

# An Examination of the Differences in the Angles Created in the Lower and Upper Extremities During Tennis Serves by Male and Female Players

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## Abstract

The present study was conducted on 4 female and 4 male tennis players (Average age  $11.6 \pm 0.7$  years; height  $153.2 \pm 6.9$  cm; body mass index  $42.0 \pm 3.9$  kg; player experience  $6.4 \pm 1.3$  years). All the participants volunteered to participate in the study. The players hit their tennis serves at the maximum speed they could, imagining that they were in a real tennis match. The images for successful and unsuccessful tennis serves were recorded synchronously with a speed of 60 pictures/ second by using two video cameras. These recorded images were subjected to photogrammetric evaluation using Pictran software. The ankle, shoulder and elbow angles of the players were observed during the tennis serve before hitting, at the time of hitting and after hitting the ball.

**Keywords:** digital photogrammetry, motion analysis, tennis serve

## 1. Introduction

In parallel to the development of technology in recent years, the 3-D reconstruction of images using digital photogrammetric methods has brought a new dimension to the evaluation of various body motions. The biomechanical analysis of joints and muscles has been studied through different methods particularly for various branches of sports science [1].

Tennis is a performance sport in which aerobic and anaerobic demands exist together and which at the same time requires high levels of certain biometric characteristics such as strength, speed, resistance, flexibility and coordination [2, 3]. An effective serve is of utmost importance in showing a successful performance in this branch of sport. One of the most important criteria for determining the serve performance is the speed of the ball during the serve [4]. Tennis players continuously try to increase the ball speed in tennis serves in order to gain an advantage against their opponents. Andy Roddick currently holds the world record for the fastest serve ever recorded, which clocked in at a startling 249.4 km/h at the 2004 tennis season. Fast serves with high percentage help the player win more points, which increase the chance of winning the tennis match [5].

During tennis serves, ball speed depends on the synchronous action of anthropometric, biometric and biomechanical factors which are dependent on one another at the correct level. Among these factors, the physical fitness, strength and joint motion range of the player and the speed of joints and the racket during the serve are highly important [6]. A limited number of studies have been conducted to study the relationship between ball speed during tennis serves and physical fitness and biomechanical parameters mentioned above. In a study conducted on tennis players with expert serve technique, [7] found a statistically significant relationship between serve velocity and wrist flexion, shoulder flexion and internal rotation. The existence of a moderate and weak relationship was observed in the studies between ball speed and upper extremity isokinetic torque [7, 8]. During the tennis serve, physical preparation is achieved through the kinetic chain formed by the entire body. With the start of the serving motion, the force produced by the leg muscles is first transferred to the waist and the shoulder, and subsequently to the elbow, wrist and the racket [9, 10].

The parameters of strength and joint motion range, which are among the most important requirements in a tennis serve, should certainly be trained. Various researchers state that strength and joint motion range trainings increase functional goals and athletic performance in tennis [11, 12, 13,14]

However, it is necessary to investigate physical fitness and biomechanical parameters that affect the speed of the ball during a tennis serve in order to plan the trainings more effectively. [15] examined the joint angles of 9 players and could not find any significant differences between successful and unsuccessful tennis serves. The aim of the present study is to investigate the differences in ankle, shoulder and elbow angles of male and female tennis players during successful and unsuccessful tennis serves.

## 2. Material and Method

The study was conducted on junior tennis players (Average age  $11.6 \pm 0.7$  years; height  $153.2 \pm 6.9$  cm; body mass index  $42.0 \pm 3.9$  kg; player experience  $6.4 \pm 1.3$  years) who volunteered to take part in the study. Markers were placed on certain parts of the players' bodies (Figure.1)

