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Original Article

Ball position during the tennis serve toss performed by junior athletes: comparison between the first and second service

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Abstract:
The purpose of this study was to compare between the first and second serve the position of the ball in space 1) at the moment when the ball loses contact with the athlete's hand, 2) when it reaches the maximum height, and 3) the considered ideal position. Seven youth tennis players accomplished fifteen serves of each service (first and second service). Paired t-test was used and a significance level of 0.05 was used. There was no significant difference between the position of the ball under the real and ideal conditions. When hitting the ball, it was further ahead of the athletes' body on the first serve compared to the second. By positioning the ball where it should ideally be at the moment of contact with the racket strings, the junior athletes placed it closer to the body on the mediolateral axis to perform the second serve. However, this did not occur when the service was actually performed. This study found that juvenile tennis athletes throw the ball to serve very similarly in both the first and the second service.
Key words: biomechanics; cinemetry; tennis; service strategy.

Introduction

ennis is considered the most popular sport among racket sports (Guedes et al., 2010), resulting in many studies in the various areas of knowledge, such as biomechanics, physiology, motor control and psychology, providing support for coaches and physical trainers (Knudson, 2007).

About the serve, specifically, there are many studies to understand and improve their elements and movements, since it is a complex skill that requires precision and consistency in controlling multiple body segments and joints (Knudson, 2008; Elliott, 2010; Marshall & Elliott, 2000; Tanabe & Ito, 2007; Bahamonde, 2000; Bonnefoy-Mazure et al., 2010; Cooke, 2000; Ivancevic et al., 2008, Mavvidis et al., 2014).

The serve is defined as the shot that starts the point. By the rule, the athlete has the right of a second attempt, if he/she fails in the first one. For this reason, in the first serve (also called first service) usually the ball is thrown into the air and hit with the maximum force and rotation, almost always towards the weaker side or in the direction of the body of the opponent. On the other hand, in the second serve, the main characteristic is the rotation of the ball, because it is aimed a lower risk of errors (Silva, 2007). The first serve, because there is the possibility of performing the second, is hit with greater power. The second requires more precision and, therefore, is less potent (Okazaki et al., 2012).

Vretaros (2004), when analyzing eight single matches in the youth category of the 33rd Banana Bowl Tournament in 2003, verified that about 80 serves were performed in both men and women's, and this was the most used gesture during the matches. On the other hand, Johnson and McHugh (2006) analyzed 616 matches, of 22 professional male players, during the four most important annual tennis events 2003 (Australian Open, French Open, Wimbledon and US Open), and verified that the first serve was the most accomplished gesture, with the first service executed twice as much as the second one. In order to improve serve performance in the initial learning stages of this gesture, coaches usually instruct their juvenile athletes to divide the serve in two or more movements. Reid, Whiteside and Elliott (2010) verified the effectiveness of this training strategy when comparing the position of the ball when the serve movement is interrupted after the throw (toss) with the complete serve performed. In the first condition, the ball was thrown higher, ahead and to the left than in the second condition, suggesting that a decomposition of the service may impair the movement pattern rather than aiding its development.

If the opponent anticipates the direction of the ball during the serve by observing the throw, he/she will be in advantage. For this reason, coaches instruct their athletes to vary the trajectory of the ball the least during the throw to serve, apart the direction that it is intended to shoot the ball (Reid, Whiteside & Elliott, 2011). It is

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common for coaches to instruct athletes to perform different serves from the same throwing pattern, changing the stroke in the final moments, avoiding the opponent from anticipating where the ball will touch the serve area.

In a study reported by Reid, Whiteside and Elliott (2011), experienced players were instructed to serve (first and second serve) by directing the ball to the lateral, medium or medial third of the serve area. Three valid serves as first service and three as a second serve were conducted directing the ball in each of these areas. The variable studied was the position of the ball in space at the moment of its contact with the racket. It was observed that in the first service the ball is thrown more laterally in relation to the body of the athlete when he intends to serve by directing the ball into the medial third of the serve area. According to the authors, the toss of the ball for the second service does not show differences according to the direction that the athlete wants to address the ball.

