

# The Difference of Angles Between Down-The-Side Line Shot and Cross Shot of the Two-Handed Backhand Stroke in Tennis as a Basis for Skill Training

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**Abstract:** The purpose of this study was to investigate the difference in angles between a Cross shot and Down-The-Side line shot stroke for the skill of the Two-Handed backhand in beginning of back swing, end of back swing, ball impact, and end of follow through. There are 9 players in the Top -10 of Association of Tennis professional (ATP) are used two-handed backhand batting Technology, that is 90%. Two-handed backhand grips influence both the strength and the coordination used in the stroke. Sample of subjects Five experienced young boys' tennis players from Sporting club in Alexandria, Egypt. They are participating in national championships. Biomechanics is an essential tool for understanding movement and the adjustments in the stroke of tennis. Methods we are using Simi 3D motion analysis V.9.0.6 Program of Kinematic analysis to data analysis. The results of Man-Whitney nonparametric test for comparing 2 independent groups. Results This study success to show differences in angles between a Cross shot and Down-The-Side line shot stroke for the skill of the Two-Handed backhand. Conclusion Cross shot stroke for the skill of the Two-Handed backhand need to more rotation in lower and upper body than Down-The-Side line shot stroke for the skill of the Two-Handed backhand to hit the ball in cross court successfully. We may need more research to understand more of the differences between a Cross shot and Down-The-Side line shot stroke for the skill of the Two-Handed backhand from other sides.

**Keywords:** Two-Handed Backhand, Joint Angles, Tennis

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## 1. Introduction

The most commonly used technique in tennis competition is forehand and backhand, and the majority player's backhand technique is weaker than forehand. There are 9 players in the Top -10 of Association of Tennis professional (ATP) are used two-handed backhand batting Technology, that is 90% [1]. Two-handed backhand grips influence both the strength and the coordination used in the stroke [2].

It is interesting to note that the backhand has attracted less research attention than the serve and forehand [3]. The backhand ground stroke is a neutral or defensive stroke used on the dominant side of the body after the ball bounces.

Players at the baseline will hit most shots with a backhand [4]. An understanding of tennis biomechanics arms the coach with technical insight into why and how the body move. Coaches need to make sure, however, that the technology they are using adds value to the training session [5]. Young tennis players refer to play on Baseline because that very good angle plays to make a cross shot or Down-The-Side line shot with aggressive Backhand stroke and hit point [6]. Many players benefit from the two-handed backhand, especially in the early learning stages. Both arms are used, increasing the power of the stroke, and fewer body segments are involved, which helps learning players coordinate the movement [7].

Any meaningful discussion of variations of tennis stroke

technique requires knowledge of sport biomechanics.

The research focuses on studying the difference in angles between a Cross shot and Down-The-Side line shot stroke for the skill of the Two-Handed backhand because that may provide valuable information to the tennis coaches and athletes in training.

As far as the researchers know, there is a dearth of research that has dealt with study difference between a Cross shot and Down-The-Side line shot stroke for the skill of the Two-Handed backhand. Biomechanics is an essential tool for understanding movement and the adjustments in the stroke of tennis.

## 2. Materials and Methods

### 2.1. Sample of Subjects (Participants)

Five experienced young boys' tennis players from Sporting club in Alexandria, Egypt. Mean  $\pm$  SD of characteristics of players in this study (age:  $13.20 \pm 0.837$  years; Tennis practice:  $5.40 \pm 0.548$  years; Weight:  $53.40 \pm 3.507$  Kg; Height:  $164.20 \pm 4.147$  Cm). They are participating in national championships.

### 2.2. Tools

Basler scA640 – 120gc-High-Speed camera (100 frame / Sec). (Figure 1).

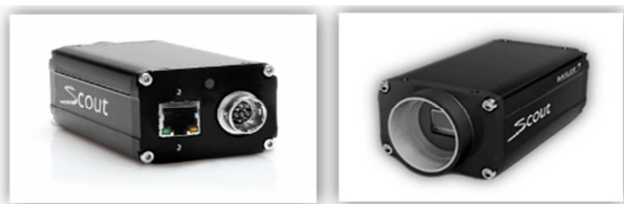


Figure 1. Basler scA640 – 120gc-High-Speed camera.

