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Correlational Analysis of A Serve With Hand-Eye Laterality Profile Among Professional Tennis Players in Chennai

Subhashree Easaki[1], S. F. Mariyam Farzana[*2]

[1]Student, SRM College of Physiotherapy, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur-603203, Kanchipuram, Chennai. Tamilnadu, India

[*2]Associate Professor, Faculty of Medicine Health and Science, SRM College of Physiotherapy, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur 603203, Kancheepuram, Tamilnadu, India

[*]**Corresponding Author:**

Email ID: mariyamf@srmist.edu.in

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ABSTRACT

Background: Tennis serve is a crucial and complex technique. It demands a sense of timing to make precise ball-racket contact when the player tosses the ball in the air. Hand-eye laterality is one major factor that decides this contact's quality, if not the overall gameplay. Earlier studies have estimated that a contralateral hand-eye profile is seen more in professional athletes compared to the normal population. However, analysing the serve based on the players' laterality profile is necessary to conclude if it plays a role in accuracy or not.

Objective: The analysis aims to determine the importance of hand-eye laterality profile in a tennis serve in case of accuracy among professional players.

Methodology: A group of professional tennis players was made to perform the Dominant Eye Test, according to which they were divided into two batches: A and B. Batch A comprised of players with ipsilateral profile (same side hand-eye profile), and batch B comprised of players with contralateral profile (opposite side hand-eye profile). The players were asked to demonstrate 4 types of serves based on the court markings: 1. A basic serve inside the serve box, 2. A serve towards the outer corner of the serve box (wide serve), 3. A serve towards the inner corner of the serve box (down the T) and 4. A serve towards the outer corner of the serve box with the player standing on the side where his/her dominant hand is placed opposite to the serve box (cross serve). Each serve was demonstrated 5 times by each player. Based on the number of serves placed correctly for each type out of 5 demonstrations, the accuracy of the serve was determined.

Result and Conclusion: The study concludes that hand-eye laterality plays a role in accuracy of a tennis serve in a cross, wide and down the T variation.

Keywords: *TENNIS, SERVE, TENNIS SERVE ACCURACY, DOMINANT EYE, HAND-EYE LATERALITY*

1. INTRODUCTION

Lawn tennis is an elegant yet fierce sport that displays powerful strokes and commendable agility flaunted by the players. It is a poly-structural sport with acyclic characteristics. [1] It is one of the many sports that is cherished worldwide. The first-ever tennis tournament was the 1877 Wimbledon Championship held at the All-England Croquet and Lawn Tennis Club. It is played on hard, grass, and clay surfaces. The rising popularity of the sport even leads it to the 1988 Summer Olympics in Seoul, South Korea as a medal sport.[2] Depending on the court surface, a regular 5-set match is played on an average of 137 to 154 minutes.[3] A typical match lasts for 1 to 2 hours.[4]

Success in tennis is based on several factors that can be classified into the following criteria:

1. Social (availability of resources)
2. External (Family and coach support)
3. Internal (motivation and passion) [5].

Tennis involves the use of a racquet and a ball. The racket is used to hit the ball to propel it towards the opponent. The duration of racquet-ball contact is estimated to be 0.003 to 0.006 seconds. Along with this timing range, the ball and racquet should align complimentary to each other during the swing to attain a perfect stroke [6]. Ball and racquet kinematics (position, duration, acceleration, and velocity) is also a valid component for producing efficient strokes.[7] The tennis serve is an important stroke that if performed on biomechanical stances, produces great efficiency in a point.[8] Therefore, it is key to successful outcomes in a match. [8] The serve action involves a kinetic process of sub-movements with forces (linear and angular momentum) that is cumulatively expressed in a proximal to distal manner i.e., from leg to trunk and then to the arm or racquet [10][11]. The components involved in the kinetic motion of a tennis serve are the trunk rotation, lower limb movements, and upper limb distributions of positioning.[12] The shoulder joint is a critical component of the upper extremity kinematics of a tennis serve that provides racquet accuracy as well as efficient ball contact. [13] Based on previous data, mean arm flexion isometric force generation during a serve is 131.22 ± 41.27. [14] Arm pronation and elbow extension add to the desirable racquet speed.[15] The leg drive is also one major mechanical point that optimizes the serve technique.[16] It plays an important role in the kinetic chain of the serve.[17] This action depends on various aspects like coordination, agility, speed, quickness, cardio-respiratory endurance, local muscle endurance, strength, and power [18].

Coordination is the synchronicity between two entities which gives rise to a resultant conclusive product. Coordination between different body parts results in every single activity that is required for us to exist independently. In the case of sports, it plays a key role in the player's performance.

