# The effect of the leg and back strength of the serve and tennis players to the serve throwing speed and agility

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* The aim of this study was to examine the effect of leg and back strength on serve throwing speed and agility of 19-23 year old male tennis players who are studying at university.

*Material:* Twelve male tennis players, aged between 19 and 23, who were studying at university in Kayseri participated in the study voluntarily. Individuals who played tennis for at least 5 days per week participated in the study and leg and back strength measurements and their relation with the serve and agility were compared.

*Results:* In the study, leg strength test, back strength test, agility test and serve throwing speed tests were applied to the subjects. These tests reveal a significant relation between back strength and serve throwing speed (R=,660, R2=,435; p<,050). When the t-test results on the significance of the regression coefficient are examined, it is seen that back strength level (t=2,774, p = ,024) affects serve throwing speed and explains approximately 43% of the total variance. There is a significant relation between leg strength and serve throwing speed (R=,586, R2=,343; p<,050). When the t-test results on the significance of the regression coefficient are examined, it is seen that leg strength level affects serve throwing speed and it explains approximately 34% of the total variance.

*Conclusions:* As a consequence, it has been revealed that leg strength and back strength in tennis players have a statistical relationship with agility and serve throwing speed. For this reason, it is considered necessary to apply training programs to improve leg and back strength in trainings.

**Keywords**: Tennis, Back Strength, Agility, Service Throwing speed.

## Introduction

Tennis is a sports branch in which anaerobic metabolism is used intensively. Anaerobic power is defined as the work that can be created by using the ATP-CP energy source at a unit of time. During the competitions, the maximal heart rate of the players reaches 90% during the period of 2.5 - 3 hours. During this time all the strokes are made with explosive power, showing how important the anaerobic power is [1].

Tennis has the feature of an intermittent game which includes 10-20 sec pauses after a short but at a high tempo game [2]. Strength is a very important parameter for performance to be displayed in tennis. It can be seen as the statement of the performance amount that is displayed in a certain period of time. Lower extremity strength ensures both to catch the ball in the shortest time and to hit the ball harder during the match [3]. An effective serve throwing is highly important in tennis to display a successful performance. In the serve and volley, the player who throws the serve makes a move towards the net after throwing the serve and throws the returned ball by volley to the corner that the opponent cannot reach. Besides, one of the most important criteria in determining serve performance is the ball speed in serve throw [4]. The speed of the ball in serve throws depends on the fact that the interdependent factors are in a complex whole. Among these factors, the physical structure, strength, joint range of motion of the tennis player, and speed of the joints and racket during serve throw are very important [5]. Throw speed is directly related to the range of motion of the joints that create the throw strength because the agonist muscles responsible for the movement will stretch in accordance with the wide joint motion at the beginning of the movement. This will also increase the throwing speed [6, 7]. Agility is the coordination skill that allows the body and joints to remain in the right position in space during very fast direction changes during a series of motion [8]. Agility consists of two main components, psychological and physical, such as decision-making mechanisms and speed of direction change [9]. The speed of direction change is influenced by factors determining the quality of the lower extremity muscles, such as straight sprint, technical and reactive (elastic) strength, concentric muscle strength, and right-left leg strength imbalances [9, 10].

It is an indisputable fact that tennis should be supported by scientific studies in order to achieve international achievements.

*Hypothesis:* Service and volley tennis players with high leg and back strength have better service throw speed. *Purpose:* In this study, it is aimed to investigate the effect of leg and back strength of male tennis players on the serve throwing speed and agility.

## Material and Method

*Participants.*

*Forming Voluntary Groups:*

Twelve male students aged between the ages of 19-23 who played tennis at university level voluntarily participated in the study. Participants consisted of individuals who had 5 days tennis activity per week. The volunteers were informed before participating in the study and confirmation forms were received.

*Research Design.*

*Age, Height and Body Weight measurements:* A measuring tape with the 0,01 cm degree of precision was used to measure the heights of the volunteers.


doi:10.15561/20755279.2018.0502

Measurements were obtained while the volunteers were barefoot. While the measurements were taken, the heads were upright position, soles were on the floor, knees were stiff, ankles were contiguous and bodies were upright position. The body weights were measured barefoot and with minimal clothes by using a bascule with 0.1 degree of precision.