Wand Calibration (60Cm) and L- Frame calibration. (Figure 2). Simi 3D motion analysis V.9.0.6 Program of Kinematic analysis.

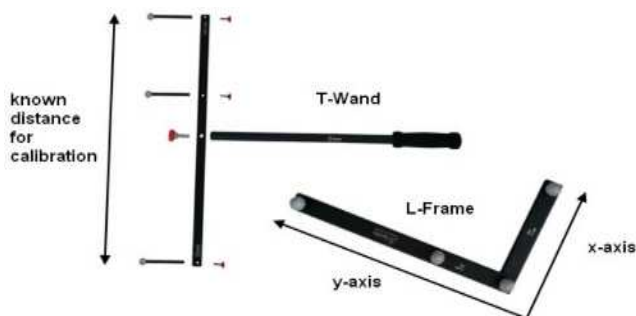


Figure 2. Wand Calibration (60Cm) and L- Frame calibration.

### 2.3. Performance Data Collection

Each collection session started with placed cameras on the tennis court, The cameras were placed at approximately a 90-degree angle, participants wore tight clothing during the

experiment and reflective markers were placed on the joints of the player's bodies. Testing Procedures were explained to all players in accordance with approved. After a thorough Warm-up each player performed four attempts successful Cross shot of the Two-Handed Backhand stroke and four attempts to Down-The-Side line shot successful of the Two-Handed Backhand stroke were record.

### 2.4. Kinematic Data Analysis

The synchronized pictures of beginning of back swing, end of back swing, ball impact and end of follow through to Down -the side-line shot (Figure 3) and Cross shot (Figure 4) of the Two-Handed backhand stroke obtained from cameras were digitized. And then Right and left (shoulder, Elbow, Wrist, Hip, Knee and Ankle) joint angles were analyzed using Simi 3D motion analysis V.9.0.6 Program of Kinematic analysis.

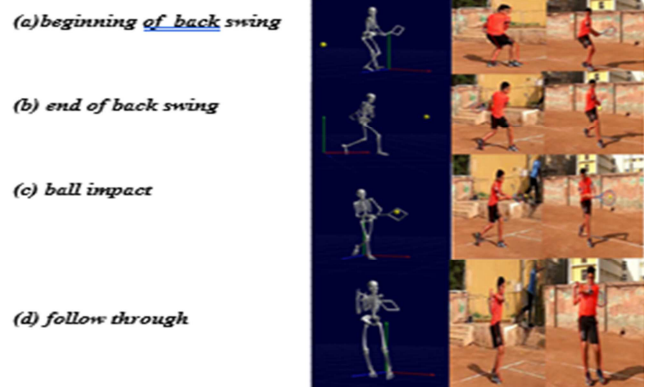


Figure 3. Down -the side-line shot of the Tow-Handed backhand.

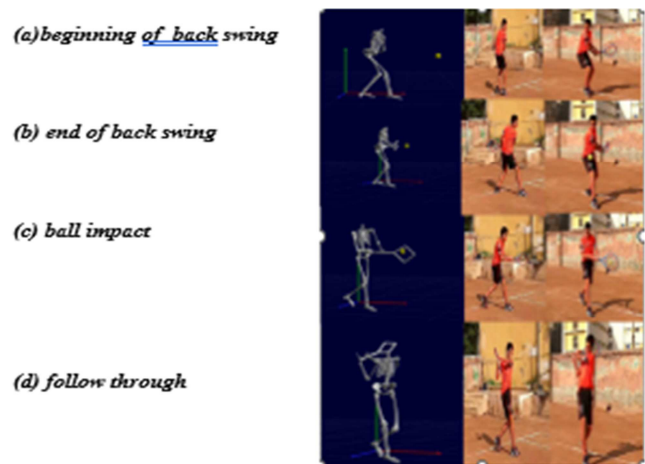


Figure 4. Cross shot of the Tow-Handed backhand.

