Performance Analysis in Sport and Exercise

Ankara University Performance Analysis in Sports Application and Research Center

Available online 5 December 2022

Investigation of Relationships Between Tennis Serve Performance, Anthropometry, Somatotype and Range of Motion According to Sex

Mustafa Can Eser [1] *

[1] Faculty of Sport Sciences, Ankara University, Ankara, Turkey

Abstract

Serve is one of the most important strokes of tennis. The aim of the study is to examine relationships between anthropometric features, shoulder range of motion (ROM), somatotype and serve performance (serve accuracy & serve speed) according to sex. 15 male (age: 19.00 ± 1.06 years) and 14 female (age: 18.64 ± 0.92 years) tennis players participated in this study. The descriptive and anthropometric measurements (age, competitive experience, height, body mass, body mass index, arm & wrist circumferences) and ROM (internal & external shoulder rotation degrees) were taken and recorded. Somatotype determined based on Heart Carter method. In order to determine serve performance, a pre-designated test, which evaluates serve speed and accuracy for both "first serve and "second serve" carried out. The Pearson's coefficient of correlation was used to study the correlation between serve performance and the anthropometric, somatotype and ROM variables. Student's t-test was used to comparison of sexes. To compare correlations coefficients among sexes, Fisher's z transformation performed. As hypothesized, results showed that serve performance determinants were differ according to sex.

Key Words: Serve speed, serve accuracy, shoulder ROM, gender comparison

INTRODUCTION

Tennis is one of the most popular sports worldwide for both professionals and recreational players (18). In the last two decades, tennis has evolved into a more speed, power and strength-based sport (13). With this progression, the importance of serve, the most strength-demanding stroke in tennis has increased (15). Since serving in the aimed area is important for reducing the effectiveness of the opponent's offensive and defensive systems during the game, a good serve may be consider as one of most important factors of an efficient attack (11).

To date, many studies conducted to investigate determinants of serve performance (1, 5, 7, 14, 17, 24). These studies mainly reported anthropometric features, upper extremity strength, hip, wrist and shoulder rotation are some determinants of serve performance. Besides, previous studies demonstrated that serve speed is influenced by player’s experience (14). There are also findings about physical and morphological profiling tennis players may contribute development of more specific attributes (2, 8, 10, 23). Within the research investigating the tennis serve kinematics, some researchers have focused on the lower/upper body joints as well as the movement of the racquet (4, 6); while others have investigated the relationship between some specific joint kinetics and serving performance (9, 19, 22, 25). Although previous studies have reported determinants of serve performance, there is a scarcity of studies examining these determinants sex-wise.

Besides scarcity of gender studies, above-mentioned studies mostly investigated determinants of “first serve”. However, the first and second serve are strokes with different characteristics. While first serves faster, inconsistent and includes slight spins; seconds serves are slower but more accurate and involving sidespins. Therefore, these two serve manners expected to have different needs.

The purpose of this study was to investigate the relationships between serve performance (i.e. serve speed & accuracy) and anthropometric, somatotype shoulder ROM and compare these correlations among sexes. Results of the study may contribute to the knowledge of serve performance for players and coaches.

METHODS

Study Design

This was a descriptive, cross-sectional study. The population of study included college level Turkish male and female tennis players.

Subjects

The sample consisted of 29 tennis players (15 male & 14 female). The inclusion criteria were attending tennis competitions for at least 5 years, training at least eight hours a week and being healthy. Descriptive data of participants have represented in table 1. All the participants have briefed about testing protocols.

Table 1. Descriptive data.

	Male	**Female**	**t**	**p**
Age (years)	19.00 ± 1.06	18.64 ± 0.92	0.957	0.347
Height (cm)	176.70 ± 4.44	168.61 ± 4.68	4.771	**0.000**
Competition Experience (years)	6.66 ± 1.44	6.57 ± 1.91	0.152	0.880
Body Mass (kg)	70.30 ± 4.51	59.41 ± 5.43	5.881	**0.000**
BMI (index)	22.51 ± 1.20	20.84 ± 0.86	4.262	**0.000**

Procedures

All tests were performed in two different days. At first day, participants' anthropometric, somatotype and ROM data were collected. At the second day serve test was carried out. Measures of anthropometric characteristics were represented by 7 variables, these being: body height (cm), forearm length (cm), upper arm length (cm), wrist circumference (cm), arm circumference (cm), body mass (kg), body mass index (index). Internal and external rotation angles were collected as shoulder ROM variables. The somatotype values of the participants were determined using Heath Carter method of somatotyping (3).

