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LEG MUSCLE QUALITIES AND CHANGE OF DIRECTION SPEED OF VOLLEYBALL PLAYERS

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Abstract

Volleyball is an open skill sport with explosive – dynamic muscle actions, jumping ability and speed in executing rapid, multidirectional movements. Twenty one collegiate volleyball players, (age 19.85 +/- 0.83 years; height 181.67 +/- 12.03 cm; weight 72.62 +/- 12.99 kg; training experience 6.76 +/- 2.21 years), were recruited for this study. The purpose of this study was to examine the relationship between leg muscle qualities and change of direction speed. The following tests were performed: Block jump, Spike jump, Standing broad jump, Jelka test, T – test, 93639 m test, and Dash 20 m. Pearson's coefficient of correlation from package SPSS 15.0 was used for data processing. The results showed that vertical jump abilities, straight sprinting speed and change of direction speed are distinct physical qualities. Therefore, training and testing these extremly important abilities for performance of volleyball players should be highly specific.

Keywords: volleyball, CODS, VJ

Introduction

Volleyball is an open skill sport with predominant anaerobic alactic acid power. The "kinanthropometric" profile of volleyball players includes great height, muscle power, jumping ability, velocity and coordination, all necessary in a game involving strength and elevation to block, strength and speed to spike, resistance to play the sets, as well as great technical ability. At higher skill levels, performance characteristics are mainly determined by speed and vertical jumping. The physical capacities determining an athletes' performance are explosive – dynamic muscle actions, jumping ability and speed in executing rapid, multidirectional movements (Ciccarone, Croisier, Fontani, Martelli, Albert, Zhang, Kloes, 2008).Serve, reception, set, attack and block are typical game actions that are decisive aspects of winning or losing in international competitions (Rodriguez-Ruiz, Quiroga, Miralles, Sarmiento, De Saa, & Garcia-Manso, 2011).

Many field and court sports involve some straight sprinting, but more often repeated short sprinting with changes of direction. The ability to sprint and change direction while sprinting is a determinant of sport performance in field and court sports, as evidenced by time and motion analysis, validation of testing batteries for elite and non-elite performers, and coaching analysis for sports such as rugby (Docherty, Wenger, & Neary, 1988; Meir, Newton, Curtis, Fardell, & Butler, 2001), field hockey (Keogh, Weber, & Dalton, 2003) and soccer (Reilley, Wiliams, Nevill, & Franks, 2000).

In an attempt to elucidate potential factors that influence agility performance, Young, James, & Montgomery (2002) proposed a deterministic model of agility (Figure 1). This is intended to indicate the main factors that determine agility, and can be applied to sports involving fast changes of direction such as most team and racquet sports. It highlights that the strength qualities of the leg muscles have potential to influence agility performance along with several other factors.

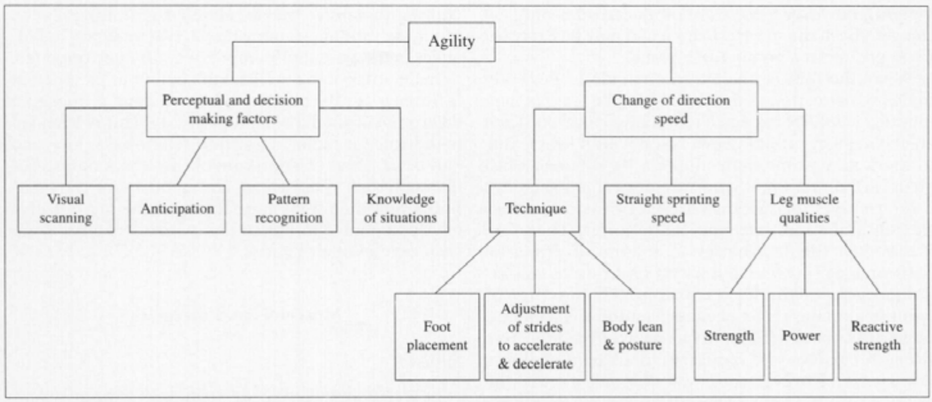

Fig. 1.—Model indicating the main factors determining agility. *Agility*: running speed with at least one change of direction performed in a competitive game. This may include being in possession of a ball or piece of equipment; *visual scanning*: ability to process visual information in competitive game; *anticipation*: prediction of an event in a game that influences the movements of a player in a game; *pattern recognition*: the ability to recognise patterns of play by an opposing team or player; *knowledge of situations*: knowledge of the probable movements of other players, based on previous experience of the game.