In a study by Chiang, Chiang and Chen (2006), elite players performed the first and second service to hit a target placed in the service box. They verified that the ball is projected forward in the toss of the first service if compared to the second. In the literature, there are questions about the degree of specificity in the training of young athletes, considering that they are not mini adults and, therefore, it becomes unfeasible to apply the same training loads used in training adults. On the other hand, not specific work would not bring the aimed results (Simões et al., 2011). There is still room for research aiming at improving the learning and performance of young athletes (Pacharoni & Massa, 2012) as reported in the studies of Athanailidis, Laios & Zaggelidis (2015) that aimed to understand the role of the tennis coach at school and Athanailidis et al. (2016) that investigated the level of self-assessment of tennis coaches on their knowledge. For this reason, we opted to analyze young athletes in the present study, so that we can contribute with the researches that investigate the learning process and training.

The present study aimed to compare the position of the ball in the mediolateral, vertical and anteroposterior axis during the first and second service execution. The position of the ball was compared at the moment it lost the contact with the athlete's hand, when it reached the maximum height, when contact with the racket strings occurred, as well as at the moment of contact with the racket strings in the position chosen by the athlete as the best position of the ball at the moment of the racket / ball contact (ball still on air).

Materials & methods

The sample consisted of 7 athletes, three women and four men, tennis competitors. In Table 1, the following characteristics of the sample are presented: class (according to Brazilian Tennis Federation), tension used in the racket stringing, total practice time in tennis and daily and weekly training hours.

Table 1. Sample description.

Athlete	Class	Racket string tension (lb)	Total practice time (years)	Daily training hours	Weekly training hours
1	3	51	9	5	25
2	3	60	8	5	25
3	5	55	3	4	10
4	5	55	5	3	9
5	4	50	3	3	15
6	4	57	13	3	15
7	3	55	6	4	20
Average	-	54.7	6.7	3.8	17
Standard-Deviation	-	3.4	3.5	0.9	6.5

In Table 2, the sample is characterized for the anthropometric profile, that is, age, weight, height and height with racket (measured in the position with the dominant upper limb elevated above the head, holding the racket in the same grip for the serve, considering the head of the racket as the highest point of the whole athlete-racket).

Table 2. Anthropometric sample data.

Athlete	Age (years)	Body mass(kg)	Height (m)	Height atlete-racket (m)
1	16	62	1.66	2.67
2	16	62	1.67	2.61
3	14	79	1.85	2.80
4	15	57	1.65	2.60
5	14	88	1.91	2.90
6	17	70	1.73	2.67
7	16	64	1.66	2.58
Average	15.4	68.8	1.73	2.69
Standard-Deviation	1.1	11.0	0.10	0.11

To take part in the research, the athletes´ parents or tutors were asked to read and sign a Consent Form, whose prior approval was obtained from the local Ethics Committee.

The athletes wore a fit and black suit to facilitate the contrast of the markings used in the cinemetry and the visualization of the ball, and received a specific mark on the metatarsal-phalangeal joint of the left foot (opposite the one of the racket handle), a 3-M® reflective paper, 3 cm wide.

Two 30-Hz digital video cameras (JVC), supported on tripods, were used between 9 and 12 meters away from the athletes and placed at a height that allowed capturing the whole body image, the ball and the racket during the whole serve movement. Between the cameras and the athlete was formed a 90º angle. The position of the cameras can be seen in Figure 1.