The most talked about coordination in general as well as sports point of view is the coordination between limbs. The body parts can exhibit specific coordination patterns with each other for different tasks [19]. In soccer, coordination training has generated adaptation in agility, which translates into the sum of different factors such as acceleration, deceleration, and change of direction. [20] Inter joint coordination is important in all sports, even in the execution of a productive tennis serve.[21] The coordinated rotation of joints during a serve is required for optimal results.[22] But there is another type of coordination that decides the performance of an athlete: hand-eye coordination. Hand-eye coordination is the ability of the central nervous system in which the eyes perceive information from the external environment which in turn guides the hands in accomplishing the task. It has been a topic of interest in sports since the beginning of time. Just like any other sport, tennis is highly dependent on a good motor and visual system for performance. Every person has a dominant hand which they use to perform various motor tasks like gripping an object, writing, etc. Similarly, every individual has a dominant eye. Eye dominance is the tendency to prefer visual input from one eye over the other [24]. Normal people have 50-90% right eye dominance according to previous studies.[25] The dominant eye has been proven to play a significant role in regulating the relationship between time taken for response and head movements during task identification. [23] Studies state that the eye transmits information picked up from the environment to the brain where it is processed into a three-dimensional image. This phenomenon is called fusion. [26] The next step after fusion in which the eye participates is called object tracking, which is the calculation of object trajectory in the frame. [27] Previous studies provide evidence on peripheral vision aiding in tracking multiple objects moving in a surrounding along with detecting changes that demand a response.[27] It is the vision outside the fovea that covers approximately 99.9% of the visual field.[28] This statement is backed up by a study done on basketball players in which the players proved to have more court coverage due to efficient peripheral vision.[29] It also aids in the successful return of a serve. [30] The eye is of primary importance for perception in an individual.[31] In a tennis serve, it is essential to receive feedback that regulates the spatiotemporal aspects of the environment.[32] Though visual function is one of the most important sensory systems that is taken into consideration during sports performance studies, it is rarely considered a component to be trained by the industry. [33]

Upon further exploration of hand-eye coordination, a phenomenon called laterality emerged.

Laterality is the asymmetry of bilateral structures or biases in behavior in living organisms.[34] A study done on the measurement of laterality states it to be a 'multidimensional construct' that involves active development influenced by both environmental and genetic factors.[35] Hand-eye laterality profile is the pair of a subject's dominant hand and dominant eye. There are two types of laterality profiles: (a) An ipsilateral profile (same side hand and eye are dominant), and (b) a cross lateral profile (opposite side hand and eye are dominant).

Previous studies state the prevalence of 70-90% of the regular population displaying an ipsilateral profile and 10-30% displaying a cross-lateral profile.[36] Further exploitation of the concept also revealed that in some sports the population of cross lateral profile is higher when compared to the regular population. Among such sports, tennis consists of 42% of cross-lateral profiles. [36]

It has been revealed that the pattern of hand-eye dominance plays a role in athletic proficiency in baseball players in a 1998 study. [37] Similar studies conclude the importance of this laterality in tennis is lacking.

The study aims to analyze and evaluate the accuracy of a tennis serve of players based on their laterality profiles. This study gives clarity on whether hand-eye laterality holds visible importance in the placement of serves or not. It further sheds light on the prevalence of these profiles in the sport itself. It also excavates the adaptation of an eye among high-level target sport athletes like tennis.

METHODOLOGY: This is a non – experimental study with a correlational design. This study involves a feasibility sampling method. 30 players competing in AITA or equivalent state-level tournaments from age 12 to 25 of both genders were taken as samples for this study. Players with less than 4 years of experience playing the sport and not competing on a professional basis often were excluded.

They were allowed to use their rackets which they usually trained and played tournaments with, because, according to the mere exposure effect, repeatedly applied stimuli give better and efficient results compared to recently introduced stimuli. [38] They were asked to warm up by serving a few times before starting the actual procedure. This pre-procedural preparation aided in recording the performance in the most candid manner possible. Warm-up also aids in preventing injuries. [39]

