

Biomechanical Analysis Of Double-Handed Backhand Drive Technique: Square Stance Vs. Open Stance"

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Abstract

Study purpose: The main purpose of this study is a comprehensive biomechanical analysis of square stance and open stance in tennis backswing. The analysis involves examining the different variations between two-handed tennis players focusing on open stance and square stance.

Materials and methods. This study is a descriptive research with biomechanics analysis involving 30 Junior male tennis Players who have played AITA tournaments. The age range of players are 12-14 years. The Hewitt Tennis test was applied for the analysis of Open stance and Square stance. Analysis of biomechanical variables using descriptive statistics and correlation between different variables was tested using Pearson's Product Moment Correlation. A comparative test was conducted to assess the difference between various variables in the square stance and the open stance. The significance level for this test was set at an alpha level of 0.05, ensuring statistical robustness.

Results. The first goal was to determine the comparison between a square stance and an open stance of the tennis backswing. Analysis of the study revealed that there is a significant difference between the right shoulder joint in square posture and open posture as p-value (0.022) is less than .05.

Conclusions. The strike zone of the two strikes is different in the square stance and the open stance. In the square stance, the contact point is slightly earlier than in the open stance. An open stance can be used in defensive situations. The square stance recruits more large muscle groups to initiate the kinetic chain,

which makes it more effective, but it also means we have to take an extra step on the ball, so we have to work a little harder to get there first.

Introduction

The backstroke in tennis represents an important stroke that requires precision, power and control. An important part of a player's arsenal, often used in power rallies or defensive moves. Variations in the stance adopted during the execution of this stroke-mainly the square stance and the open stance-differentiate the biomechanical strategies used by the players. Square posture involves placing your feet about shoulder-width apart and keeping your torso parallel to your core. This posture allows you to create a more stable base that facilitates rotation of the body and hips while maintaining balance. An open stance, on the other hand, allows the front leg to move away from the midline of the body, allowing the hips and shoulders to open in the direction of the kick. This stance allows the shot to travel faster, increasing power generation and the ability to reach the ball wider. The biomechanical analysis of this position involves a kinetic chain that involves a coordinated sequence of movements through various joints and muscle groups. Backstroke starts with the lower body, where the legs and hips play a key role in power generation. In the quad, it starts with a slight shift of the weight to the hind leg, followed by a strong rotation of the hip in the direction of the axis. This rotation creates torque, which lifts the kinetic chain upwards and ultimately moves the racket into the user's hand. In contrast, the open stance relies on the legs to initiate the stroke, using the rotational force generated by the hips and core to propel the shot forward. Joints involved in this movement experience special movements. The hip joint in both postures undergoes external rotation during preparation, facilitating potential energy loading. As the stroke progresses, the hip joints begin to rotate and transfer energy to the upper body. The elbow joint plays an important role in the back propulsion, allowing the arm to move towards the midline of the body and allowing for a whip-like movement that is important for the speed of the racket head..

Objective of the study:

- To find out the Comparison between square stance and open stance in tennis backhand drive.
- To study the relationship of selected variables of square stance with the speed of the ball after the contact.

Hypothesis of the study

1. There may be a significant difference between square stance and open stance in Tennis backhand drive.
2. There would be a significant relationship between selected linear and angular kinematic variables of square stance with the speed of the ball after the contact.

Selection of the subject:

The selection of **thirty male tennis players** from prominent academies in Gwalior was deliberate, ensuring a diverse yet skilled sample. The inclusion criteria involved participants who were **junior national players** with a demonstrated proficiency up to the second round of AITA-level tournaments.

Variable Selection and Biomechanical Analysis:

The meticulous selection of kinematic variables reflects a comprehensive approach to understanding the nuances of the two-handed backhand drive in tennis. The choice of linear and angular parameters, both in square and open stances, demonstrates a nuanced exploration of factors influencing performance. These variables, including center of gravity height, ball speed after contact, racket speed, and joint angles, collectively contribute to a detailed biomechanical analysis, allowing for a holistic interpretation of player mechanics.

For the Biomechanical analysis of Two-handed backhand drive following kinematic variables were selected:

- A. Linear kinematics variables in square stance.
- Height of center of gravity at back swing.
- Height of center of gravity at moment of contact.
- Height of center of gravity at follow-through.

- Speed of the ball after the contact.
- Horizontal Speed of the racket

Filming protocol

For the biomechanical investigation of the various stages of double-handed backhand drive, the method of videography was utilized. The movement was recorded with a GoPro Hero 5 camera at a frequency of 120 frames per second. Since every person photographed was right handed, the camera was positioned on the sagittal plane from the individuals' right side. For the purposes of the study, a total of three phases—the preliminary phase, the moment of contact, and the follow-through phase—had to be observed and recorded. Additionally, the researcher was able to produce the necessary stick figure based on sequence images taken from the movie, and it was also used to compute the other biomechanical factors.