At the first day, each participant's body height was measured with a fixed stadiometer (Holtain, England) and bodyweight measured by a scale with bioelectrical impedance analyzer (Tanita, TBF 401A, Japan). After that, forearm & upper arm length and wrist & arm circumference measurements carried out consecutively with a measurement tape. For the wrist circumference, tape is applied around the wrist while not applying any pressure to the distal to the styloid processes of the radius and ulna. The ROM measurements carried out with a goniometer by an experienced physiotherapist with standard methods. Based on Heart Carter (3) method, body weight, height, biceps and calf circumference during flexion, humerus and femur breadth, triceps, subscapular, suprailiac and calf skinfold were measured and the formula used to calculate somatotype values. All measurements were performed before noon.

The serve test was performed on a standard indoor clay tennis court. Participants were free to use their own racquets in order to avoid familiarization related issues. After 10 minutes of individual warm up session, participants instructed to perform in total 40 serves to two pre-designated targets on each serve boxes. 20 first serve and 20 second serve for both right and left serve boxes were executed according to player's choice. Two observers; one of them behind serve-side long line and the other one behind baseline checked if the serve is "in" or "out". Between trial rest intervals given as much as players want. During each trial, participants used newly opened balls (Wilson US Open, Wilson Sporting Goods Co, Chicago, IL, USA). Serve speed measured by a radar gun (Speed Gun SR3600, Sports Radar, FL, USA).

Statistical Analyses

All data were analyzed using statistical software (IBM SPSS Statistics 20, IBM, USA) with the level of significance set at $p<0.05$ Normality of data was checked by Shapiro-Wilk test ($p<0.05$). The Pearson's coefficient of correlation was used to study the correlation between serve performance and the anthropometry, somatotype and ROM variables. Student's t-test was used to comparison of sexes. To compare correlations coefficients among sexes, Fisher's z transformation performed.

FINDINGS

Table 2. Serve, Anthropometry, ROM, Somatotype data.

	Male (Mean ± St. D.)	**Female (Mean ± St. D.)**	**t**	**p**
First Serve Speed (km/h)	167. 28 ± 8.91	149.58 ± 12.51	4.409	**0.000**
First Serve Accuracy (score)	0.52 ± 0.14	0.50 ± 0.08	0.356	0.725
Second Serve Speed (km/h)	133.34 ± 8.19	117.09 ± 10.44	4.679	**0.000**
Second Serve Accuracy (score)	0.71 ± 0.11	0.71 ± 0.07	-0.128	0.899
Upper Arm Length (cm)	30.34 ± 1.66	27.39 ± 0.90	5.868	**0.000**
Forearm Length (cm)	29.66 ± 2.02	25.70 ± 0.66	6.953	**0.000**
Wrist Circumference (cm)	15.97 ± 1.20	15.25 ± 1.20	1.606	0.120
Arm Circumference (cm)	29.12 ± 2.28	25.57 ± 1.26	5.121	**0.000**
Internal Shoulder Rotation (deg)	43.00 ± 2.09	41.08 ± 1.08	3.052	**0.005**
External Shoulder Rotation (deg)	125.00 ± 3.25	121.88 ± 1.92	3.119	**0.004**
Endomorphy	1.66 ± 0.89	1.71 ± 0.46	-0.177	0.861
Mesomorphy	2.80 ± 0.94	1.92 ± 0.73	2.772	0.010
Ectomorphy	3.53 ± 1.12	4.14 ± 0.86	-1.627	0.115

The findings observed separately for all four serve conditions. For male participants first serve speed, there was no correlation observed except BMI ($r=-0.69$, $p<0.05$). However, height ($r=0.53$, $p<0.05$) upper arm length ($r=0.61$, $p<0.05$) and arm circumference ($r=0.80$, $p<0.01$) was significantly correlated for females. First serve accuracy of male correlated with arm circumference ($r=-0.60$, $p<0.05$), internal shoulder rotation ($r=0.67$, $p<0.05$), endomorphy ($r=-0.76$, $p<0.01$) and ectomorphy ($r=0.65$, $p<0.05$). First serve accuracy of females correlated with height ($r=0.58$, $p<0.05$), competition experience ($r=0.69$, $p<0.05$), body mass ($r=0.53$, $p<0.05$) and internal rotation ($r=0.79$, $p<0.01$).