*Leg Strength Test;*

Measuring leg strength: The measurement was made using the takei physical fitness test brand leg dynamometer. After warming up for five minutes, the subjects placed their feet on the dynamometer table as their knees were bent. They pulled the dynamometer bar vertically upward by using their legs at maximum rate as their arms were stretched, backs were straight and the bodies were slightly leaned forward. This pulling was repeated twice and the best value for each subject was recorded in kg [11].

*Back Strength;*

Measuring back strength: The measurement was made using the takei physical fitness test brand back dynamometer. After the volunteers placed their feet on the dynamometer table as their knees were stretched and as their arms were stretched, backs were straight and bodies were leaned forward slightly. They pulled the dynamometer bar that they gripped by their hand vertically upward at maximum rate. The pull was repeated twice and the best result was recorded in kg [11].

*Measuring agility*

T test was used to measure the agility. This test was applied to determine the speed in covering a distance by changing direction such as sprinting forward, drifting left and right and backward run [12].

Cones were placed so that the distance between them would be 4.57 m. The subjects started at cone A. They sprinted to cone B and touched it. They then run to cone C and D by side steps and touched them in turn. They shuffled back to cone B and completed the test by reaching cone A running backward. Volunteers' test completion times were measured by a stopwatch. Each volunteer repeated the test twice and the best time was recorded as the volunteer's score in sec [13, 14].

*Serve Throwing Speed;*

The speed of the ball during the serve was measured by a "Stalker solo 2" brand radar device with the ±0,8 km.h-1 degree of precision that can make the speed measurement of between 8-224 km.h-1. Measurements were taken 1.5 higher than the serve end line by the same person [15]. Measuring the Ball Speed in Serve Throw; All serves were thrown in a closed tennis court in order to control the effect of the air. The subjects warmed up until they reached the maximal serve speed level. 3 minutes after the subjects warmed up, test phase started and they were asked to throw 5 serves at maximal speed. In accordance with the tennis rules, it was required to throw the service to the serve point, the cross-court service box, with backhand. The serve was not recorded as a value in case of it was thrown to the net or out of the service box. All serves were thrown to the left service box for the right-handed players (from right) and to the right service box for the left-handed players (from left). All players were asked to use the flat service technique. For the data analysis, the fastest service (km/h) out of the 5 services that the players threw at maximal speed was analyzed as the maximal service (Vmax) [5, 16].

*Sport Age:*

The time that the volunteers spent in tennis branch was recorded as year.

*Statistical Analysis.*

In this study, to obtain the statistical results, SPSS 24 package was used. The means and standard deviation of the measurements and tested variables of all subjects were calculated. Values under $p<0,05$ were accepted as statistically significant. Pearson correlation analysis was used to analyze the relation of the data, and simple regression analysis was used to analyze the effect levels of the related values.

**Results**

When Table 1 was reviewed, it was determined that the average age of the participants was 20,75±1,28 years, average height was 177,58±3,65 cm, average body weight was 75,41±5,26 kg, sport age average was 9,50±1,31 years and the average of Body Mass Index was 23,89±1,08.

When Table 2 was reviewed, it was found that the average of the back strength was 122,16±13,16, leg strength average was 112,33±13,51, agility average was 10,12±,54 sec and serve throw speed average was 125,72±11,79 km/hour.

When Table 3 is reviewed, it is seen that there is a high level of positive relation between serve throw speed

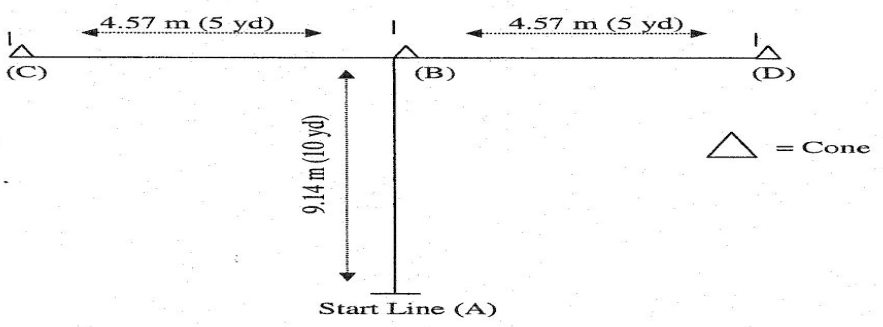


**Fig. 1.** T test used to measure the agility

**Table 1.** The Demographic Characteristics of the Participants

| Variables | n | X±SD | minimum | Maximum |
|---|---|---|---|---|
| **Age (Year)** | 12 | 20,75±1,28 | 19,00 | 23,00 |
| **Height (cm)** | 12 | 177,58±3,65 | 172,00 | 185,00 |
| **Body Weight (kg)** | 12 | 75,41±5,26 | 69,00 | 90,00 |
| **Sport Age (Year)** | 12 | 9,50±1,31 | 8,00 | 12,00 |
| **BMI (kg/m²)** | 12 | 23,89±1,08 | 22,78 | 26,30 |