The players were educated in detail about the need for the procedure and were asked for their informed consent before commencing the actual procedure. They were asked to fill in their primary details (name, age, and dominant hand). After filling in these details, the Dominant Eye Test was performed by every player. This test is a sighting-dominance measure, being a popular version of the concept of peeking through a hole, based on the ABC test proposed by Miles in 1920,1930.[40]The test is based on mono vision, according to which the dominant eye is usually corrected for distance and the non-dominant eye for near, based on the hypothesis that the non-dominant eye will be more easily suppressed by the relatively blurred image in the fellow eye for distance.[41] They were asked to outstretch their arms to make a triangular space (or hole) with their hands. Then they were asked to look at a distant object through the triangular space. When they were ready, they were asked to close one eye at a time and look at the distant object through the triangular space. The eye through which the player could see the object more towards the center inside the triangular space was declared as their dominant eye. Proper alignment of the eye through the space was demonstrated while giving sufficient time to the players to adjust the position effectively to achieve efficient accommodation and visual acuity. Accommodation, according to Atchison and Charman et. al, is the ability of the human eye to focus over a range of distances. [42] It is achieved with the help of the ciliary muscles of the eye that adjust the lens according to the distance and size of the object or scene.[43] This muscle is intraocular.[44]. Vision is further stabilized during movement through the ocular following response that tracks the moving object in a visual field.[45]. Previous studies have proved the accommodative lag in the dominant eye to be lesser compared to the non-dominant eye, though it was not statistically significant. [46] Visual acuity on the other hand refers to the clarity or clearness of vision. It depends on:

1. Sensitivity of the nervous system
2. Sharpness of image on the retina
3. Ability of the central nervous system to interpret visual cues. [47]

By correlating their dominant eye and dominant hand, the players were segregated into two groups: Group A and B. Group A comprised of the players with ipsilateral hand-eye profiles, and Group B comprised of players with contralateral hand-eye profiles. After identifying their profiles, the players started serving.

The players were asked to serve 4 variations:

1. A basic serve inside the box with the player's preference for placement
2. A wide serve from ad court (left side of the court)
3. A wide serve from deuce court (right side of the court)
4. A down the T

The variations are based on the markings of the court. Each variation was performed 5 times. Two players served alternatively at a time to give a considerable amount of time for recovery. The observer stood at the net post to observe the placement of the serve. Whenever precise observation due to serves getting placed on the edge of the markings was required, the observer stood at the baseline and checked the impression of the ball on the court. Players were asked to repeat the serves if they landed as let (hitting the net and getting propelled inside the service box).

2. DATA ANALYSIS

Table 1: DEPICTS THE MEAN AGE OF SAMPLES

Characteristics	Mean	SD
Age (in years)	17.6	3.3

Table 2: ILLUSTRATES DOMINANT HAND

DOMINANT HAND	FREQUENCY	PERCENTAGE
Left	1	3.3
Right	29	96.7

Table 3: ILLUSTRATES DOMINANT EYE

DOMINANT EYE	FREQUENCY	PERCENTAGE
Left	13	43.3
Right	17	56.7

Table 4: ILLUSTRATION OF IPSILATERAL (TYPE A) AND CONTRALATERAL (TYPE B) PROFILES

PROFILE TYPE	FREQUENCY	PERCENTAGE
A	18	60
B	12	40

Table 5: THE REPRESENTATION OF THE PROBABILITY OF TENNIS SERVES IN FOUR DIFFERENT VARIATIONS BASED ON THE HAND-EYE LATERALITY PROFILE.

	A	B	P value
Basic			
<3	12(66.7%)	4(33.3%)	0.078
4-5 serves	6(33.3%)	8(66.7%)	
Wide			
<3	14(77.8)	5(41.7)	**0.044**
4-5 serves	4(22.2)	7(58.3)	
Down the T			
<3	13(72.2)	4(33.3)	**0.035**

4-5 serves	5(27.8)	8(66.7)	
Cross			
<3	13(72.2)	4(33.3)	**0.035**
4-5 serves	5(27.8)	8(66.7)	

3. RESULT

The P values of the number of accurate serves being places were expressed in Table 2. According to the calculated statistics, the P value in the case of a basic serve was negative and the other three serves had a positive association with the contralateral hand-eye profile.

- Basic serve - 0.078 (-)
- Wide serve – 0.044 (+)
- Down the T – 0.035 (+)
- Cross serve – 0.035 (+)

4. DISCUSSION

This study was conducted to analyse the accuracy of a tennis serve based on the hand-eye laterality profile of the player. A total of 30 high-level athletes participated in this study. Among these 30 samples, 22 were male and 8 were female. The players were recruited from prestigious training centers from all across Chennai. 17.6 was the mean age of the cohort. Among the cohort, 96.7% were dominant right, and 3.3% presented with left-hand dominance. 56.7% of players were right-eye dominant and 43.3% of players were left-eye dominant.

On the performance of the dominant eye test, 18 samples were of type A (ipsilateral) profile and 12 samples were of type B (contralateral) profile, which expresses a minority of profile type B. Some athletes even had nearly equal eye dominance. In such cases, the level of deviation of the object from the center of triangular space was considered. The inability to close only one eye was also prevalent in some cases.