Table 3. First serve performance correlations.

	First Serve Speed				First Serve Accuracy			
	Female	**Male**	z	p	**Female**	**Male**	z	p
Age	-0.20	0.37	-	-	-0.17	0.00	-	-
Height	**0.53***	0.36	-	-	**0.58***	0.34	-	-
Competition Experience	0.31	-0.07	-	-	**0.69***	0.37	-	-
Body Mass	0.46	-0.27	-	-	**0.53***	0.28	-	-
BMI	0.32	**-0.69***	-	-	0.39	0.00	-	-
Upper Arm Length	**0.61***	0.27	-	-	0.32	0.28	-	-
Forearm Length	0.09	0.12	-	-	0.01	0.24	-	-
Wrist Circumference	-0.27	-0.25	-	-	-0.52	**-0.60***	-	-
Arm Circumference	**0.80****	-0.26	-	-	0.40	0.02	-	-
Internal Shoulder Rotation	0.39	0.05	-	-	**0.79****	**0.67***	0.62	0.535
External Shoulder Rotation	-0.08	0.34	-	-	0.38	0.40	-	-
Endomorphy	0.01	-0.07	-	-	0.02	**-0.76****	-	-
Mesomorphy	-0.12	-0.46	-	-	-0.11	-0.40	-	-
Ectomorphy	0.45	0.14	-	-	0.49	**0.65***	-	-

** p<0.01 *p<0.05 for correlation coefficients

Second serve speed of males correlated with only wrist circumference ($r=-0.59$, $p<0.05$) and there is no correlation in females for this condition. Second serve accuracy is correlated with height ($r=0.56$, $p<0.05$), wrist circumference ($r=-0.86$, $p<0.01$), internal shoulder rotation ($r=0.69$, $p<0.01$), endomorphy ($r=-0.72$, $p<0.01$), ectomorphy ($r=0.84$, $p<0.01$) for males. Lastly, second serve accuracy is correlated with height ($r=0.56$, $p<0.05$), competition experience ($r=0.61$, $p<0.05$), body mass ($r=0.57$, $p<0.05$), wrist circumference ($r=-0.56$, $p<0.05$), internal shoulder rotation ($r=0.77$, $p<0.01$), ectomorphy ($r=0.63$, $p<0.05$). The z-transformation only applied when significant correlations were observed for both sexes in same variable as explained in statistical analyses section. As calculated transformed scores shown, there is no difference between any of related correlations ($z= -1.15$ to 1.58; $p>0.05$).

Table 4. Second serve performance correlations.

	Second Serve Speed				**Second Serve Accuracy**			
	Female	**Male**	z	p	**Female**	**Male**	z	p
Age	-0.17	0.07	-	-	-0.35	-0.14	-	-
Height	0.12	0.08	-	-	**0.56***	**0.56***	0.00	1.000
Competition Experience	0.14	-0.17	-	-	**0.61***	0.38	-	-
Body Mass	0.02	0.21	-	-	**0.57***	0.44	-	-
BMI	-0.09	0.19	-	-	0.52	0.00	-	-
Upper Arm Length	0.34	0.42	-	-	0.12	0.50	-	-
Forearm Length	-0.22	0.27	-	-	-0.04	0.49	-	-
Wrist Circumference	-0.25	**-0.59***	-	-	**-0.56***	**-0.86****	1.58	0.114
Arm Circumference	0.46	0.00	-	-	0.49	0.15	-	-
Internal Shoulder Rotation	0.31	0.12	-	-	**0.77****	**0.69****	0.62	0.535
External Shoulder Rotation	0.05	-0.05	-	-	0.39	0.48	-	-
Endomorphy	0.36	-0.43	-	-	0.04	**-0.72****	-	-
Mesomorphy	-0.30	-0.05	-	-	-0.47	-0.47	-	-
Ectomorphy	0.06	0.49	-	-	**0.63***	**0.84****	-1.15	0.250

** p<0.01 *p<0.05 for correlation coefficients

DISCUSSION

To best of our knowledge, current study is the first study that investigate serve performance determinants according to sex. The primary finding of this study is that serve performance determinants are differ by sex. The results of study will be discussed under anthropometric features, somatotype and ROM subheadings.

