy of ±1 cm (SECA, Germany), and while electronic scales (Tanita BC 418, Japan) accurate to within 0,1kg were used to measure body weight.

Vertical Jump Measurements

Vertical jump performance was measured using a portable force platform (Newtest, Finland). Players performed countermovement (CMJ) according to the protocol described by Bosco et al. (1983). Before testing, the players performed self-administered submaximal CMJs (2-3 repetitions) as a practice and specific additional warm-up. They were asked to keep their hands on their hips to prevent any influence of arm movements on the vertical jumps and to avoid coordination as a confounding variable in the assessment of the leg extensors. Each subject performed 3 maximal CMJs with approximately 2 minutes' recovery in between. Players were asked to jump as high as possible; the best score was recorded in centimeters. Sufficient recovery time (30 seconds) was allowed during the trials.

Isokinetic knee strength evaluation

Before the isokinetic test, subjects performed a 5-minute warm-up on a cycle ergometer. Measurements were taken using an Isomed 2000 (Ferstl, Germany) isokinetic dynamometer. The test was performed in a seated position; stabilization straps were secured across the trunk, waist, and distal femur of the tested leg and their dominant muscles were always tested first. The dominant leg was defined as the leg which the participants selected as the preferred for kicking a ball with (Abazović, Kovačević, Kovač, & Bradić, 2015). The leg extensor and leg flexor muscle of each leg were concentrically measured at 60°/s (10 repetitions). Verbal encouragement was given to the subjects during the measurement. Before starting the test, subjects were allowed 5 trials.

Statistical analyses

Means and standard deviations are given as descriptive statistics and the muscle strength and jump performance were evaluated by Pearson product Moment Correlation analysis. Whether the correlation strength differs between WG (weaker group - PT/BW<2) and SG (stronger group - PT/BW>2) group was evaluated using Fisher r-to-z transformation. Analyses were executed in SPSS for Windows version 17.0 and the statistical significance was set at $p < 0,05$.

Results

The isokinetic knee PT values, CMJ height and morphological measurements are displayed in Table 1. Table 2 shows the correlations between CMJ performance and isokinetic knee muscles PT. Isokinetic concentric knee extension and flexion PT was significantly correlated with CMJ performance. However, higher correlation coefficients were obtained at the non-dominant leg.

Table 1: Anthropometric measurements, knee extension and flexion PT and CMJ height

Age	BW	BH	Knee Extension		Knee Flexion		CMJ
			Dominant	Nondominant	Dominant	Nondominant	
20,41±4,49	72,2±12,95	183,34±8,52	152,66±47,04	149,63±54,00	79,29±23,44	82,56±27,82	28,23±7,66

Table 2: Correlations between knee extension and flexion PT and CMJ height

Correlations				
	DKEPT	DKFPT	NDKEPT	NDKFPT
CMJ	,596**	,559**	,673**	,626**
**p<0,01				

Table 3: Correlations between knee extension and flexion PT and CMJ height in weaker and stronger group

Correlations					
		DKEPT	DKFPT	NDKEPT	NDKFPT
WG	CMJH	,451	,128	,761**	,647**
SG	CMJH	,529**	,611**	,509*	,526**
Fisher Z		-0,3	-1,7	1,28	0,54
** Correlation is significant at the 0,01 level * Correlation is significant at the 0,05 level					

Table 3. shows weak and strong group coefficients and the difference between them. No significant differences were found but mere trend favoring non-dominant leg muscles in the weaker group.

Discussion

The purpose of this study was to evaluate the relationship between knee extensor and flexor muscles strength and vertical jump in professional female volleyball players. As stated before, many previous authors delt with this issue and found coefficients ranging from r=0,097 (Blackburn & Morrissey, 1998).

Table 2. shows there are significant correlation coefficients between CMJ and all isokinetic variables. As it can be seen, the coefficients were larger for the non-dominant leg. Furthermore, significant correlation strength, between CMJ height and peak torque values, ranged from ,56 to ,67 (p<0,01) show that, according to (Hopkins, 1997) classification, there is strong positive correlation between these two parameters.

Previous authors addressing this issue found similar results. For example, Binet et al. (2005) included 57 22-year-old football players in their study and have found significant correlation coefficients (r=0,64; p<0,001). Additionally, (Gerodimos, 2006; Hopkins, 1997), find similar results in active athletes.

Smaller coefficients (r=0,363), however, have been found in recreationally trained males (Almuzaini & Fleck, 2008), whilst somewhat larger (r=0,922) coefficients were obtained in a study by Singh et al. (2017) who included basketball players in their study sample. There are even authors whose results show the absence of correlation between PT and CMJ. For example, (Atabek & Sönmez, 2009; Blackburn & Morrissey, 1998; Kovačević, Abazović, Bradić, & Vrcić, 2012), reported statistically insignificant correlation coefficients between these variables.

Main difference and similarity could be found in participants physical activity considering the absence of statistical significance was found in studies with sedentary and inactive participants.

These results further emphasize the conclusions made by previous authors that, considering the fact that isokinetic dynamometry is one of the safest ways to measure muscle force output, using this type of, i.e., rehab protocols, can definitely provide more insight in future jump performance after the initial rehab phases. Furthermore, when comparing previous results, it is indicative that physical activity level determines the correlation strength, as well as the type of sport athlete is involved in (Ebert, Leigh, & Konz, 2018), for example, found that correlations between isokinetic testing and pre-season and post-season testing of jump height indicate the influence of athlete training throughout the season.

As stated earlier, many authors addressed this issue but never compared weaker and stronger participants and as so to determine whether this correlation is strength-dependent participants were divided into two groups and compared. Table 3 shows nonsignificant difference in correlation magnitude between these two groups but, as it can be observed, whilst the stronger group correlation significance for both legs the weaker group showed significant correlation only between CMJ and nondominant leg PT. These results show the presence of lower limb neuromuscular or just functional asymmetries. These findings were observed in some previous research. For example, Menzel et al. (2013) found a 6,77% difference between the right and left leg in vertical jump values in CMJs in Brazilian professional soccer players while (Yanci & Camara, 2016) found differences up to 4,55% between the dominant and nondominant leg in CMJ variables. Furthermore, (Mahmutović, 2020) stated that vertical jump inter-limb asymmetry index can be up to 15%, and is higher in female volleyball and basketball players.

Considering we did not measure the unilateral power output and have found higher correlation coefficients between CMJ height and non-dominant strength, as stated by (Mahmutović, 2020) that weaker volleyball players tend to modify their technique as to perform a jump higher than bilateral, primarily extending their dominant arm in the highest jump phase.

Conclusion

Considering the purpose of this study, the results showed strong positive correlation between isokinetic knee PT values and CMJ height in professional female volleyball players. When divided and compared to WG and SG the results indicate differences in the correlation magnitude but the difference is not statistically significant. Weaker players tend to modify their technique individually and towards unilaterality as so they could maximize their performance.

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Corresponding information:

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Correspondence to: Ifet Mahmutovic
University: University of Sarajevo
Faculty: Faculty of Sport and Physical Education
E-mail: ifet.mahmutovic@fasto.unsa.ba