FLAT SERVE IN RELATION WITH OPTOKINETIC RESPONSE

The eye movements involve a combination of visual motion and hand movements. [48][49][50] The visual motions aid in posture control and gait patterns.[51][52][53] The optokinetic response is the movement of the eye in a reflex on the motion of an object in the visual field.[54] It is highly influenced by the characteristics of a scene in motion.[55] It is stimulated by slowly developing reflex velocity in response to the motion stimuli of an image.[56] Improving efficiency in the optokinetic response in players through reflex conditioning training can be of great help in tackling players with an abbreviated serve.

SERVE TOSS

The inclination of the toss can be vividly seen right on top of the player's dominant eye. This accentuates the importance of toss training concerning body coordination during a serve for improving efficiency. [57] Training players with different types of serves for the same toss technique is not good.[58] The serve toss is a crucial part of the game, as it can be used as a trick point for deceiving the opponent. [59]

SERVE CHARACTERISTICS

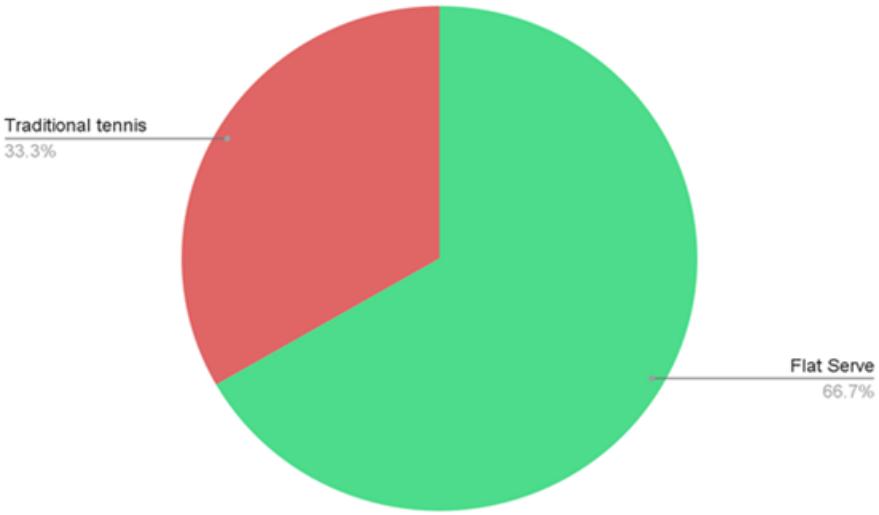
There are usually three types of serve in tennis:

1. Topspin or traditional
2. Abbreviated or flat
3. Slice.

A topspin serve is consistent while an abbreviated serve has high velocity.[60] The kinematic development of the abbreviated serve and slice serve are similar.[61] Through observation, it was seen that players type B profile tend to opt for an abbreviated serve or a flat serve with a short swing time and narrow base of support. This kind of serve has been reported to provide more advantage in performance over the conventional tennis serves.[62] The high-velocity aspect of the abbreviated serve is what seems to be plausible reasoning for the advantage it holds over traditional serves.[63] On observation, the speed of the serve is comparatively higher in an abbreviated serve with the ball being placed flat rather than a characteristic spin of a

traditional serve. This kind of serve also has a faster point of contact during the toss, which again leads to high-speed serves.[64] The fast arm and racquet motion are another factor that aids in the speed of abbreviated serves. So it is important to have good peripheral racquet velocity at the point of contact during the toss.[65] Abraham GD et.al and Sheets et.al have pressed upon the influence of high velocity in a serve in their investigations.[66] Even though high-speed serves are advantageous, consistency is still an important skill to win a point.[67]Though serve efficiency ranges between 63-75% depending on the court surface,[68] (concluded in the case of a grass court)[69] an ideal player should be able to succeed in 70% of first serves.[70] Though there is a valid advantage of an abbreviated serve, it cannot be used as a lethal weapon all the time as in professional tennis, experienced players anticipate the ball direction from information gained from the arm and racquet configuration and also have high motor response.[71] Hence practice is necessary to overcome these skill-based hurdles.[72] Segregation of top performers and poor performers on evaluation based on all aspects is key to scouting true talent.[73]

FIGURE: DISTRIBUTION OF PLAYERS WITH TRADITIONAL SERVE AND ABBREVIATED SERVE



HAND POSITIONING OR GRIP STYLE

The grip positioning is highly linked with the racquet response in motion during ball impact in a serve. Players with an abbreviated or a slice serve usually opt for a hammer grip that is held by positioning the wrist outwardly on the racquet handle. Previous studies done on intermediate players prove the efficiency of this grip in producing high-velocity serves.[75]