Sheppard and Young (2006) proposed a new definition of agility for sport as follows: "a rapid whole-body movement with change of velocity or direction in response to a stimulus". This new definition of agility recognizes both the cognitive and physical components involved in agility for sport.

Almost all existing literature that has attempted to describe relationships with some measure of agility or training to improve agility has used a timed task involving one or more changes of direction, also known as change of direction speed. Based on the similar results presented by Baker (1999), Buttifant, Graham, & Cross (1999), Draper and Lancaster (1985), and Young, Hawken, & McDonald (1996), straight sprint testing appears not to be related strongly to sprinting with changes of direction testing in subject samples of rugby, soccer and football players, respectively. Furthermore, and perhaps most importantly, straight sprint training does not improve performance in sprints with changes of direction (Young, McDowell, & Scarlett, 2001).

Based on the results of Djevalikian (1993), Webb and Lander (1983) and Young et al. (1996, 2002), but see Negrete & Brophy, 2000, concentric strength and power measures appear to be poor predictors of change of direction speed. Perhaps the difference observed between these studies is the nature of the task used to evaluate change of direction speed. Negrete and Brophy (2000) used a complex multi-directional task over short distances, whereas the others (Djevalikian, 1993; Webb & Lander, 1983; Young et al., 1996, 2002) used sprint tests that involve some straight sprinting and changes of direction while sprinting. It would appear that strength and power measures have an influence on change of direction speed (Negrete

& Brophy, 2000), but that this relationship might only be observable when comparing tasks involving changes of direction speed over short distances.

With this in mind, the purpose of this study was to investigate the relationship between change of direction speed, sprinting speed and power measures of the lower extremity of volleyball players.

Method

Subjects

Twenty one collegiate volleyball players (age 19.85 +/- 0.83 years; height 181.67 +/- 12.03 cm; weight 72.62 +/- 12.99 kg; training experience 6.76 +/- 2.21 years), were recruited for this study. The subjects were familiarized with the procedures involved in testing. All subjects received a clear explanation of the study, and written consent for testing was obtained.

Testing procedures

As per the normal testing protocol for this group, the subjects completed their typical practise warm-up prior to testing sessions. In brief, this warm-up included 10 minutes of general activity (light running with change of direction and accelarration), followed by 10 minutes of dynamic activity that increased in speed and intensity (skips, leg swings, arm swings), followed by 3-5 minutes of rest without static stretching, prior to commencing the testing session. Subjects were re-familiarized with the testing protocol.

The subjects performed three trials of each motor test, and the best trial from the attempts for each motor test, was kept for analysis.

Variables

The sample of measuring instruments consisted of seven motor variables: block jump (BJ), spike jump with three steps approach (SJ), standing broad jump (SBJ), Jelka test (JT), T test (TT), 93639m test and 20m dash (20m).

Statistical analysis

The data gained were subjected to statistical analysis in the SPSS 15.0 package. Central and dispersion statistics are shown in Table 1 for all variables, and the Pearson's correlation coefficient was used to calculate the relationship between variables (Table 2).

Results and Discussion

The descriptive statistics of the volleyball players are shown in Table 1. The table shows that the index of nutritional status for volleyball players is within the limits of normal (22.04), so these research subjects belong in the category of average nourished population. The Body mass index values seen in the literature for female volleyball players of different age, nationality and competition level vary between 20.5 kg/m^2 and 22.5 kg/m^2. The mean value in BMI found in the present study (21.41 kg/m^2) is corresponding to values reported in recent investigations (Gualdi-Russo & Zaccagni, 2001; Papadopoulou, Gallos, Paraskevas, Tsapakidou, & Fachantidou, 2002; Malousaris, Bergeles, Barzouka, Bayios, Nassis, & Koskolou, 2008), mean BMI values 22.1kg/m^2, 20.5kg/m^2, 21.9kg/m^2, respectively. Although the mesomorphy used to be the primary component of competitive female volleyball players somatotype in the last two decades, in the latest studies it appears that the ectomorphy may be taking over at the expense of mesomorphy.