Anthropometric Features

When we examine correlations of anthropometrics with speed, while four moderate to strong significant correlations observed for first serve (height, upper arm length, arm circumference and BMI), there is only one (wrist circumference) correlation observed for second serve. Therefore, we can state that first serve speed is more dependent to anthropometric features according to second serve speed. To be more specific, female players' height, upper arm length and arm circumference & male players' BMI moderately correlated with first serve speed. Nevertheless, none of these correlations is common for both sexes. Thus, we can state that first serve speed determinants are different for male and female players.

Since BMI of the participants in the study was found to be 20.84 ± 0.86 & 22.51 ± 1.20 for females and males respectively, it was observed that it was within normal range (16). In our study BMI correlated with first serve speed in males (r= -0.69). Former studies also found and explained similar negative correlation between BMI and serve speed by possible effects of greater muscle mass and consequent greater strength (10). In line with those explanations, we used arm circumference as strength indicator and found a positive correlation with females first serve speed (r= 0.80). While previous studies observed positive correlation with peak serve speed (12, 24) and body height, we did not observe such correlation. The authors explained above-mentioned correlations by a mechanism, which offers body height and limb length correlated therefore contributes serve speed. Our upper arm length finding in females (r=0.61) may possibly support this point of view in addition to our body height and serve speed findings (r=0.53).

Somatotype

Contrary to the literature, our subjects were dominantly ectomorph (20, 21). Current study showed that somatotype is a great determinant of serve accuracy especially for male players. Ectomorphy and serve accuracy are moderately (r=0.65) and strongly (r=0.84) correlated for male players in both first and second serve conditions respectively. Besides, there are negative strong correlations (r=-0.72, r= 0.76) among endomorphy and accuracy only in males. The accuracy of ectomorphs may be explained by their ability to make finer movements during wrist-snap phase of serve. In line with literature, somatotype found to be not correlated with serve speed in our study too (10, 20).

ROM

The main finding in ROM section is that while internal rotation strong indicator of accuracy level for both sexes (r=0.67-0.79) and there is no correlation between external rotation and any serve performance parameter. and these findings are in line with a previous study which investigates ROM and serve performance relationship in a wide scope (17).

We assessed shoulder ROM with only internal and external rotation because of time limitations. Also, menstrual cycles of female participants -which may directly affect explosive strength- did not followed. We let players use their own racquets in order to avoid familiarization related problems. Therefore, future studies can examine effect of racquet-related variables such as string tension, string type and racquet weight.

CONCLUSION

This study is original in sex comparison of serve performance determinants context. The main finding of study is that serve performance determinants are generally differ by sex. From this aspect, current study provides a correlation analysis across players' tennis serve, anthropometrics, ROM and somatotype, which may contribute to the knowledge of serve performance for players and coaches. However, it should be noted that serve is one of most complex strokes in tennis so there are many indicators may possibly effect serve performance than evaluated in this study.

ACKNOWLEDGEMENTS

The researcher thanks to all players for their honest efforts and participation.

Funding: This research received no external funding.

Conflicts of Interests: The author declares no conflict of interest.