Result and Analysis

The statistical examination of thirty junior national tennis players' worth of data. The purpose of the data collection was to examine the biomechanical differences between square and open stances during backhand drives in tennis, as well as the correlation between speed and a chosen kinematic variable in both stances. In order to learn more about the varied linear and angular variables throughout different phases, the participants executed 10 backhand drives with each stance. The results were recorded and examined. Descriptive statistics were used to analyze the biomechanical variable data and examine the relationships between the different variables. Person's product moment correlation was employed, and paired "t" tests with an alpha of at least one were performed to compare the various open stance and square stance variables. paired 't' test were used and alpha was set at 0.05 level of significance.

TABLE – 1 DESCRIPTIVE STATISTICS OF ANGULAR KINEMATICS OF SQUARE STANCE IN TENNIS BACKHAND DRIVE

S.No.	Variables(angle)	Mean(in degree)	Std. Deviation
1	Right shoulder joint	016.83	03.48

2	Left shoulder joint	022.53	05.75
4	Right elbow joint	0147.01	06.81
5	Left elbow joint	0132.20	010.96
6	Right hip joint	0145.30	05.65
7	Left hip joint	0161.50	06.27
8	Right knee joint	0156.16	08.27
9	Left knee joint	0142.56	06.87

Table 1 shows the descriptive statistics of selected angle variables of the quadriceps position in the tennis backswing technique.

From the table, the mean and standard deviation of the squared position angle variables are right shoulder angle (16.83 ± 3.48), left shoulder angle (22.53 ± 5.75), right elbow angle (147.46 ± 6.81), left elbow angle (132.20 ± 10.96), right knee angle (145.30 ± 5.65), left knee angle (161.16 ± 6.27), right knee angle (156.16 ± 8.27) and left knee angle (142.56 ± 6.87).

TABLE – 2 DESCRIPTIVE STATISTICS OF ANGULAR KINEMATICS OF OPEN STANCE IN TENNIS BACKHAND DRIVE

S.N.	Variables(angle)	Mean(in degree)	Std. Deviation
1	Right shoulder joint	15.30	03.20
2	Left shoulder joint	19.93	05.34
3	Right elbow joint	146.53	06.50
4	Left elbow joint	131.46	10.52
5	Right hip joint	157.10	06.21
6	Left hip joint	145.76	04.76
7	Right knee joint	154.96	07.03
8	Left knee joint	141.53	05.90

Table 2 shows the descriptive statistics of the selected open position angle variables in the tennis backswing technique. The table shows the mean and standard deviation of the open position angle variable, right shoulder angle (15.30 ± 3.20), left shoulder angle (19.93 ± 5.34), right elbow angle (146.43 ± 6.50), left elbow angle ($131.46 \pm 131.46 \pm 1$), right kidney angle (157.10 ± 6.21), left kidney angle (145.76 ± 4.76), right knee angle (154.96 ± 7.03) and left knee angle ($141.53 \pm 5, 90$).

GRAPH 1 COMPARISON OF MEANS OF DIFFERENT ANGULAR KINEMATIC VARIABLES OF SQUARE STANCE AND OPEN STANCE

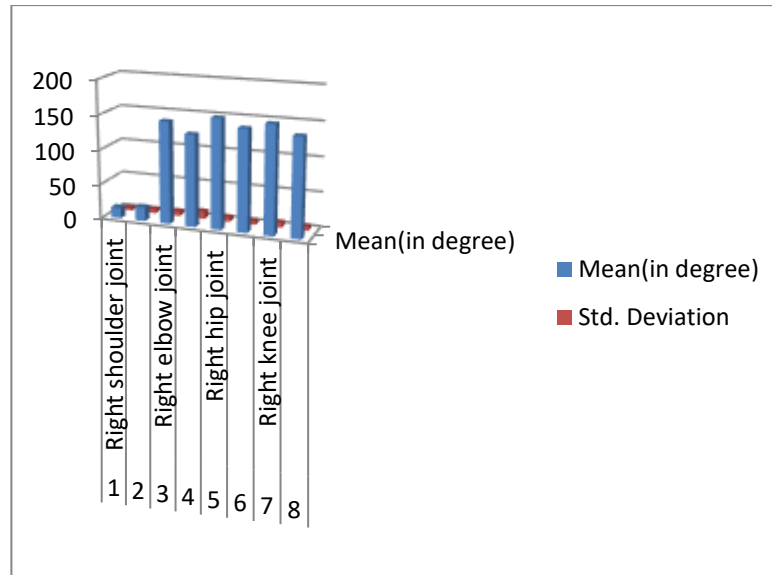


TABLE- 3 DESCRIPTIVE STATISTICS OF LINEAR KINEMATIC VARIABLE OF SQUARE STANCE IN TENNIS BACKHAND DRIVE

Variables	Mean	Std. Deviation
COG at backswing phase (in cm)	94.36	4.64
COG at moment of contact (in cm)	99.73	5.18
COG at follow through (in cm)	104.53	4.47
Speed of the ball after contact (in km/h)	106.33	8.42
Horizontal speed of racket (in m/s)	21.44	1.89

Table 3 shows the descriptive statistics of linear kinematic variables selected from the quadriceps position in the tennis backhand technique.

