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TENNIS PERFORMANCE AND THE DOMINANT ARM STRENGTH VELOCITY IN MALE AND FEMALE TENNIS PLAYERS

Key words: tests, strength velocity, dominant arm, differences between girls and boys.

ABSTRACT

Strength velocity is one of important components in tennis. The study used three throw tests to assess in what way the serve velocity was related to the prospects of its development and the respective performance during particular tests. The research sample was composed of 26 tennis athletes (13 boys and 13 girls), aged 21 ($\pm$1.4) years, with more than four years of tennis experience. The correlation between the tests was assessed with the aid of Pearson correlation, and the differences between the sexes were measured with t-tests. The level of statistical significance was set at $p<0.001$. As for boys, the serve velocity was statistically most strongly correlated with the strength velocity of the dominant hand during the tennis ball throw and centrifuge ball throw tests. As for girls, there was no correlation between serve velocity and the three throw tests. The results of the study showed that the strength velocity of the dominant hand affected the serve velocity in boys and girls in a different way.

INTRODUCTION

Strength and its impact on the performance of tennis players are determined by certain parameters. More specifically, the increase in strength through training can either negatively influence joint mobility and endurance, or modify properly acquired automated techniques; at the same time the strike velocity may increase. The key aspect is the increase of a special feature of strength, called strength velocity (outdoing minor resistance through repetition) (Behm, 1988; Deutscher Tennis Bund, 2, 1996). On the other hand, insufficient development of muscle strength may lead to injuries, which is an inhibitory parameter of the tennis player's development (Morris et al., 1989). Coordination ability and suitable technique have to be combined with strength velocity in order to achieve maximum performance as far as tennis serve and other tennis strikes are concerned. Swinging during these strikes is mostly a matter of acceleration rather than strength (Hakkinen & Komi, 1983; Jentsch, 1984).

Groppel & Roetert (1992) report that training schedules have to be planned accordingly to the muscles mostly used during the game; they should also be based on the type of strength used during particular strikes and sports. Except for the speed attained during the tests, it is also important that the exercise simulates a real game. In this way, not only are the muscles involved in the movement trained, but also the muscular system adapts to specific conditions (Andrews & Vaughan, 1983).

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Rieder's survey focused on the diagnosis of physical fitness of tennis players. All the tests used in the survey were highly credible and assessed strength velocity, throw strength, halt, speed acceleration, endurance and joint mobility. According to Rieder, a parameter of primary importance in tennis playing is that of strength velocity, whereas strength endurance and maximum strength are of secondary importance. Many researchers have proved that athletes who have undergone strength velocity training are able to attain a significantly higher percentage of strength during high velocity movement than athletes who have followed a slow velocity practice (Palmieri, 1987; Hamrick et al., 2006).

Many researchers, e.g. Jobe et al. (1983), Aldernick & Kuck (1986) and Elliot & Wood (1992), tried to explain the impact of the strength of all body muscles, not just that of the upper arm, on serve velocity. Fabrocini (1995) is of the same opinion and maintains that in order for a serve to be performed at the maximum possible velocity, coordination of all body muscles must be ensured. The muscles of the upper limb are part of the kinetic chain. Groppel & Roetert (1992) are of the same opinion and conclude that the simultaneous exploitation of these strengths is of decisive importance. They also claim that if this collaboration is not feasible, then, not only will there appear errors in technique but strike velocity will also be reduced. Likewise, Chu (1995) reports that since our whole body is built of muscles, the body, leg and arm muscles should be equally taken into consideration in organizing the training schedule. To sum up, it is estimated that the performance of tennis serves or other strikes is the result of the right function of the kinetic chain based on correct technique, elasticity and strength of muscles (Groppel & Roetert, 1992; Coen et al., 1994). The most recent studies (Bahamonde, 2000) on the vertical and horizontal angular velocity of the body attempted to explain its contribution to the serve strike. Two more significant angular velocities have been found along the horizontal and vertical axes (X, parallel to the baseline; Y, normal to the baseline and pointing towards the net; and Z pointing upwards).

The present study compared serve velocity and strength velocity of the dominant hand as they developed during three tests. The aim of the study was to examine which one or ones of the three tests are most conducive to the performance of the tennis serve and should be taken into account in developing of prospective training schemes.

METHODS

The sample for the study consisted of 26 tennis players aged 21 (±1.5) years, with more than four years of tennis experience. The serve velocity was assessed using a calibrated Juggs radar gun (Tribar CO, Montreal, Canada). The participants carried out 10 serves. Only those landed within the service court were registered. The credibility of the tests was verified and proved satisfactory (r = 87).