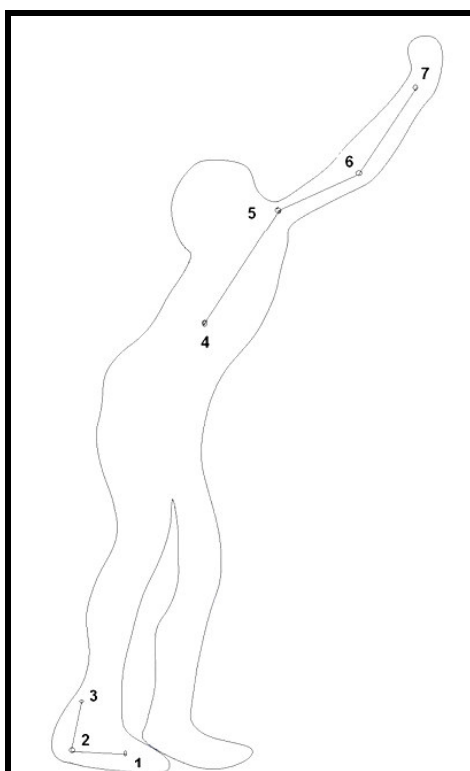


Figure.1 Marker Positions

- Marker 1: Head of metatarsal V
- Marker 2: Lateral process of calcaneus
- Marker 3: Lateral malleolus
- Marker 4: Coxal tuber
- Marker 5: Acromion
- Marker 6: Head of radius
- Marker 7: Styloid process of radius

The players were asked to hit their first serves. The serves were recorded at a rate of 60 frames by using two synchronized cameras (Dragon Fly) from the start to the end of the movement for 5 successful and 5 unsuccessful serves (Figure). A calibration frame consisting of 12 control points was used during the recording. The coordinates of the calibration frame (X,Y,Z) were obtained with a precision of  $\pm 1$ mm by repeatedly measuring with Topcon 3007 EDM. Afterwards, the three dimensional coordinates of the markers on each player were found by using Pictran 2.1 photogrammetric software. Ankle, shoulder and elbow angles were computed by using these coordinates.