From the tabular form, the average and standard deviation of linear kinematic variables are COG during the backswing phase (94.36 ± 4.64), COG at the moment of contact (99.73 ± 5.18), COG

(104.64 $\pm$ 4.56), ball speed after contact. (106.33 $\pm$ 8.42), and horizontal racket speed (21.44 $\pm$ 1.89).

TABLE- 4 DESCRIPTIVE STATISTICS OF LINEAR KINEMATIC VARIABLE OF OPEN STANCE IN TENNIS BACKHAND DRIVE

Variables	Mean	Std. Deviation
COG at backswing phase (in cm)	91.16	4.24
COG at moment of contact (in cm)	96.16	4.84
COG at follow through (in cm)	104.21	4.56
Speed of the ball after contact (in km/h)	102.13	7.93
Horizontal speed of racket (in m/s)	20.50	1.52

Table 3 shows the descriptive statistics of linear kinematic variables selected open position in tennis backswing technique.

The table shows the mean and standard deviation of the open position linear kinematic variables, COG during the backswing phase (91.16 $\pm$ 4.24), COG at the moment of contact (96.16 $\pm$ 4.84), COG (102.08 $\pm$ 4.76), ball speed after contact (103.36 $\pm$ 8.08) and the horizontal speed of the racket (21.08 $\pm$ 1.30).

TABLE- 5 COMPARATIVE STATISTICS OF ANGULAR VARIABLES OF SQUARE STANCE AND OPEN STANCE IN TENNIS BACKHAND DRIVE

Variables	Mean dif.	Std. Deviation	t-value	p-value
Angle at right shoulder joint in square stance	1.53	3.47	2.41	.022
Angle at right shoulder joint in open stance				

Angle at left shoulder joint in square stance	2.60	5.28	2.69	.012
Angle at left shoulder joint in open stance				
Angle at right elbow joint in square stance	1.13	6.41	.968	.341
Angle at right elbow joint in open stance				
Angle at left elbow joint in square stance	.73	11.28	.356	.725
Angle at left elbow joint in open stance				
Angle at right hip joint in square stance	-11.80	7.81	-8.27	.000
Angle at right hip joint in open stance				
Angle at left hip joint in square stance	15.73	8.08	10.65	.000
Angle at left hip joint in open stance				
Angle at right knee joint in square stance	1.20	8.72	.753	.457
Angle at right knee joint in open stance				
Angle at left knee joint in square stance	1.03	8.05	.703	.488
Angle at left knee joint in open stance				

From Table 5, it can be seen that the t-statistics of the joint angle of the right shoulder in the square stance and open stance is 2.41.

This is a significant value because the p-value is less than .022. Therefore, it can be concluded that the average angle in the right shoulder joint in the square stance and the angle in the right shoulder joint in the open stance are not the same. In addition, looking at the values of the average angle in the right shoulder joint (16.83) and the right shoulder joint of the open stance (15.30) from Tables 1 and 2, you can note that the average angle decreases in the open position. grip, so it can be concluded that players with an open grip make contact with the ball closer

to the body. People with a square stance move a bit in front of the body and the ball, so they have a bigger angle. From the table, it can be seen that the left shoulder joint angle statistic is 2.69 in square stance and open stance. This value is significant because the p-value is less than .012. Therefore, it can be concluded that the average angle in the left shoulder joint in the square stance and the angle in the left shoulder joint in the open stance are not the same.

Table 7 COEFFICIENTS OF CORRELATION BETWEEN ANGULAR KINEMATIC VARIABLES OF SQUARE STANCE AND SPEED OF THE BALL

S.N.	Variables	Speed of the ball	
		r-value	p-value
1	Angle at right shoulder joint	.909**	.000
2	Angle at left shoulder joint	.890**	.000
3	Angle at right elbow joint	.282	.131
4	Angle at left elbow joint	.490**	.006
5	Angle at right hip joint	.255	.174
6	Angle at left hip joint	.101	.595
7	Angle at right knee joint	.378*	.039
8	Angle at left knee joint	.320	.084

Discussion of Hypotheses

Based on the results, it is hypothesized that there may be a significant difference between the square stance and the open stance in tennis double-handed drive.