The three tests were racquet throw, tennis ball throw and centrifuge ball throw tests. In all three tests the subjects' performance was measured in metres and only the best of the three throws was taken down. The credibility level was checked on the test-retest scale and was proved satisfactory (r = 76, r = 89, r = 79, respectively).

Racquet throw test. A player was standing behind a line and threw the racquet (an old Pro Kennex, the same for all athletes) using the forehand strike (movement performed by a right-hand player to strike the ball coming from his right).

Tennis ball throw test. A participant was standing behind a line, and threw the tennis ball as far as possible.

Centrifuge ball throw test. A participant was standing behind a line and threw a centrifuge ball used in track training.

The data was presented in terms of mean values and standard deviation separate for both sexes, using MS EXCEL. Pearson's correlation scale was used, while the differences between the sexes were measured using a t-test scale (SPSS 10).

RESULTS

Figure 1 shows clear differences in test performance between boys and girls. A significant difference was noted between the serve velocity results (118.91/84.38 km/h). The tennis-ball throw test produced higher values as compared with the other two tests. These differences were all statistically significant, as presented in Table 1 ($p < 0.001$).

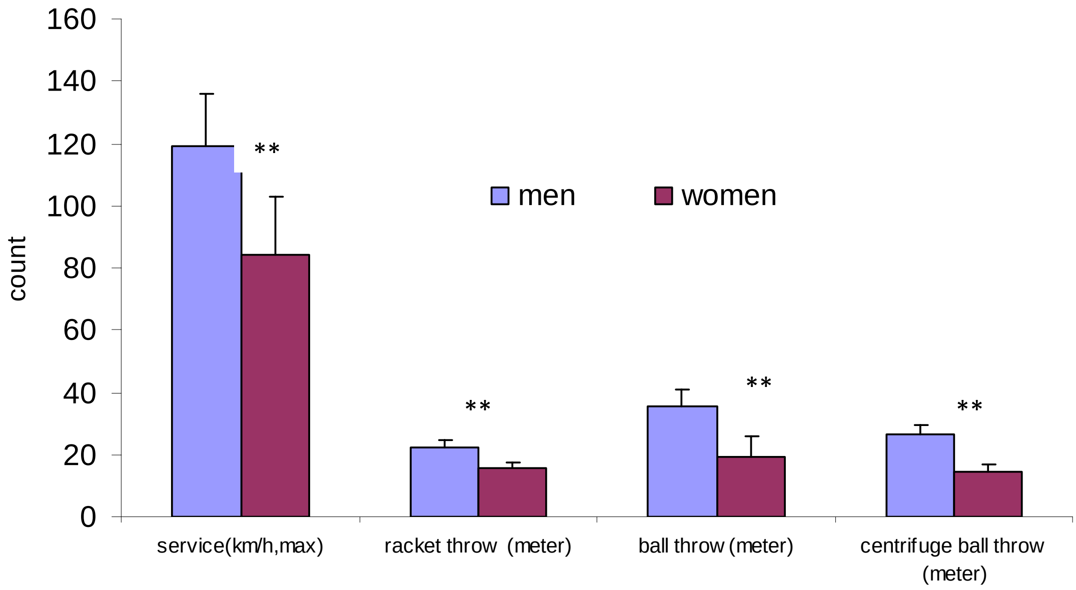

Figure 1. Difference in performance between men and women (**p < 0.001)

Table 1. Correlation between the serve velocity and the results of three tests

		Racquet throw (meters)	Tennis ball throw (meters)	Centrifuge ball throw (meters)
Serve velocity (km/h, max)	Pearson Correlation	0.321	0.630*	0.554*
	Sig. (2-tailed)	0.285	0.021	0.049
men	N	13	13	13
Serve velocity (km/h, max)	Pearson Correlation	0.198	0.389	0.088
	Sig. (2-tailed)	0.517	0.189	0.774
women	N	13	13	13

* p > 0.05 (2-tailed)

The serve velocity in the boys' group revealed a high statistical correlation with the strength velocity of the dominant hand in the tennis ball throw test and the centrifuge ball throw test (Table 1). Conversely, in the group of girls, there was no correlation with the serve velocity in all three throw tests.

The correlation between the results of the tests was statistically significant in the case of men tennis players (from r = 0.554, p = 0.049 to r = 0.789 p = 0.001). As for the girls, the results of the racquet throw test were only correlated with the centrifuge ball throw test (r = 0.634, p = 0.020); the correlation between the results of the tennis-ball throw test and centrifuge ball throw test was statistically significant (r = 0.789 and p = 0.001).