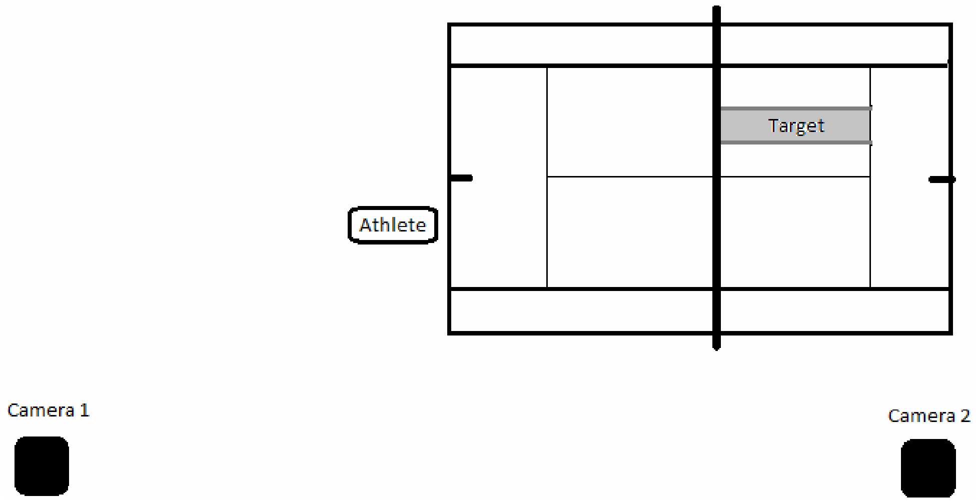

Fig 1. Cameras positioning.

A system consisted of 30-millimeter-diameter spherical marks, fixed in four plumb lines, coupled on 4-meter-high wooden rods, was used to calibrate the cameras. The anteroposterior, vertical and mediolateral mark coordinates were known and measured in relation to an established point. After calibration and scanning the images, the reference point used to analyze the values was the mark on the metatarsophalangeal joint of the left foot of each athlete, that is, a point on the body itself, used to normalize the measurements.

A computer program, called Dvídeow, that allows system calibration, automatic point capture, three-dimensional coordinate reconstructions and data storage as described by Figueroa, Leite and Barros (2003) was used.

The athletes performed the first and second service, respectively, until 15 valid serves of each type in the center of the service box, as shown in figure 1, were completed, simulating the serve in the direction of the opponent´s body.

Warm up was previously performed according to what each athlete was used to doing before playing. They also used their own racket during the study. Breaks occurred every 20 servings, or when requested by the athletes.

At the end of the trials, participants were asked to show what they considered to be the ideal position of the ball at the racket/ball impact instant. The athletes positioned the ball in the anteroposterior, vertical, and mediolateral axes. To keep the ball still in the desired position, a support was developed as illustrated in figure 2.

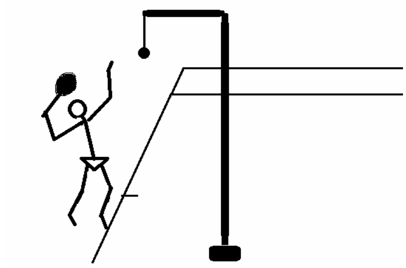

Fig 2. Support used to identify the position of the ball considered ideal by each athlete.

Once the Kolmogorv-Smirnov test showed that the data had normal distribution, a paired t-test was performed to compare the position of the ball in the anteroposterior, vertical and mediolateral axes between the first and second services. The three-dimensional coordinates of the ball were analyzed and compared between the first and second service in the following moments: 1) loss of contact with the athlete's hand; 2) maximum height reached; 3) contact with the racket strings; 4) contact with the racket strings when the ball was placed in the position chosen by the athlete as being the ideal one (inert ball attached to the support).

Results

The number of serves made by each subject to reach the goal of 15 serves in the stated area of the service box, simulating the serve towards the opponent's body, is showed in Table 3. It was observed that the number of first service is 48% bigger than the second to achieve the goal of success.

Table 3. Number of services needed to reach the goal of 15 valid services.

Athlete	1st service	2nd service	Total
1	39	28	67
2	33	25	58
3	80	44	124
4	75	46	121
5	45	36	81
6	52	30	82
7	67	54	121
Average	55.86*	37.57	93.43
Standard-Deviation	18.32	10.74	27.97

* Value significantly higher compared to the second service ($t = 4.4$; $p < 0.01$).