RISK OF INJURY

Injuries usually have a mechanical pathology behind them.[76]

The serve demands high energy, played 45 to 60% of all strokes in a tennis match, [77] exposing the shoulder to overuse injury and rotator cuff tears.[78] Even if a player is experiencing anterior shoulder instability, they can achieve a similar outcome in a serve as a premorbid player with a different implementation strategy.[79] However previous studies present a simulation of internal impingement which can lead to labral lesions,[80] which may lead to impairment in service execution. This arm motion effect is observed during the scapular motion, [81] which might lead to a SICK scapula as a sequel. [82] Due to the high-velocity characteristic of abbreviated serve, players in the type B profile can be more prone to repetitive strain injuries of the shoulder.

During the toss, the lumbar arch was more significant in abbreviated serves. This can lead to possible evidence of lumbar repetitive strain injuries being more prevalent in type B profiles with abbreviated serves. Previous studies prove that there is a greater lumbar loading in an abbreviated serve (or a flat serve) compared to a kick serve, though the differences are minimal. [83] A study done on junior players claims that male players experienced more intense injuries compared to female players. The study also observed that the lumbar spine injury was most prevalent in both sexes within the age group of 14 to 18 years. [84] The repetitive serve action throughout a tennis player's career may be a reasonable explanation for overuse upper limb injuries being common among their population. [85]

Lower trunk injuries are quite prevalent among tennis players.[86] Both hypermobility and hypomobility can be evident causes of lower back pain.[87] Some of the obvious lower trunk muscles that are activated during a serve action are:

1. Rectus Abdominis

2. External Oblique

3. Internal Oblique

4.Erector Spinae [86]

The lower trunk is dominantly active during the acceleration phase of a serve. [86] During this phase, the lower trunk experiences compressive load,[86] which at prolonged or higher degrees can cause lumbar spine pathologies. Repetitive hyperextension and lateral flexion aid in the presentation of shear force on the lumbar spine.[86] The first serve is performed with maximal ball speed [86], which requires faster biomechanical movements (especially trunk rotation) which can also be considered a prominent cause of lumbar injuries among this population. [88] Stress on L5 vertebrae and disc/facet degeneration at the L4/L5 intervertebral space were the most common radiological pathologies seen in the lumbar spine of adolescent tennis players. Therefore, L4 and L5 vertebrae seem to be susceptible to injuries among adolescent tennis players,[89][90] with type B profiles being more at risk due to a more appreciated lumbar arch during the serve.

Other injuries that are highly prevalent among professional tennis players are hip, knee, ankle, and shoulder injuries, some of which have been deemed career-threatening based on gender, with males being more susceptible to them compared to females. [91] Elbow injuries are predominant among most of the incidences.[102] It is a common array of injuries among the Indian professional tennis population.[92] One such elbow injury is the tennis elbow which affects the muscles attached to the lateral condyle of the elbow i.e. Extensor carpi radialis longus and anconaeus.[100] 50% of players have a chance of developing tennis elbow at some point in their career.[101] In his study, Hamilton also observed a relapse of the injury in some players. [99] As it is a repetitive injury based on force of action, it can be assumed that it will be a common issue among type B profiles.

Tennis players with traditional and slice serve adapt to smaller joint angles during the action than flat serves.[96]

These injuries can be prevented if the players train their muscles concentrically and eccentrically during fitness sessions.[97]

In context to the results, serve performance of type A can be improved by visual training programmes. [92] It can also be implemented among type B profiles to enhance and polish their natural accuracy. An 8-week visual enhancement program tested on football players that improved head steadiness, gaze control, and central-peripheral vision showed significant improvement in fusion flexibility, central-peripheral awareness, hand-eye coordination, and visual adjustability. [95]

5. CONCLUSION

The study concluded by showing that players with cross-lateral hand-eye laterality have a higher chance to place accurate serves when compared to players with ipsilateral hand-eye laterality. Thus, the hand-eye laterality profile plays a role in the accuracy of a tennis serve in the case of a wide, cross, and down the T variation.

Tennis today is a sport with increased popularity in various nations, putting pressure on the sports management sectors to work towards its development.[98] It is important to come up with versatile assessment and training tools to enhance performance. A holistic assessment of the player is important.[93][94] Through this study, a holistic approach to player evaluation, training, and injury prevention by including eye and game style characteristics influenced by it as a component is suggested.

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