European Journal of Physical Education and Sport Science
ISSN: 2501 - 1235
ISSN-L: 2501 - 1235
Available on-line at: www.oapub.org/edu

10.5281/zenodo.215206

Volume 2 | Issue 6 | 2016

EVALUATION OF THE RELATIONSHIP BETWEEN ISOKINETIC STRENGTH AND FIELD PERFORMANCE IN PROFESSIONAL MALE VOLLEYBALL PLAYERS

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Abstract:
The purpose of this study was to investigate the relationship between the isokinetic quadriceps and hamstring strength and, sprinting ability, agility and vertical jump performance in male volleyball players. Twenty professional male volleyball players (average age 24.5±1.1 years; mean body height 186.5±5.02 cm; mean body mass 75.34±8.39 kg) participated in this study voluntarily. For each player, isokinetic concentric muscle strength tests were performed at 60°/s and 300°/s, jump performance was evaluated by countermovement jump (CMJ) and squat jump (SJ) tests, sprint ability was determined by single sprint performance (10-30 m), and agility performance was measured using the T drill agility test. There were statistically significant correlation between peak torque of extensor and flexor muscles strength at 60°/s, 300°/s contraction velocities and squat jump, countermovement jump ($p<0.01$). There was no significant correlation between isokinetic knee strength and T drill test and sprint tests (10-30 m) ($p>0.05$). Moreover, statistically significant relations were found between the performances of athletes in different field tests ($p<0.05$). This study has shown that isokinetic peak torque of quadriceps and hamstring are significant predictor for field based anaerobic tests, SJ and CMJ, that are similar to the actions made in the game for volleyball players.

Keywords: isokinetic strength, vertical jump, anaerobic, volleyball

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1. Introduction

Volleyball is a discipline of sports that requires high technical, tactical, and athletic demands on the players (Kugler et al., 1996). A strong block for an offense and a smash or spike for an attack are desirable for a successful performance (Coleman et al., 1993). One of the objectives of the volleyball spike is to hit the ball at the highest possible speed that starts with a vertical jump, a crucial skill performance in voleyball (Kugler et al., 1996).

Success in many athletic endeavors as well as volleyball is dependent on the ability of muscles to produce high intensity power instantaneously or within several seconds. Generation of explosive strength depends on the ratio between velocity of movement and the strength developed by the specific muscle groups (Alexander, 1990). Therefore success of an athlete is related to both the physical capacity of the athlete to perform actions as quickly as possible and with high intensity and to the degree of motor skill development in volleyball (Smith et al., 1992).

Volleyball is considered as an interval type of sports with both anaerobic and aerobic components. Anaerobic performance is composed of anaerobic power and capacity. Aerobic capacity is positively associated with recovery during repeated high-intensity bouts (Castagna et al., 2008; Tomlin and Wenger, 2001). Moreover, the high intensity movements of volleyball players are closely related to the development of strength, speed and agility (Castagna et al., 2007; Forthomme et al., 2005). Explosive strength, take-off 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 (Forthomme et al., 2005). In particular explosive muscular strength has been accepted as a crucial component of anaerobic and sprint performance (Dowson et al., 1998).

Different aspects of lower limb strength and power are frequently examined using the isokinetic knee joint test, sprint test and the vertical jump test. Since the knee joint is one of the main contributors in vertical jumping and sprint performance, several studies have attempted to correlate these tests but with various results (Anderson et al., 1991; Trzaskoma et al., 1996). The variation in the results may be due to a number of differences, such as joint angular velocities and the positioning of the participants, affecting muscle length and velocity of contraction and participant characteristics (Iossifidou et al., 2005).

While some studies have investigated the relationships between isokinetic knee strength, anaerobic performance, sprinting ability, agility, and vertical jump performance in other athletes, an insufficient number of studies have been conducted on volleyball players. Therefore the aim of this study was to investigate the relationship between isokinetic quadriceps and hamstring strength, sprinting ability, agility and vertical jump performance in male volleyball players.