REFERENCES

1. Bonato M, Maggioni M, Rossi C, Rampichini S, La Torre A, and Merati G. Relationship between anthropometric or functional characteristics and maximal serve velocity. *J Sport Med Phys Fitness* 55: 1157-1165, 2015.
2. Buti T, Elliott B, and Morton A. Physiological and anthropometric profiles of elite prepubescent tennis players. *The Physician and Sportsmedicine* 12: 111-116, 1984.
3. Carter JL, Carter JL, and Heath BH. *Somatotyping: development and applications.* Cambridge university press, 1990.
4. Chow J, Carlton L, Lim Y-T, Chae W-S, Shim J-H, Kuenster A, and Kokubun K. Comparing the pre-and post-impact ball and racquet kinematics of elite tennis players' first and second serves: a preliminary study. *Journal of sports sciences* 21: 529-537, 2003.
5. Cohen DB, Mont MA, Campbell KR, Vogelstein BN, and Loewy JW. Upper extremity physical factors affecting tennis serve velocity. *The American Journal of Sports Medicine* 22: 746-750, 1994.
6. de Subijana CL and Navarro E. Kinetic energy transfer during the serve. *Journal of Human Sport and Exercise* 4: 114-128, 2009.
7. Ellenbecker T and Roetert E. Velocity of a tennis serve and measurement of isokinetic muscular performance: brief review and comment. *Perceptual and motor skills* 98: 1368-1370, 2004.
8. Fernandez-Fernandez J, Ulbricht A, and Ferrauti A. Fitness testing of tennis players: How valuable is it? *British journal of sports medicine* 48: i22-i31, 2014.
9. Fleisig G, Nicholls R, Elliott B, and Escamilla R. Tennis: Kinematics used by world class tennis players to produce high-velocity serves. *Sports Biomechanics* 2: 51-64, 2003.
10. Gale-Watts AS and Nevill AM. From endurance to power athletes: The changing shape of successful male professional tennis players. *European Journal of Sport Science* 16: 948-954, 2016.
11. Gencer YG and Beyza Ö. An Analysis On The Relationship Between Serving Strength And Anthropometric Properties And Tennis Serving Success In Young Women Volleyball Players. *Turkish Journal of Sport and Exercise* 22: 183-188, 2020.
12. Hayes MJ, Spits DR, Watts DG, and Kelly VG. Relationship between tennis serve velocity and select performance measures. *The Journal of Strength & Conditioning Research* 35: 190-197, 2021.
13. Kovacs MS. Tennis physiology. *Sports medicine* 37: 189-198, 2007.
14. Martin C, Bideau B, Ropars M, Delamarche P, and Kulpa R. Upper limb joint kinetic analysis during tennis serve: Assessment of competitive level on efficiency and injury risks. *Scandinavian journal of medicine & science in sports* 24: 700-707, 2014.
15. Martin C, Kulpa R, Delamarche P, and Bideau B. Professional tennis players' serve: correlation between segmental angular momentums and ball velocity. *Sports Biomechanics* 12: 2-14, 2013.
16. Organization WH. Obesity: preventing and managing the global epidemic. 2000.
17. Palmer K, Jones D, Morgan C, and Zeppieri Jr G. Relationship between range of motion, strength, motor control, power, and the tennis serve in competitive-level tennis players: A pilot study. *Sports health* 10: 462-467, 2018.

18. Pluim BM, Miller S, Dines D, Renström PA, Windler G, Norris B, Stroia KA, Donaldson A, and Martin K. Sport science and medicine in tennis. *British Journal of Sports Medicine* 41: 703-704, 2007.
19. Reid M, Elliott B, and Alderson J. Shoulder joint kinetics of the elite wheelchair tennis serve. *British journal of sports medicine* 41: 739-744, 2007.
20. Sanchez-Munoz C, Sanz D, and Zabala M. Anthropometric characteristics, body composition and somatotype of elite junior tennis players. *British journal of sports medicine* 41: 793-799, 2007.
21. Söğüt M and Altunsoy K. Physical and Morphological Characteristics of Turkish National Adolescent Tennis Players and Their Association with Serve Speed. *Spor Hekimligi Dergisi/Turkish Journal of Sports Medicine* 54, 2019.
22. Tanabe S and Ito A. Application of the extrapolation method to motion analysis of the flat power serve in tennis. *International Journal of Sport and Health Science* 5: 157-167, 2007.
23. Ulbricht A, Fernandez-Fernandez J, Mendez-Villanueva A, and Ferrauti A. Impact of fitness characteristics on tennis performance in elite junior tennis players. *The journal of strength & conditioning research* 30: 989-998, 2016.
24. Vaverka F and Cernosek M. Association between body height and serve speed in elite tennis players. *Sports Biomechanics* 12: 30-37, 2013.
25. Whiteside D, Elliott B, Lay B, and Reid M. A kinematic comparison of successful and unsuccessful tennis serves across the elite development pathway. *Human Movement Science* 32: 822-835, 2013.