### 2.5. Statistical Analysis

Data analyzed with SPSS ver. 23.00 using nonparametric tests due to small sample size ( $< 40$ ) [8] the following tests and measures used Mean and standard deviation, Shapiro-Wilk normality test, and Man-Whitney nonparametric test for comparing 2 independent groups.

### 3. Results

Table 1 showed the significance of the differences in the angle joints of the body between Down-The-side line shot and Cross shot two-handed Backhand stroke at beginning of back swing.

Table 1 results reveal that angle differences between Down-The-side line shot and Cross shot two-handed Backhand are: Statistically significant ( $p < 0.05$ ) in left shoulder, left elbow, left wrist, right hip, left knee, right ankle, and left ankle angles where Down-The-side line shot angles were smaller than Cross shot angles.

Statistically significant ( $p < 0.05$ ) in right shoulder, right elbow, right wrist, and left hip angles where Down-The-side line shot angles were greater than Cross shot angles.

Statistically insignificant ( $p > 0.05$ ) in right knee angle.

Table 2 showed the significance of the differences in the angle joints of the body between Down-The-side line shot and Cross shot two-handed Backhand stroke at end of back swing.

Table 2 results reveal that angle differences between Down-The-side line shot and Cross shot two-handed Backhand are: Statistically significant ( $p < 0.05$ ) in right shoulder, left elbow, left wrist, left hip, right knee, left knee, and right ankle angles where Down-The-side line shot angles were smaller than Cross shot angles.

Statistically significant ( $p < 0.05$ ) in right elbow, right wrist, right hip, and left ankle angles where Down-The-side line shot angles were greater than Cross shot angles.

Statistically insignificant ( $p > 0.05$ ) in left shoulder and right wrist angles.

**Table 1.** The significance of the differences in the angle joints of the body between Down-the-side line shot and cross shot at beginning of back swing ( $n=10$ ).

Angle ( $\theta$ )	Descriptive			Mann-Whitney Test									
	Down-The-side line shot two –Handed Backhand			Cross shot two –Handed Backhand			Down-The-side line shot two –Handed Backhand		Cross shot two –Handed Backhand		U	Z	Significance (P)
	Mean	$\pm$	SD	Mean	$\pm$	SD	Mean rank	Sum of ranks	Mean rank	Sum of ranks			
Rt: Shoulder angle	31.92	$\pm$	0.733	29.34	$\pm$	0.371	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Shoulder angle	25.94	$\pm$	1.230	26.98	$\pm$	0.332	7.60	76.00	13.40	134.00	21.000	2.222	0.026
Rt: Elbow angle	128.05	$\pm$	0.558	58.65	$\pm$	0.693	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Elbow angle	100.94	$\pm$	0.541	101.88	$\pm$	0.323	7.60	76.00	13.40	134.00	21.000	2.222	0.026
Rt: Wrist angle	172.94	$\pm$	0.490	164.13	$\pm$	0.889	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Wrist angle	164.78	$\pm$	0.249	166.87	$\pm$	0.167	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Hip angle	118.82	$\pm$	0.375	124.92	$\pm$	0.826	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Hip angle	143.06	$\pm$	2.403	139.44	$\pm$	0.520	14.60	146.00	6.40	64.00	9.000	3.142	0.002
Rt: Knee angle	130.16	$\pm$	7.148	124.66	$\pm$	2.390	12.50	125.00	8.50	85.00	30.000	1.533	0.125
Lt: Knee angle	120.97	$\pm$	0.091	132.31	$\pm$	1.127	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Ankle angle	106.82	$\pm$	1.772	123.48	$\pm$	0.381	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Ankle angle	90.07	$\pm$	3.168	96.92	$\pm$	1.759	5.50	55.00	15.50	155.00	0.000	3.832	0.001

**Table 2.** The significance of the differences in the angle joints of the body between Down-the-side line shot and cross shot at end of back swing ( $n=10$ ).