2. Materials and Methods

2.1 Participants

Twenty male first division volleyball players participated in this study. The mean measurements gathered were as follows: age: 24.5±1.1 years; body height: 186.5±5.02 cm; body mass: 75.34±8.39 kg. They were all nonsmokers. 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, the players participated in anthropometric measurements (body height, body mass) followed by a squat jump, countermovement jump tests. Isokinetic leg strength tests were conducted on the third day. Then, on the fifth day, players performed the sprint test and they performed agility test two days later. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki. Additionally, the approval of experimental procedures were provided by Pamukkale University Ethics Committee and also written consent forms were obtained from all subjects, who were completely informed about the procedures.

2.2 Procedures

2.2.1 Anthropometric Measurements

The body height of the volleyball players was measured using a stadiometer with an accuracy ± 1 cm (SECA, Germany), and an electronic scale (Tanita BC 418, Japon) with an accuracy of ± 0.1 kg was used to measure body mass.

2.2.2 Isokinetic Strength

Before the isokinetic test, subjects warmed-up on a cycle ergometer pedaling at a work rate of 20 watts at 50 rpm for 5-minutes. An isokinetic dynamometer (Cybex Humac Norm 770, USA) was used to measure knee flexion and extension torque. The test was performed in a seated position with hands gripping the handles at the sides of the chair. The test was performed in a seated position; stabilization straps were secured across the trunk, waist and distal femur of the tested leg. The most prominent point of the femoral epicondyle on the lateral surface of the knee joint was aligned with the axis of rotation of the dynamometer. The shin pad was placed distally approximately two finger breadths above the lateral malleolus. The range of motion for the knee was from 90 degrees of knee flexion to 10 degrees of extension. Isokinetic concentric quadriceps and hamstring muscle strength tests were performed at 60°/s with 5 repetitions and 300°/s with 15 repetitions without gravity for both right and left legs. Verbal encouragement was given to the subjects during the measurement. Before starting the test, subjects were allowed 5 trials. A 30 s time interval was provided between repetitions whereas a 2 min rest period was given between angular velocity tests (Tsiokanos et al., 2002).

2.2.3 Vertical Jump Measurements

Vertical jump performance was measured using a portable force platform (Newtest, Finland). Players performed countermovement (CMJ) and squat jumps (SJ) according to the protocol described by Bosco et al. (Bosco et al., 1995). Before testing, the players performed self-administered submaximal CMJ and SJ (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 and SJs, with approximately 2 minutes' recovery in between. Players were asked to jump as high as possible; the best score was recorded in centimeters (Bosco et al., 1995).

2.2.4 10-30m Sprint Test

The subjects performed 2 maximal 30 m sprints (with 10 m split times also recorded) on the basketball court. There was a recovery period of 3 minutes between the 30 m sprints. Prior to each sprint test, players performed a thorough warm-up consisting of 10 minutes of jogging at 60-70% of heart rate$_{max}$ and then 5 minutes of exercise involving fast leg movements over short distances of 5 to 10 m and 3-5 single 15 m shuttle sprints with 2 minutes of passive recovery. Times were measured using an electronic timing system (Prosport TMR ESC 2100, Tumer Engineering, Ankara, Turkey).

2.2.5 T-Drill Agility Test

Four 22.86 cm collapsible agility cones were arranged as outlined in Semenick (Figure 1). At the tester's signal, subjects sprinted forward 9.14 m and touched the tip of the cone (B) with their right hand.

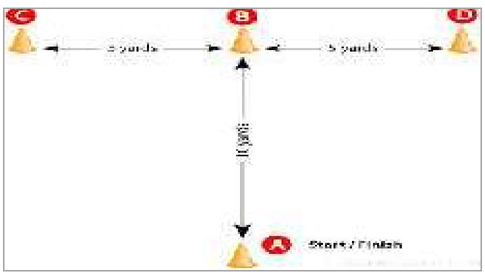

Figure 1: T drill test

Then they performed a lateral shuffle to the left 4.57 m and touched the tip of the cone (C) with the left hand. Subjects then changed direction and shuffled 9.14 m to the right to touch the tip of the cone (D) with their right hand. They then shuffled 4.57 m to the left to touch point (B) with their left hand. Finally, the subjects back-peddled 9.14 m, passing through the finish at point A. Times were measured using an electronic timing system (Prosport TMR ESC 2100, Tumer Engineering, Ankara, Turkey).