DISCUSSION

The present study took into account neither the technique of the service strike nor that of the actual throws. The level of performance is another issue for consideration. At a strictly professional level and when examining serves of much higher velocity, the correlation between the performance during the specific tests could have been different, offering a chance for further research. In this study, nonetheless, it was indicated that the correlation between the serve velocity and the throw test results was statistically significant as the male tennis players achieved a much higher speed of their performance.

The higher correlation values between the tennis-ball throw test and serve velocity in the present study correspond with the results obtained by Cohen et al. (1994), who examined the correlation between anthropometric parameters, strength of upper limbs and serve velocity. The participants, boys and girls at a national competence level, performed a series of tests during which their serve velocity was measured with the aid of a radar. The strength of the upper dominant limb during fast (180 deg/sec) and slow (80 deg/sec) movements was measured with the use of Cybex equipment. The measurements of the strength and serve velocity showed that the serve velocity was highly correlated with the strength of the upper limb during fast movement, as it was also the case in the present study during the throw test with the least resistance (tennis-ball throw).

Ellenbecker (1991) studied not only the correlation between the strength of the upper limb and the serve velocity but also between the strength of the dominant and non-dominant limbs. The sample for his study comprised 22 advanced tennis players whose inner-outer rotation of the shoulder, flexion-stretch, prone-supine and flexion-stretch of both the dominant and non-dominant limb were measured by means of an isokinetic dynamometer. A statistically significant isokinetic strength was assessed to be that of the dominant hand for all movements. Contrary to the results of earlier studies, Ellenbecker found no correlation between the measured service strike velocity and isokinetic strength. In fact, the strength of the dominant hand was different than the strength during the tennis-ball throw test.

The racquet throw test seems to be weakly correlated with serve velocity. The movement during a specific throw is performed by muscles which participate in the forehand strike but not in the serve. Conversely, the movement during the tennis ball throw test resembles more the serve movement. At this point, researchers who support the view that tests should be conducted in order to check all groups of muscles participating in a strike are justified (Andrews & Vaughan, 1983; Groppel & Roetert, 1992).

The muscles involved in the serve movement include quadriceps femoris, gluteus, infranspinatus, subscapularis, latissimus dorsi, triceps brachii and forearm (Behm, 1988). According to Ryu et al. (1988) these muscles are subscapularis, pectoralis major, serratus anterior and biceps branchii. These muscles should be trained to improve strength velocity and endurance as strength velocity traits should always be combined with the right technique to achieve a good performance level. According to Behm (1988) when emphasis during the service strike is placed on strength velocity, the strain during training should not exceed 50% of the maximum strength of the athletes. Repetitions should range from 12 to 15, and the number of sets from 1-3.

Ferrauti & Bastiaens (2007) carried out a study on a group of teenager tennis players and revealed that serve velocity did not improve significantly after a training session with a heavier ball (600 g). Mont (1994), though, stressed the importance of specific training aimed at strength development in athletes. More precisely, the results of his study of advanced American players showed there had been an increase in serve velocity after an intensive 6-week weight-lifting training of the inner and outer rotation of the shoulder. There was a statistically significant correlation between the serve velocity and the explosive strength of the shoulder.

The strengthening of the muscles of the upper limb and shoulder was also studied with the aid of special exercises by Treiber et al. (1998). The objective of their research was to see whether or not it was possible to improve shoulder strength and serve velocity in a group of highly competent players after a 4-week training session with latex bands and small-weight (4-6 kg) dumbbells. The players underwent initial and final measurements of their serve velocity and of their inner-outer rotation of the shoulder with the use of an isokinetic dynamometer. After a 4-week training period, a significant improvement of the strength of the inner-outer swing of the shoulder as well as of serve velocity (6% increase of the maximum speed and 8% of the average speed) were noted. It was concluded that resistance training with latex bands and light weight dumbbells had positive effects on the correlation between the strength of the upper limbs and serve velocity in highly competent athletes.

Anderson (1994) observed that the joint mobility of the shoulder and wrist positively affects serve velocity. The correlation between the strength of the inner and outer rotation of the shoulder significantly affects service strike velocity. Mont (1994), who also focused on torsal strength in his study, shares the same opinion.

On the other hand, a study carried out by Gordon & Dapena (2006) in a group of advanced women players, showed that the rotation speed horizontally and vertically to the shoulder axis revealed statistically non-significant differences, following the examination of racquet acceleration during the serve.

The present study showed that the strength of the dominant hand contributed to serve velocity in men and women, and that serve velocity was mostly correlated with the results of tennis-ball throw and centrifuge ball throw tests. These throws are mostly controlled by the groups of muscles participating in the serve. In both cases, strength velocity played a significant role. With its appropriate improvement through training of respective muscles, a further positive step can be taken towards the improvement of serves of all tennis players.

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