Tables 4, 5 and 6 show, respectively, the position of the ball in space (with reference to the point located in the first metatarsal-phalangeal joint of the athlete's support foot), at the moment the ball loses contact with the athlete´s hand, when it reaches the maximum height, and when it´s hit by the racket.

Table 4. Ball position, in meters, in the anteroposterior, vertical and mediolateral axis when it loses contact with the athlete´s hand. The reference is the point located in the first metatarsal-phalangeal joint of the athlete's support foot.

Athlete	Service	Anteroposterior	Vertical	Mediolateral
1	1	0.13 (0.03)	1.79 (0.05)	0.22 (0.08)
	2	0.11 (0.02)	1.78 (0.03)	0.25 (0.08)
2	1	0.33 (0.03)	1.85 (0.04)	0.14 (0.05)
	2	0.29 (0.04)	1.87 (0.04)	0.14 (0.07)
3	1	0.45 (0.02)	1.81 (0.07)	0.06 (0.05)
	2	0.45 (0.04)	1.86 (0.07)	0.03 (0.03)
4	1	0.02 (0.02)	1.71 (0.04)	0.31 (0.11)
	2	0.03 (0.02)	1.71 (0.11)	0.25 (0.12)
5	1	0.33 (0.03)	2.09 (0.05)	0.39 (0.17)
	2	0.31 (0.04)	2.06 (0.03)	0.36 (0.12)
6	1	0.20 (0.08)	1.71 (0.05)	0.24 (0.05)
	2	0.22 (0.06)	1.69 (0.04)	0.26 (0.04)
7	1	0.07 (0.04)	1.67 (0.05)	0.23 (0.05)
	2	0.03 (0.02)	1.68 (0.04)	0.27 (0.05)
Average (SD)	1	0.22 (0.15)	1.80 (0.14)	0.23 (0.11)
	2	0.20 (0.16)	1.81 (0.13)	0.22 (0.11)

Table 5. Ball position, in meters, in the anteroposterior, vertical and mediolateral axis when it reaches its highest point during the toss.

Athlete	Service	Anteroposterior	Vertical	Mediolateral
1	1	0.31 (0.05)	3.01 (0.04)	0.07 (0.05)
	2	0.24 (0.07)	3.03 (0.04)	0.08 (0.06)
2	1	0.44 (0.07)	3.05 (0.06)	0.10 (0.05)
	2	0.38 (0.04)	3.03 (0.04)	0.10 (0.06)
3	1	0.31 (0.05)	3.02 (0.07)	0.40 (0.09)
	2	0.25 (0.06)	3.05 (0.05)	0.34 (0.07)
4	1	0.31 (0.05)	3.44 (0.06)	0.13 (0.10)
	2	0.25 (0.05)	3.42 (0.07)	0.10 (0.08)
5	1	0.54 (0.05)	3.30 (0.05)	0.14 (0.09)
	2	0.52 (0.08)	3.32 (0.04)	0.14 (0.11)
6	1	0.11 (0.10)	3.13 (0.04)	0.17 (0.07)
	2	0.18 (0.09)	3.14 (0.07)	0.16 (0.07)
7	1	0.22 (0.09)	3.35 (0.07)	0.07 (0.04)
	2	0.17 (0.07)	3.28 (0.07)	0.08 (0.06)
Average (SD)	1	0.32 (0.14)	3.19 (0.17)	0.15 (0.11)
	2	0.28 (0.12)	3.18 (0.16)	0.14 (0.09)

The reference is the point located in the first metatarsal-phalangeal joint of the athlete's support foot.

Table 6. Ball position, in meters, in the anteroposterior, vertical and mediolateral axis at the time it is hit by the racket strings.