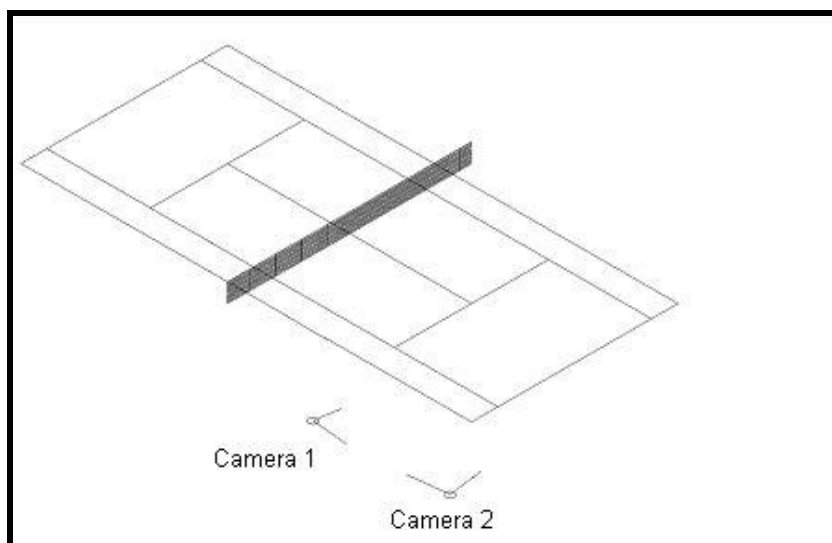


Figure ,2 Serve Shooting Plan

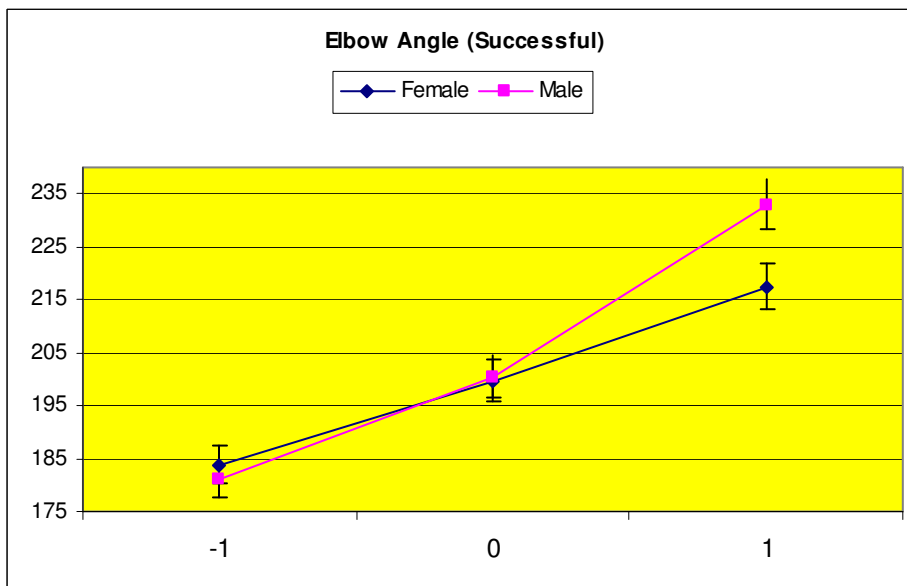
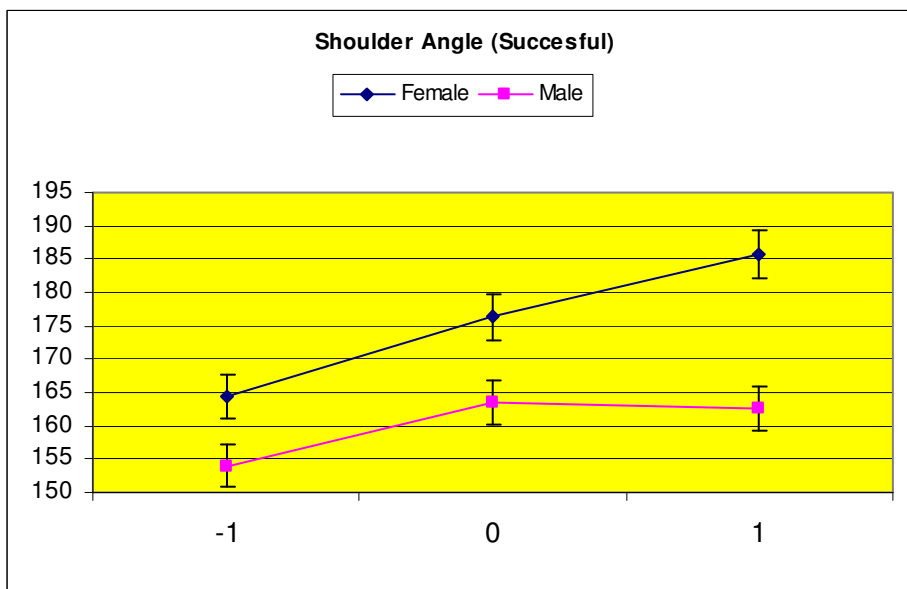
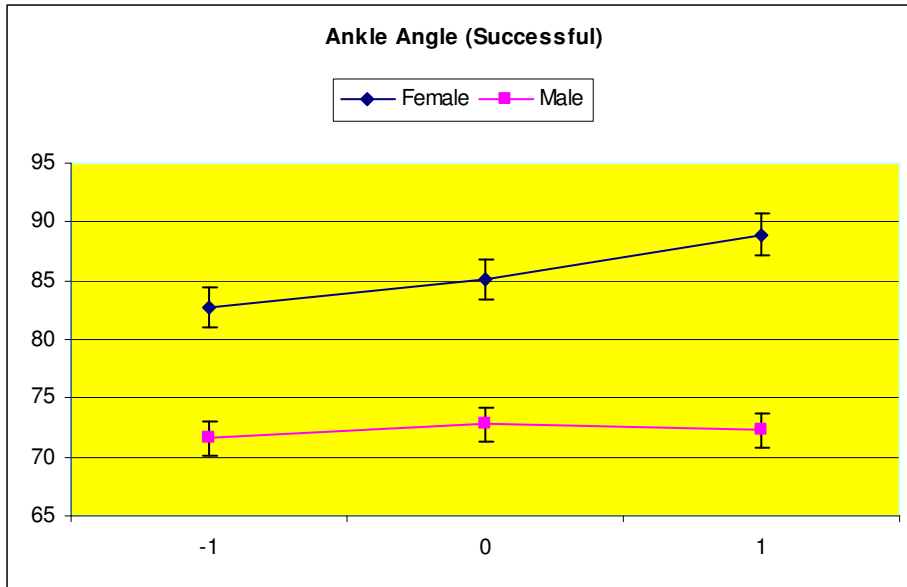
### 3. Results