Body height is considered a determinant factor for good performance in volleyball and, together with its relation to body weight, is used as a criterion for the selection of promising volleyball players. The mean value of volleyball players' height in our study was 181.67 +/- 12.03 cm, with a range from 161 cm to 203 cm. When comparing the volleyball players of this study to other male and female volleyball teams, our subjects are inferior with regard to BH (Gualdi-Russo & Zaccagni, 2001; Papadopoulou et al., 2002; Malousaris et al., 2008; Sheppard, Cronin, Gabbett, McGuigan, Etxebarria, & Newton 2008;Carvajal, Betancourt, Leon, Deturnel, Martinez, Echevarria, Castillo, & Serviat, 2012), which can be explained due to comparable level of competition, and selection trough training history. In particular, the BH values of the present study are lower than those investigating others in the literature evaluating competitive female volleyball players. Body height and body weight of male and female volleyball players from National Team of Serbia from London 2012 are (mean value, N=20), 199.75 cm, 84.55 kg; 186.45 cm, 71.95 kg respectively, which is in accordance with demands of contemporary volleyball competition. The obvious differences seen in BH and BW between samples are expected, since the players of Serbian National Team and samples from A1 division (Gualdi-Russo & Zaccagni, 2001; Papadopoulou et al., 2002; Malousaris et al., 2008; Sheppard et al., 2008; Carvajal et al., 2012), go through a stricter selection procedure and may follow more closely professional advice regarding training and diet.

On the basis of these results, we can resume, that subjects in our study, by it's anthropometric characteristics, clearly belongs to the population of college students from Sports Sciences and close to the averaged values on their 20-years-old counterparts (Mihajlović, Petrović & Šolaja, 2011; Rakić, 2009).

Table 1. Descriptive statistics (M-Mean, SD-Standard deviation)

VARIABLES	**Volleyball players (N=21)**			
	M	**SD**	**MIN**	**MAX**
Age (decimal years)	19.85	0.83	18.94	21.89
Years of playing	6.76	2.21	3	12
Body height (cm)	181.67	12.03	161	203
Body weight (kg)	72.62	12.99	54	100
Body mass index (kg/m^2)	22.04	2.35	18.9	27.4
Block jump (cm)	271.53	19.76	237	311
Spike jump (cm)	287.68	22.74	245	318
Standing broad jump (cm)	234.17	37.14	164	313
Jelka test (0,1s)	35.60	3.79	27.69	41.45
T test (0,1s)	10.36	0.56	8.95	11.91
93639 m (0,1s)	7.79	0.40	7.11	8.52
20m dash (0,1s)	3.60	0.30	3.02	4.11

The correlation coefficients describing the relationships between the tests are shown in Table 2. Variables that represent change of direction speed ability T-test and 93639 m test are in statistically significant relationship only to each other (r=0.63; p=0.00) and to Jelka test and Standing broad jump. Jelka test is the test of CODS ability but with different energy demands compared to T-test and 93639 m. Tests of different durations may be subject to influences of energetics rather than just assessing CODS ability. The complexity of each test can be categorized either by the number of changes of direction required or by the type of movements and forces that are primarly used throughout the test. Certain test can have as few directional changes (L run, T-test, 93639 m test) whereas others (Jelka test, Illinois test) can incorporate many more changes of direction. Each change of direction requires braking force follwed propulsive force, which in turn may increase the importance eccentric-concentric force capability of muscle and endurance as the number of turn increase. The application of force during the actual COD is more difficult to determine because it would rely heavily on individual technique. However, it is accepted that lateral forces would be involved in certain COD movements such as those in a T-test when the COD is preceded by shuffling movements (Brughelli, Cronin, Levin, & Chaouachi, 2008). In terms of the interrelationships amongst CODS tests, Draper and Lancaster (1985) have found that there was a significant correlation between the Illinois test and the up and back test (r=0.63) and the up and back and 5-0-5 test (r=0.51), but no significant relationship between the Illinois test and the 5-0-5 test (0.25). The researchers suggested that the results of most COD tests were independent from one another and they believed that this was a result of the duration and complexity of each COD test. In our study relationships amongst CODS tests were all statistically significant but it is interesting that T-test and 93639m (with shorter duration and less number of COD in respect to Jelka test), had statistically significant relationship only with SBJ (horizontal force application), while the Jelka test had statistically significant relationship with all tests applied, which can be justified by differences in direction of force application and/or energetic requirements as discussed previously.

If we observe model described in figure 1, we note that Sheppard and Young proposed that straight running speed and leg muscle qualities were important determinants of COD ability. In our study straight running speed (20 m Dash) had statistically significant relationship with all tests except the ones for CODS T-test (r=0.15) and 93639m test (r=0.29), while with the Jelka test relationship was statistically significant (r=0.68). In literature, most correlations between CODS and straight running speed would be described as moderate (r=0.3-0.5). Brughelli et al. (2008) found that the lowest correlate reported was for the 20 m sprint and 5-0-5 agility test (r=0.055) and the highest significant correlates reported in females between the T-test and sprint acceleration and velocity (r=-0.63 to -0.69). In research of Young, James, & Montgomery (2002) the mean times taken to complete the various sprint tasks indicated that as the change in direction increased from the straight sprint by 20^0 to 40^0 to 60^0, the times to cover 8 m increased. Sheppard and Young (2006) stated that generally, the more changes in direction, the less the transfer from straight running speed to COD. This does not seem the case given the data above regarding CODS tests used in this research. But this is just at first sight. Having in mind different distance covered and duration of three tests of CODS applied, different statistical correlations with straight sprinting speed are clear and expected. Namely, in task resolving of Jelka test trough the average of 35.6 sec there are many more distance covered in which straight running speed could be more included, while in T test and 93639m there are requirements for COD after shorter distances which is the case likewise in the reaserch of Sheppard and Young (2006). In terms of the shared variance between variables, it would seem that straight sprinting speed and COD speed seem to be, for the most part separate motor qualities.