2.3 Statistical Analyses

The data are reported as means and standard deviations. The relationships between isokinetic knee strength, sprinting ability, agility and vertical jump performance were evaluated using Pearson Product Moment Correlation analysis. All analysis was executed in SPSS for Windows version 17.0 and the statistical significance was set at $p < 0.05$.

3. Results

Male voleyball players' mean age, body height and weight were 24.5 (1.1) years, 186.5 (5.02) cm, 75.34 (8.39) kg respectively. The sprint, agility, isokinetic knee strength and vertical jump measurements of the volleyball players in the study are displayed in Tables 1 and 2.

Table 1: Field performance test results of volleyball players

10m (s)	1.71 ± 0.26
30m (s)	4.31 ± 0.13
CMJ (cm)	40.6 ± 4.71
SJ (cm)	37.8 ± 5.72
T Drill test (s)	9.15±0.46

CMJ: Counter movement jump; SJ: Squat jump;
Values are given as mean ± SD

Table 2. Peak isokinetic concentric knee extension and flexion torques of volleyball players

	Hamstring Right (Nm)	Hamstring Left (Nm)	Quardriceps Right (Nm)	Quardriceps Left (Nm)
60º/sn	163.76 ± 26.45	147.18± 27.12	205.26 ± 35.02	199.16± 27.42
300º/sn	137.63 ± 25.99	130.45± 20.12	175.12 ± 25.32	171.46± 24.34

Values are given as mean ± SD

Table 3 shows the correlations between sprint, agility, vertical jump performance and isokinetic knee strength are presented. As can be seen from Table 3, there were statistically significant correlation between peak torque of extensor and flexor muscles strength at 60°/s, 300°/s contraction velocities and squat jump, countermovement jump ($p<0.01$). There was no significant correlation between isokinetic knee strength and T drill test and sprint tests (10-30 m) ($p>0.05$). Moreover, statistically significant relations were found between the performances of athletes in different field tests ($p<0.05$), as it can be seen in Table 4.

Table 3. Correlations between isokinetic knee strength and field performance test

		T drill test	10 m	30 m	CMJ (cm)	SJ (cm)
60°/s	PTF (Nm)	NS	NS	NS	0.712**	0.618**
	PTE (Nm)	NS	NS	NS	0.679**	0.741**
300°/s	PTF (Nm)	NS	NS	NS	0.795**	0.657**
	PTE (Nm)	NS	NS	NS	0.894**	0.783**

PT: peak torque; F: fleksor; E: extensor; p< 0.05; ** p<0.01*

Table 4. Correlations between field tests

	CMJ	SJ	10 m	30 m	T drill test
CMJ (cm)		0.810**	NS	-0.602*	-0.584*
SJ (cm)	0.810**		NS	-0.730*	-0.482*
10 m (s)	NS	NS		NS	NS
30 m (s)	-0.602*	-0.730*	NS		0.520*
T drill test (s)	-0.584*	-0.482*	NS	0.520*	

*CMJ: Counter movement jump; SJ: Squat jump; * p< 0.05; ** p<0.01*

4. Discussion and Conclusion

The main findings of the present study was that there were statistically significant correlation among peak torque of extensor and flexor muscles strength at 60°/s, 300°/s contraction velocities and squat jump, countermovement jump.

In addition to volleyball, many sports including football, soccer, baseball, lacrosse, and gymnastics use anaerobic metabolism extensively during competition. Depending on the intensity and duration of the effort, different energy systems will be predominantly taxed. An anaerobic activity is the form of energy energy that uses anaerobic metabolism during an exhaustive effort and lasts less than 90 seconds. The very short, high intensty activity lasting less than 1-2 s will mostly involve the adenosibe triphosphate (ATP) depots in the muscles. The high intensity activities lasting up to 5-6 s depends on the high energy phosphagen, phosphocreatine depots in addition to the ATPs. The longer but stil high intensity activities will depend more on the muscle fibers ability to produce ATP through the glycolytic pathway, the non aerobic breakdown of carbohydrate. SJ and CMJ are used as methods for the calculation of anaerobic metabolism of lower limb muscles, measures the ability of the muscles to work using both the ATP-phosphocreatine and glycolytic systems (Bencke et al., 2002).