**Table 2.** The average results of the participants' selected motoric properties

| Variables | n | X±SD | minimum | Maximum |
|---|---|---|---|---|
| **Back Strength** | 12 | 122,16±13,16 | 105,00 | 140,00 |
| **Leg Strength** | 12 | 112,33±13,51 | 85,00 | 132,00 |
| **Agility** | 12 | 10,12±,54 | 9,05 | 11,20 |
| **Serve Throw Speed** | 12 | 125,72±11,79 | 105,40 | 142,50 |

**Table 3.** The correlation analysis between the serve throw speed and other variables

| Variables | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Back Strength | **r** | 1 | | | |
| | **p** | - | | | |
| Leg Strength | r | ,863 | 1 | | |
| | p | ,000** | - | | |
| Agility | r | ,441 | ,314 | 1 | |
| | p | **,152** | ,320 | - | |
| Serve Throw Speed | r | **,660** | **,586** | -,149 | 1 |
| | **p** | **,020*** | **,045*** | ,643 | - |

*p<0,05 **p<0,001

**Table 4.** Regression analysis regarding the prediction in serve throwing speed in tennis

| Variables | *β* | t | *P* | *R* | *R²* | F | p |
|---|---|---|---|---|---|---|---|
| **Constant** | | | | ,660 | ,435 | 7,698 | ,020 |
| Back Strength | ,660 | 2,774 | ,020 | | | | |
| Constant | | | | ,586 | 343 | 5,222 | ,045 |
| Leg Strength | ,586 | 2,285 | ,045 | | | | |

P<0,05

and back strength (p<0,05, r=,863). A medium level of positive relation between serve throw speed and leg strength is determined (p<0,05, r= ,586). There is no significant relation between serve throw speed and agility (p>0,05).

When the table is reviewed, it is seen that there is a significant relation between back strength and serve throw speed (R=,660, $R^2$=,435; p<,050). When the results of the t-test regarding the significance of the regression coefficient are examined, it is found that the level of the back strength (t=2,774, p = ,024) affects serve throw speed and it explains approximately 43% of the total variance. There is a significant relation between leg strength and serve throw speed (R=,586, $R^2$=,343; p<,050). When the t-test results regarding the significance of the regression coefficient are examined, it is seen that leg strength level (t=2,285, p= ,045) affects serve throw speed and it explains 34% of the total variance.

**Discussion**

In this study, which 12 male students aged 19-23 who played tennis at university level participated in voluntarily, it is aimed to display whether serve throw speed is statistically related to leg strength and back strength.

In the study, it was determined that the average height of the players was 177,58±3,65 cm, body weight average was 75,41±5,26 kg and body mass index average was 23,89±1,08 kg/m$^2$.

Houston et.al determined the body mass indexes as 22,1± 5,50 kg/m$^2$ in their study they conducted on tennis players [17]. Cohen et.al determined the body mass indexes as 22,3±7,40 kg/m$^2$ in their study on tennis players [16]. These results are similar to our study.

An efficient serve is a parameter related to the stature directly and workout age expresses the experience of serving [18]. Tall tennis players seems to be more advantages than the short ones since they meet the ball higher and they create a bigger angle. This angle means hitting the ball harder. Flat services need to be shot at least 254 cm high in order not to hook the net. Balls shot at 254 cm height can reach up to 179 km/h because of the vertical angle range [19]. For faster services, the ball and racket meeting point must be higher, which explains the relationship between service ball speed and height. A study was conducted on the serve speed according to the

anthropometric characteristics of the tennis players. It is stated in this study that there is a positive relation between the ages (r=0,60; p<0,01), statures (r=0,58; p<0,01) and body weights (r=0,47; p<0,05) of the male tennis players and the service speed [20]. In another study, a relation is found between the statures (p<0,01) and workout ages (p<0,05) of the tennis players and the speed of the ball in the serve. It is reported in this study that a significant relation is not found between the ball speed and age and body weights [5].

In our study, the relation between the serve throw speed and stature has not been studied, and it is recommended this comparison to be included in other studies.