Ankle, shoulder and elbow angles of male and female players were obtained through photogrammetric evaluation (Table.1). These angles were studied for the phases before hitting (-1), at the time of hitting (0) and after hitting (+1) the ball.

Table.1 Average angles for male and female players

	FEMALE (Successful)			FEMALE (Unsuccessful)		
	Ankle angle	Shoulder angle	Elbow angle	Ankle angle	Shoulder angle	Elbow angle
-1	82,7±8,9	164,5±22,8	183,8±13,1	78,2±5,2	158,3±23,6	187,9±15,2
0	85,11±8,9	176,3±21,8	199,6±17,4	81,3±10,9	172,4±25,7	200,1±19,6
1	88,9±15	185,7±26,2	217,5±21,3	87,2±11,9	177,8±24,9	224,2±21

	MALE (Successful)			MALE (Unsuccessful)		
	Ankle angle	Shoulder angle	Elbow angle	Ankle angle	Shoulder angle	Elbow angle
-1	71,6±9	154±19,4	181,1±11,3	68,8±11,5	155±22,1	175,5±11,7
0	72,8±10	163,6±16,9	200,4±23,6	72,3±9,8	159,9±22,2	199,6±16,6
1	72,3±10,5	162,7±18,9	232,9±20,4	75,5±7,5	159,2±23,2	236,3±25,8