The following observations were made:

1. If there is a kinematic angle variable selected, the right shoulder joint angle in the square stance and the right shoulder joint angle in the open stance, the left shoulder joint angle in the square stance and the left shoulder joint angle in the open stance, the right hip angle in the square and open stance, right hip joint angle stance, left hip angle square stance and left hip angle in an open stance, stance, right and left knee joint angles in a square stance and assumptions about the right and left knee joints in an open stance are not accepted.

A significant relationship between the speed of the ball after contact and the linear kinematic variables and the selected angle of the square stance was hypothesized.

The following observations were made:

1. Chosen kinematic variable angle of quadriceps stance, right shoulder angle, left shoulder angle, left elbow angle, and right knee angle, null hypothesis rejected for right elbow angle, angle Right knee joint angle, left knee joint angle, and left knee joint angle are accepted, while right elbow joint angle, right knee joint angle, left knee joint angle, and left knee joint angle are rejected.
2. In the case of quadratic stance, the linear kinematic variables selected are COG (center of gravity) in the backward phase, COG in the contact phase, COG in the forward phase, and the horizontal velocity of the racket.

The table shows the correlation analysis between tennis ball speed and various biomechanical variables related to the player's shoulder and knee joints during the tennis backswing. The variables and corresponding statistical measures (r-value and p-value) are shown below.

COEFFICIENTS OF CORRELATION BETWEEN LINEAR KINEMATIC VARIABLES OF SQUARE STANCE AND SPEED OF THE BALL

Speed of the ball			
S.N.	Variab les	r-value	p- value
1	COG at back swing phase	.638**	.000
2	COG at moment of contact phase	.658**	.000
3	COG at follow-through phase	.711**	.000
4	Horizontal Speed of the racket	.791**	.000

Table 8 shows the statistical significance of the correlation coefficient between the selected linear kinematic variables of the square stance after contact and ball speed in tennis double hand drive.

The correlation coefficient required to be significant at the 0.01 level for 28 degrees of freedom is (0.463), and the 0.05 level is (0.361). Table 8 shows a significant correlation between COG (center of gravity) in the recoil phase (0.638), COG in the contact phase (0.658), COG in the forward phase (0.711) and horizontal velocity of the missile (0.79). to the speed of the ball after contact because the value received is higher than the cumulative value.

Table 10 COEFFICIENTS OF CORRELATION BETWEEN LINEAR KINEMATIC VARIABLES OF OPEN STANCE AND SPEED OF THE BALL

S.N.	Variables	Speed of the ball	
		r-value	p-value
1	COG at back swing phase	.646**	.000
2	COG at moment of contact phase	.634**	.000
3	COG at follow-through phase	.273	.145
4	Horizontal Speed of the racket	.755**	.000

Table 10 shows the statistical significance of the correlation coefficient between selected linear kinematic variables of the open stance and ball speed after contact in tennis double hand movement.

The correlation coefficient required to be significant at the 0.01 level for 28 degrees of freedom is (0.463), and the 0.05 level is (0.361). Table 10 shows that COG (center of gravity) in the backswing phase (0.646), COG in the contact phase (0.634) and the horizontal speed of the racket (0.755) are significantly correlated with the speed of the ball after contact. the score obtained is higher than the cumulative score. Meanwhile, the correlation coefficient obtained for COG in the next stage (0.273) was found to be insignificant because the value obtained was lower than the required value.

Discussion of Findings

The present study was conducted to biomechanically analyze the square stance and the open stance in the two-hand drive of tennis. To meet the research objectives, the data is divided into three stages, taking into account the research objectives defined at the beginning of the research.

The first goal was to determine the comparison between a square stance and an open stance of the tennis backswing. Analysis of the study revealed that there is a significant difference between the right shoulder joint in square stance and open stance as p-value (0.022) is less than .05. Therefore, it can be concluded that the angle of the right shoulder in the square stance and the angle of the right shoulder in the open stance are not the same. In addition, looking at the value of the mean angle in the right shoulder joint (16.83) and the right shoulder joint (15.30) of the open stance from Tables 1 and 2, you can note that the average angle decreases in the open position. position. Grip, so it can be concluded that open grip players make contact with the ball closer to the body to reduce the shoulder angle. People in a square stance move the ball a little further in front of the body, so they have a bigger angle. Data analysis concluded that there is a significant difference between the left shoulder joint in the square stance and the open stance as the p-value (0.012) is less than 0.05. Therefore, it can be concluded that the mean angle in the left shoulder joint in the square stance and the angle in the left shoulder joint in the open stance are not the same.

Conclusions

The following conclusions were made based on the analysis and limitations of the current study:

1. In the case of square stance and open stance the hitting zone of both the stance were different. In square stance contact point was slightly earlier than the open stance. It can be said that open stance is used in the defensive situations.
2. A square stance recruits more of the large muscle groups to initiate the kinetic chain of power, which makes it more efficient,

but it also means we have to take an extra step to the ball, so we have to run a little harder to get there in the first place.

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