The most common type of jump used to predict COD was the vertical jump (Brughelli et al., 2008). In our study we used specific jumps for volleyball Block Jump (which is basically counter movement jump with elbows at shoulder height and hands above head with fingers spread in ready position) and Spike Jump with three steps approach with arm swing. Additionally we used Standing broad jump test for assesing leg power through jump horizontal distance. Intuitively, it would seem more appropriate to use jump tests that not only involve the application of vertical ground reaction forces, but also horizontal ground reaction forces, given that most human motion is a combination of these two types of forces. Results of our research are showing that only Standing broad jump was in statistically significant relationship with CODS tests, while the SJ and BJ were in statistically significant relationship only with Jelka test (r=-0.6). Djevalikian (1993) reported low (r=0.15) and non-significant correlations between power measures (15 s vertical jump performance) and a "boomerang run" that involved seven changes of direction. Web and Lander (1983) used a single vertical jump and a single standing broad jump in comparison with an L-run change of direction speed test. Again, low and non-significant correlations were reported for both Standing broad jump (r=-0.35) and the vertical jump (r=-0.19) in relationship with the L-run for change of direction speed. Marković (2007), using a bilateral long jump with arm swing, reported small correlations (r=-0.12 to -0.27) to their three tests of COD ability. Peterson et al., 2006, using a standing broad jump, found that horizontal jump distance was significantly correlated to the T-test for both males (r=-0.613) and females (r=0.713). Finally, Negrete and Brophy (2000) reported a correlation of r=-0.65 between a single-leg hop for distance and a diamond-shaped agility test. This horizontal jump measure was greater than their vertical jump measure (r=-0.38). Furthermore, the Peterson et al., 2006, horizontal jumps were greater than the vertical jump correlations. Given the results, it may be tentatively claimed that jumps that involve the combination of both HGRF and VGRF may better predict COD ability.

Table 2. Correlation Coefficients for Study Measures – Volleyball players (N=21)

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. Block Jump	1.00						
2. Spike Jump	0.94**	1.00					
3. Standing broad jump	0.79**	0.80**	1.00				
4. Jelka test	-0.60**	-0.60**	-0.74**	1.00			
5. T-test	-0.10	-0.12	-0.44*	0.46*	1.00		
6. 93639 m test	-0.29	-0.29	-0.60**	0.63**	0.63**	1.00	
7. 20 m Dash	-0.75**	-0.66**	-0.75**	0.68**	0.15	0.29	1.00

*p<0.02; **p<0.00

Conclusion

Many different tests have been used to assess CODS performance and more are continually being developed in order for researchers to assess the specific demands of the sport for which they are used. There are a multitude of tests that have been used. A difficulty with these tests is that they may contain a varity of movement patterns, such as forward sprinting, backwards running, sideways shuffling, lateral cutting, and lateral crossover stepping. The duration and intensity, the number of directional changes and the angle of change vary considerably among the tests. We need to identify the specific movement patterns used by successful athletes in particular sport.

In this correlational analysis, main conclusions are that CODS ability varies on the duration and intensity, the number of directional changes and the angle of change applied trough test situation. It is independent form vertical jumping ability and straight sprinting speed and related to jump distance trough horizontal force applied. Training and testing these abilities for performance of volleyball players should be highly specific.

It is an oversimplification to suggest that the leg muscle groups are solely responsible for COD movements. Change of direction speed ability needs to be viewed as a function of entire kinetic chain with adequate core stability, rather than just function of legs.

Sport practioners and researchers are intersted in determining the effect of various training programmes on the variable of interest, in this case COD. To do this, the changes in leg muscle qualities and straight running speed need to be mapped over longitudinal training interventions. Correlational analysis is of limited value in identifying the causal relationship between certain variables and change of direction ability.

Further researchers is need to be done, it is hoped that those variables that strongly influence COD ability will be elucidated and, as a result, give the reader insight and focus as to what variables should be assessed, developed and monitored.

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