Athlete	Service	Anteroposterior	Vertical	Mediolateral
1	1	0.43 (0.07)	2.52 (0.07)	0.10 (0.06)
	2	0.29 (0.09)	2.56 (0.07)	0.09 (0.08)
2	1	0.53 (0.07)	2.57 (0.05)	0.21 (0.09)
	2	0.46 (0.07)	2.55 (0.05)	0.22 (0.08)
3	1	0.24 (0.07)	2.72 (0.03)	0.59 (0.13)
	2	0.14 (0.09)	2.75 (0.04)	0.54 (0.09)
4	1	0.55 (0.09)	2.40 (0.05)	0.19 (0.14)
	2	0.45 (0.08)	2.42 (0.06)	0.22 (0.12)
5	1	0.66 (0.06)	2.71 (0.03)	0.30 (0.19)
	2	0.62 (0.12)	2.71 (0.03)	0.36 (0.20)
6	1	0.13 (0.10)	2.53 (0.05)	0.43 (0.11)
	2	0.17 (0.12)	2.55 (0.05)	0.47 (0.11)
7	1	0.37 (0.14)	2.44 (0.04)	0.16 (0.11)
	2	0.30 (0.12)	2.44 (0.04)	0.15 (0.12)
Average (SD)	1	0.42 (0.18)*	2.56 (0.12)	0.28 (0.17)
	2	0.35 (0.17)	2.57 (0.12)	0.29 (0.17)

* Value significantly higher compared to the second service (t=3.16; p=0.02).

The reference is the point located in the first metatarsal-phalangeal joint of the athlete's support foot.

Table 7 shows the three-dimensional coordinates of the ball position considered as the ideal one by the athletes at the moment of the contact between racket and ball.

Table 7. Ball position, in meters, considered by the athlete as the ideal one at the moment of the contact between racket and ball.

Athlete	Service	Anteroposterior	Vertical	Mediolateral
1	1	0.62 (0.13)	2.45 (0.02)	0.34 (0.03)
	2	0.52 (0.03)	2.44 (0.01)	0.33 (0.03)
2	1	0.54 (0.00)	2.77 (0.02)	0.51 (0.01)
	2	0.27 (0.11)	2.74 (0.08)	0.47 (0.04)
3	1	0.23 (0.16)	2.59 (0.01)	0.17 (0.11)
	2	0.31 (0.01)	2.57 (0.01)	0.05 (0.03)
4	1	0.47 (0.08)	2.45 (0.05)	0.20 (0.04)
	2	0.37 (0.03)	2.27 (0.12)	0.13 (0.04)
5	1	0.63 (0.19)	2.84 (0.13)	0.58 (0.04)
	2	0.81 (0.09)	2.81 (0.01)	0.33 (0.05)
6	1	0.51 (0.09)	2.57 (0.03)	0.08 (0.04)
	2	0.31 (0.07)	2.40 (0.01)	0.04 (0.03)
7	1	0.48 (0.08)	2.33 (0.02)	0.17 (0.08)
	2	0.43 (0.04)	2.34 (0.01)	0.14 (0.03)
Average (SD)	1	0.50 (0.13)	2.57 (0.18)	0.29 (0.19)*
	2	0.43 (0.19)	2.51 (0.20)	0.21 (0.16)

* Value significantly higher compared to the second service (t=2.57; p=0.04).

The reference is the point located in the first metatarsal-phalangeal joint of the athlete's support foot.

Discussion

The volunteers were asked to perform 15 correct serves in the middle third of the serve box, simulating the serve in the direction of the opponent's body. In order to do it, it was necessary about 55 serves (first service) and 37 serves (second service), which represents 48% more from the first service than the second one (Table 3). In a real game situation, among professionals, the number of serves served as the first service is the double of the second because the second service is only performed when the first service is not valid, either because the ball has reached the opponent's court outside the service box or because the ball hit the net (Johnson & Mchugh, 2006).

Vretaros (2004) verified in youth athlete games that the serve was the third most accomplished movement, in a total of 80 serves, a very close value to that verified in the present study, in which 93 seves were performed, showing that the methodology used was comparable, in this parameter, to the game situation.

Silva (2007) and Okasaki et al. (2012) argue that the first service is performed in greater power due to the possibility of having the second one in case of mistaking the first one. The second service tends to be done with greater precision and therefore less power, since if there is an error, the point will be given to the opponent.