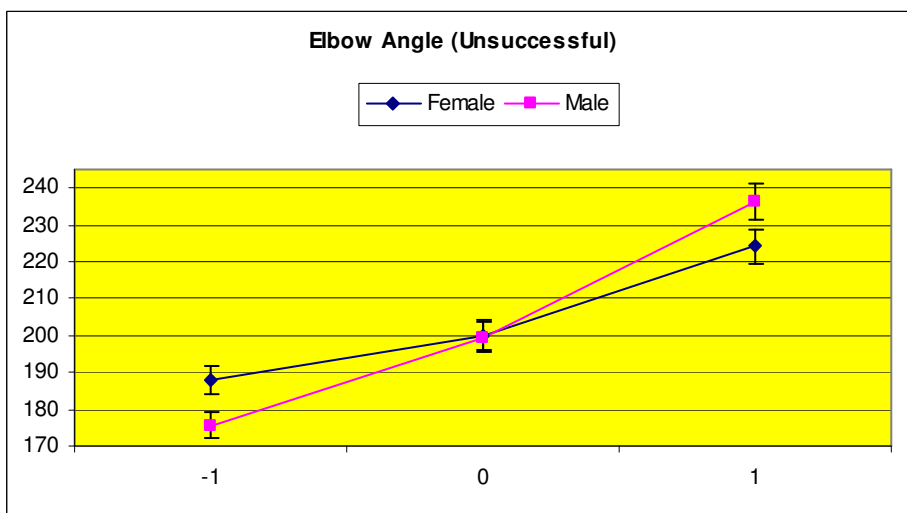
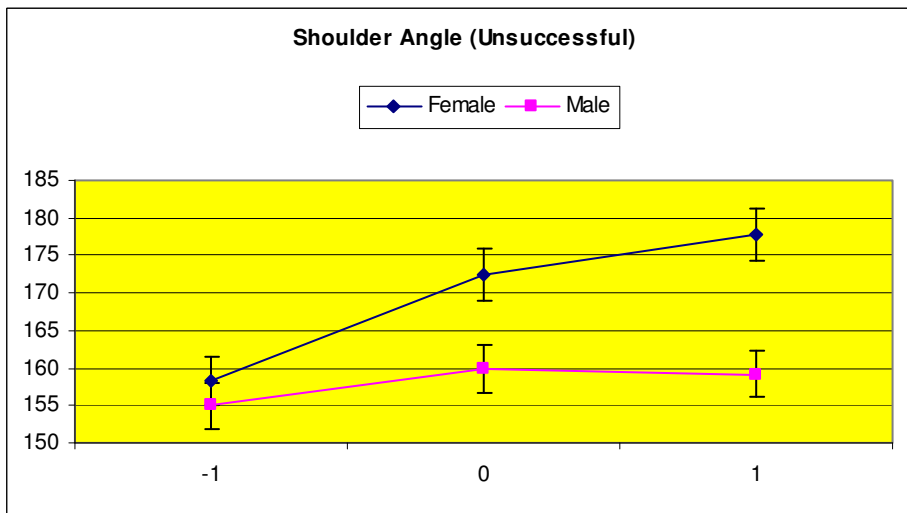
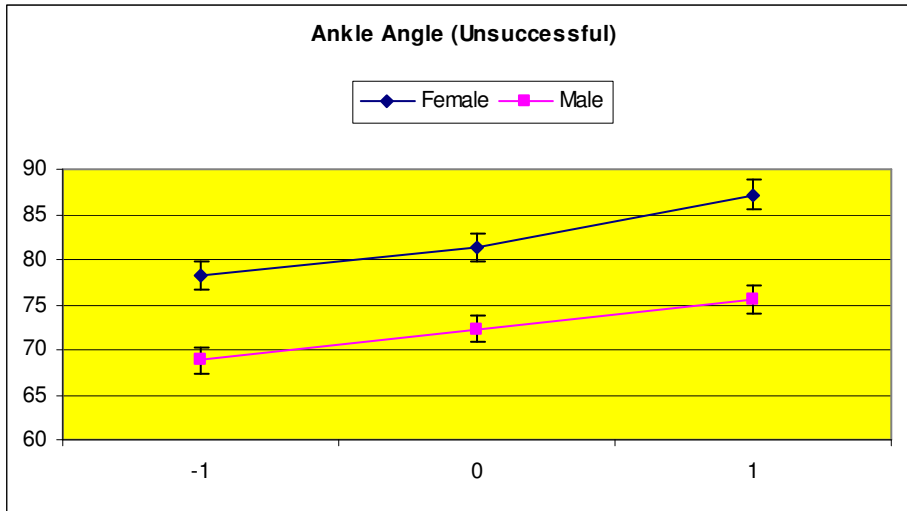


Figure.3 Average ankle, shoulder and elbow angle for female and male

## 4. Discussion

As it can be seen in the table given above, ankle angle was measured as  $(85,11 \pm 8,9)$  in females and as  $(72,8 \pm 10)$  in males for successful serves. This finding shows that female players start the movement earlier than males. This difference remains relatively unchanged for shoulder angles (male  $163,6 \pm 16,9$ ; female  $176,3 \pm 21,8$ ). However, the values for elbow angles are found to be approximately the same for both groups of players (male  $200,4 \pm 23,6$ ; female  $199,6 \pm 17,4$ ).

This finding can be explained as follows. Females have to start the movement earlier than males in order to hit a successful serve. Therefore, they spend more energy and lose their strength earlier compared to males.

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