A relationship between muscular strength and vertical jump performance (SJ and CMJ) was found by different authors (Tsiokanos et al., 2002; Paasuke et al., 2001). A significant correlation coefficients (0.51-0.64) between SJ height and knee extension torque at 120 and 180°/s were reported (Destaso et al., 1997). In another study, significant correlations (r=0.55-0.69) were reported by Saliba and Hrysomallis (2001) between isokinetic measures and vertical jump height in a sub-elite Australian football players. In addition, Tsiokanos et al. (2002) reported that the correlation coefficient for CMJ height and isokinetic torques, measured at 60°/s, 120°/s and 180°/s, were 0.57, 0.64 and 0.36 respectively. Bencke et al. (2002) reported a relationship between knee extensor strength and vertical jump performance.

There was no significant correlation between isokinetic knee strength and T drill test and sprint tests (10-30 m). Similarly, Cronin and Hansen (2005) determined no relation between extension strength and knee flexion and single-sprint performance. No relation were reported between strength measures and 10 or 40 m sprint performance in rugby players by Baker and Nance (Baker and Nance, 1999). On the other hand, Dowson et al. (1998) found a statistically significant relationship between concentric and eccentric knee extensor torques and 0-15 m and 30-35 m sprint times. Similarly, Alexander (1990) found a strong correlation between sprint performance, 100 m personal best sprint time and concentric knee extension torque, at 4.14 rad $^{s-1}$, in elite sprinters. Newman et al. (2004) reported a significant correlation between concentric isokinetic knee extension and flexion strength measures and single-sprint performance in football players.

One of possible explanation for the lack of association between isokinetic knee strength and single-sprint performance could be due to the particular characteristics of the subjects (Cronin and Hansen, 2005). Body height is very important for volleyball players and might be one of the reasons for not finding an association between strength and single sprint performance. Another important factor may be the different distances were used in sprint tests in previous studies.

The result of this study is that performances in a variety of field tests were correlated with each other in a group of volleyball players. It can be said that either the tests assess similar attributes or performance on one test is able to predict performance on another (Vescovi and Mcguigan, 2008). Cronin and Hansen (2005) reported weak negative associations between countermovement and squat jump performance and 5, 10, and 30 m sprint times. Hennessy and Kilty (2001) found countermovement jump performance was related to the times for sprint tests and that the bounce drop jump index was related with 30 m and 100 m sprint times in a group of female athletes. The relationship between linear sprinting and agility performance have been examined by few studies (Vescovi and Mcguigan, 2008, Little and Williams, 2005; Paoule et al., 2000). Moderate correlation was reported between T-test performance and 37 m sprint times in a group of college-aged women by Paoule et al (Paoule et al., 2000). In contrast, Little and Williams (2005) found a weak correlation between acceleration (10 m) and maximum speed in a zigzag agility test in a group of professional male soccer players. The association between agility and speed increases with longer distances and when examining agility with flying sprint times (Vescovi and Mcguigan, 2008). The reason of differences between studies could be the use of different agility tests (Vescovi and Mcguigan, 2008).

In conclusion, this study has shown that isokinetic peak torque of quadriceps and hamstring are significant predictor for field based anaerobic tests, SJ and CMJ, that are similar to the actions made in the game for volleyball players. The variation in the results may be due to a number of differences including joint angular velocities of the participants or utilization of different metabolic pathways and participant characteristics.

Acknowledgments
The author would like to thank all players for their willingness to participate in this study.

References

1. Kugler, A., Krüger-Franke, M., Reininger, S., Trouillier, H.H., Rosemeyer, B. (1996). Muscular imbalance and shoulder pain in volleyball attackers. *Brit J of Sport Med,* 30: 256-259.
2. Coleman, SGS., Benham, AS., Northcott, SR. (1993). A three-dimensional cinematographical analysis of the volleyball spike. *J Sports Sci,* 11: 295-302.
3. Alexander, MJL. (1990). Peak torque values for antagonist muscle groups and concentric and eccentric contraction types for elite sprinters. *Arch Phys Med Rehab,* 71: 334-339.