In table 4, which presents the values of the ball position when it loses contact with the hand of the athlete, it was verified that no significant differences were found for the anteroposterior, vertical and mediolateral axes between the first and second service. This shows that athletes, even juveniles, have already developed motor parameters with high performance for this task. Reid, Whiteside and Elliott (2011) state that the coaches´ instructions for the toss, aim to reduce their variation, i.e., the athlete must achieve the same toss pattern regardless of which direction he intends to give the ball or if it is the first or second service.

When the ball loses contact with the hand on the anteroposterior axis, it is placed about 0.20m forward the athlete. On the vertical axis, the ball was thrown about 1.80m high, which in most cases happened with the upper limb extended above the shoulder line. In the mediolateral axis, the ball lost contact with the athlete's hand about 0.20 m to the left (all athletes were right-handed). There were no significant differences between the first and second service, so these values represent the ball toss in both situations.

The ball position at its maximum height during its toss is shown in table 5. In this position, there was no significant difference between the first and second service, which agreed with the one proposed by Reid, Whiteside and Elliott (2011). The position of the ball at the maximum height point during the toss is placed in front of the left foot of the right-handed athletes. This result agrees with a study reported by Chiang, Chiang and Chen (2006), however, the data of the mentioned study were collected from adult professional athletes. It shows that, throwing the ball in front of the body to serve seems to be a strategy accomplished in the early years of training. This strategy allows the athlete to jump ahead so that the contact between the racket and the ball occurs in a position as high and ahead as possible. It increases the attack angle that the ball's trajectory will make as it passes over the net.

In table 6, the ball position is described in the anteroposterior, vertical and mediolateral axis at the instant before being hit by the racket strings. Significant differences were found when the first and second services were compared in the anteroposterior axis, that is, in the first service the ball was hit 0.07m forward than the second one. In the vertical and mediolateral axis the ball was hit, respectively, at a height of 2.56 m and at 0.30 m to the left of the athlete, so there was no difference between the first and second service. This difference in the anteroposterior axis agrees with the results obtained by Chiang, Chiang and Chen (2006), who also found that at the moment before the impact in the first service, the ball was significantly more forward than in the second.

The ball position, in the three-dimensional position defined by the athletes as being the ideal position at the time of the racket contact with the ball is shown in table 7. In this condition, the ball is inert, hung by a wire attached to a support. Athletes were asked to identify the position described above for both the first and the second service. Doing that, the results pointed to a significant difference in values referring to the mediolateral axis, between the first and second service. For the second service, the athletes considered that the best position of the ball is closer to them in the mediolateral axis, if compared to the position of the ball in the first service. Probably, the position of the ball closer to the athlete's body allows better control of the motor gesture. This is very necessary if we consider that throwing the ball out of the receiving box of the opposing court or in the net, the athlete loses the point.

When comparing the ball position, in the first and second service, in the instant before its contact with the racket strings, in the real situations and considered as ideal by the athlete, the anteroposterior, vertical and mediolateral axes did not present significant differences, indicating that the movement accomplished is close to the idealized. However, in the real situation, the ball is projected further forward when performing the first service, if compared to the second one.

The players showed a good relationship between what they do and what they believe they must do, however, the differences found show that, although the coaches' instruction is to perform the toss without variation, there are differences between them in the first and second service.

These differences show that the individuals in the sample believe that in the first service they need to hit the ball on the left, but actually they hit the ball forward. Probably, the ball is thrown forward, allowing greater time of the racket rotational movement and, consequently, greater linear velocity of the racket at the moment of the ball contact with the strings. This is just an assumption, since the speed of the racket has not been measured.

Conclusions

At the moment of impact with the racket strings, the position of the ball is similar, both in real shooting conditions and in ideal conditions (when the ball is artificially placed in the position considered ideal by athletes).

When hitting the ball, it is more ahead of the athlete in the first service, compared to the second. By placing the ball where it should ideally be in the moment of contact with the racket strings, young athletes place it closer to the body in the mediolateral axis to perform the second service. However, it does not occur when the service is actually performed.

Conflicts of interest

The authors of this study declare not to have any conflict of interest.

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