In the study, the average of the back strength was found as 122,16±13,16 kg, leg strength average as 112,33±13,51 kg, agility as 10,12±,54 sec and the average of the serve throw speed as 125,72±11,79 km/hour. In addition, when the relation between leg strength and serve throw speed was examined, a statistically significance was detected between the values. As being special to the tennis serve, many parts of the human body is required optimal strength, flexibility, timing and coordination. The performance of the service therefore depends on the fact that many interdependent factors are within a complex whole. One of the most important of these factors is undoubtedly muscle strength and joint range of motion. Muscle strength at high speed, which is an integral part of tennis service, needs to be transferred from the legs and the body to the arms at the appropriate level and time [5].

When the similar studies in the literature is viewed, it is found that Göral et.al determine the leg strength value as 155,7±7,27 kg and back strength value as 115,7±16,06 kg [21]. In another study conducted by Gelen et.al, the back strength of the major league players is determined as 143,1±12,5 kg and the minor league players' as 131,1±12,5 kg. While the leg strength of the major league players is 185,1±9,6 kg, minor league players' is 173,9±10,1 kg [22]. In the literature, although there are studies that accept there is a moderate to low level of relationship between ball speed and upper extremity isokinetic strength [16], in some studies it is stated that no relationship is found between the two [23]. In their study, Gelen and et.al state that there is a negative relationship between the ball speed in the serve throwing of tennis players and mesomorphic values (p<0,01). However, they found no relation between endomorphic and ectomorphic values [5]. A statistical significance is determined between the values when the relationship between leg strength and serve throw speed is examined according to the results of our study. This indicates that our study is supported by other studies in the literature. Besides, the finding of that there is a high level of positive relation between serve throw speed and back strength is again supported by other studies.

The overall structure of the tests analyzing the agility depends on the measurement of shuttle run speed on the horizontal plane. The scores measured in the tests applied to evaluate the agility characteristics should be independent from the maximal speed at flat sprint [9].

When the relation of the leg and back strengths with the agility is examined in our study, a statistical significance is not determined between the values. Since explosive strength is more effective in serve throwing, agility has the secondary level of importance.

In general, low or insignificant relations have been determined between agility and flat sprint, lower extremity strength and power in the studies [24, 25].

Hazır et.al reports in their study that relations between lower extremity strength measurements and agility tests have changeable values depending on the content of the agility test. They also reports that the relations between the scores obtained from average strength and agility in the 30 sec multiple jump test are not significant [10]. Similarly, in a study conducted formerly, no significant relation (r = -0,15) is determined between the strength values measured in the agility test containing $90^0$ and $180^0$ rotations and 15 sec multi jump test [9]. These results are parallel with our study.

**Conclusions**

It is determined that leg and back strengths of the tennis players participated in the study have a positive relationship with serve throw speed. Especially when the obtained results were evaluated, it was found that there was a positive and strong relationship between back strength and service speed and back strength had an effect of about 43% in the formation of service speed. With this result, there is an opinion that back strength plays an active role in a large part of the service throw. Looking at the components of the movement during the service throw speed, it is seen that the back muscles are the most active muscle group in the rotation of the arm and in the time until the moment of hitting the ball. This fact is thought to reveal the importance of back strength. It was also found that there was a positive and moderate relationship between leg strength and service rate and that leg strength had an effect of about 34% at the service throw speed. Especially since the balance is at the optimal level during the service throw, it is thought that foot strength is important during the rotation of the body during service. The lack of a relation between agility and service speed in the study may be attributed to the availability of a more stable state and a predictable movement chain especially during service, although agility has a great importance in the tennis branch.

As a consequence, it has been found that back and leg strength has an effect on service throwing speed in a positive way. It is believed that for a high speed of service throw, workouts to improve back and leg strength will contribute the performance. In further studies, it is thought that the application of different leg and back strength training programs, the inclusion of athletes in different training programs as experiment and control groups and the investigation of the effect of the different training programs on service throw speed will contribute to sports science and tennis branch.

**Conflict of interest**

The authors declare no conflict of interest.

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**Cite this article as:** Kaya M, Soyal M, Karakuş M. The effect of the leg and back strength of the serve and tennis players to the serve throwing speed and agility. *Physical education of students*, 2018;22(5):237–242. doi:10.15561/20755279.2018.0502

The electronic version of this article is the complete one and can be found online at: http://www.sportedu.org.ua/index.php/PES/issue/archive



Received: 12.08.2018
Accepted: 12.09.2018; Published: 30.09.2018