4. Smith, DJ., Roberts, D., Watson, B. (1992). Physical, physiological and performance differences between Canadian national team and universiade volleyball players. . *J Sports Sci,* 10: 131-138.
5. Castagna, C., Abt, G., Manzi, V., Annino, G., Padua, E., D'ottavıo, S. (2008). Effect of recovery mode on repeated sprint ability in young basketball players. *J Strength Cond Res,* 22(3): 923-929.
6. Tomlin, D. and Wenger, HA. (2001). The relationship between aerobic fitness and recovery from high intensity intermittent exercise. *Sports Med,* 31: 1-11.
7. Castagna, C., Manzi, V., D'Ottavio, S., Annino, G., Padua, E., Bishop, D. (2007). Relation between maximal aerobic power and the ability to repeat sprints in young basketball players. *J Strength Cond Res,* 21(4): 1172-1176.
8. Forthomme, B., Croisier, JL., Ciccarone, G., Crielaard, JM., Cloes, M. (2005). Factors correlated with volleyball spike velocity. *Am J Sports Med,* 33: 1513-1519.
9. Dowson, M., Nevill, M., Lakomy, H., Nevill, A., Hazeldine, R. (1998). Modelling the relationship between isokinetic muscle strength and sprint running performance. *J Sports Sci,* 16: 257-265.
10. Anderson, MA., Gieck, JH., Perrin, DH. et al. (1991). The Relationships among Isometric, Isotonic, and Isokinetic Concentric and Eccentric Quadriceps and Hamstring Force and Three Components of Athletic Performance. *J Orthop Sports Phys Ther,* 14: 114-20.
11. Trzaskoma, Z., Wit, A., Eliasz, J. (1996). Comparison of three laboratory tests of short duration with respect to the mechanical power output by lower limbs of athletes. *Biol Sport,* 13: 61-70.
12. Iossifidou, A., Baltzopoulos, V., Giakas, G. (2005). Isokinetic knee extension and vertical jumping: Are they related? *J Sports Sci,* 23(10): 1121-1127.
13. Tsiokanos, A., Kellis, E., Jamurtas, A., Kellis, S. (2002). The relationship between jumping performance and isokinetic strength of hip and knee extensors and ankle plantar flexors. *Isokinet Exerc Sci,* 10: 107-115.
14. Bosco, C., Belli, A., Astrua, M., Tihanyi, J., Pozzo, R., Kellis, S. et al. (1995). A dynamometer for evaluation of dynamic muscle work. *Eur J Appl Physiol,* 70: 379-386.
15. Bencke, J., Damsgaard, R., Saekmose, A., Jorgensen, P., Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scand J Med Sci Spor.* 171-178.

16. Paasuke, M., Ereline, J., Gapeyeva, H. (2001). Knee extensor muscle strength and vertical jumping performance characteristics in pre and post-pubertal boys. *Pediatr Exerc Sci,* 13, 60-69.
17. Destaso, J., Kaminski, TW, Perrin, DH. (1997). Relationship between drop vertical jump heights and isokinetic measures utilizing the stretch-shortening cycle. *Isokinet Exerc Sci,* 6: 175-179.
18. Saliba, L. and Hrysomallis, C. (2001). Isokinetic strength related to jumping but not kicking performance of Australian Foot- ballers. *J Sci Med Sport,* 4: 336-347.
19. Cronin, B. and Hansen, T. (2005). Strength and power predictors of sports speed. *J Strength Cond Res,* 19(2): 349-357.
20. Baker, D. and Nance, S. (1999). The relation between running speed and measures of strength and power in professional rugby league players. *J Strength Cond Res,* 13(3): 230-235.
21. Newman, M., Tarpenning, K., Marino, F. (2004). Relationships between isokinetic knee strength, single sprint performance and repeated-sprint ability in football players. *J Strength Cond Res,* 18(4): 867-872.
22. Vescovi, JD., Mcguigan, MR. (2008). Relationships between sprinting, agility, and jump ability in female athletes. *J Sports Sci,* 26(1): 97-107.
23. Hennessy, L. and Kilty, J. (2001). Relationship of the stretch shortening cycle to sprint performance in trained female athletes. *J Strength Cond Res,* 15: 326-331.
24. Little, T., Williams, A. (2005). Specificity of acceleration, maximum speed, and agility in professional soccer players. *J Strength Cond Res,* 19: 76-78.
25. Paoule, K., Madole, K., Garhammer, J., Lacourse, M., Rozenek, R. (2000). Reliability and validity of the t-test as a measure of agility, leg power, and leg speed in college-aged men and women. *J Strength Cond Res,* 14: 443-450.