Angle ( $\theta$ )	Descriptive			Mann-Whitney Test									
	Down-The-side line shot two –Handed Backhand			Cross shot two –Handed Backhand			Down-The-side line shot two –Handed Backhand		Cross shot two –Handed Backhand		U	Z	Significance (P)
	Mean	$\pm$	SD	Mean	$\pm$	SD	Mean rank	Sum of ranks	Mean rank	Sum of ranks			
Rt: Shoulder angle	28.46	$\pm$	2.699	48.04	$\pm$	0.904	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Shoulder angle	23.19	$\pm$	7.902	30.65	$\pm$	2.076	8.50	85.00	12.50	125.00	30.000	1.533	0.125
Rt: Elbow angle	120.17	$\pm$	3.798	27.37	$\pm$	0.923	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Elbow angle	129.37	$\pm$	1.483	135.38	$\pm$	2.612	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Wrist angle	174.50	$\pm$	3.332	170.14	$\pm$	0.084	12.50	125.00	8.50	85.00	30.000	1.533	0.125
Lt: Wrist angle	167.25	$\pm$	1.669	177.26	$\pm$	0.413	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Hip angle	140.54	$\pm$	4.714	121.20	$\pm$	0.830	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Hip angle	147.95	$\pm$	2.246	154.30	$\pm$	0.762	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Knee angle	148.74	$\pm$	2.196	158.05	$\pm$	0.256	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Knee angle	122.26	$\pm$	1.309	128.78	$\pm$	0.211	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Ankle angle	116.52	$\pm$	0.391	129.54	$\pm$	0.515	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Ankle angle	137.46	$\pm$	0.696	78.28	$\pm$	0.436	15.50	155.00	5.50	55.00	0.000	3.832	0.001

**Table 3.** The significance of the differences in the angle joints of the body between Down-the-side line shot and cross shot at ball impact ( $n=10$ ).

Angle ( $\theta$ )	Descriptive						Mann-Whitney Test						
	Down-The-side line shot two –Handed Backhand			Cross shot two –Handed Backhand			Down-The-side line shot two –Handed Backhand		Cross shot two –Handed Backhand		U	Z	Significance (P)
	Mean	$\pm$	SD	Mean	$\pm$	SD	Mean rank	Sum of ranks	Mean rank	Sum of ranks			
Rt: Shoulder angle	21.63	$\pm$	1.107	19.63	$\pm$	1.640	13.40	134.00	7.60	76.00	21.000	2.222	0.026
Lt: Shoulder angle	44.22	$\pm$	2.936	33.15	$\pm$	4.757	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Rt: Elbow angle	102.69	$\pm$	4.885	53.28	$\pm$	6.396	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Elbow angle	111.02	$\pm$	7.275	122.59	$\pm$	8.230	6.40	64.00	14.60	146.00	9.000	3.142	0.002
Rt: Wrist angle	173.04	$\pm$	2.263	178.40	$\pm$	0.561	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Wrist angle	175.42	$\pm$	1.863	172.25	$\pm$	2.007	13.40	134.00	7.60	76.00	21.000	2.222	0.026
Rt: Hip angle	155.64	$\pm$	3.743	148.36	$\pm$	0.654	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Hip angle	146.71	$\pm$	1.254	169.69	$\pm$	1.481	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Knee angle	153.84	$\pm$	0.367	164.95	$\pm$	1.101	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Knee angle	128.13	$\pm$	1.117	134.27	$\pm$	0.949	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Ankle angle	116.94	$\pm$	0.380	131.15	$\pm$	0.763	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Ankle angle	132.66	$\pm$	2.171	87.82	$\pm$	1.971	15.50	155.00	5.50	55.00	0.000	3.832	0.001

**Table 4.** The significance of the differences in the angle joints of the body between Down-the-side line shot and cross shot at end of follow through ( $n=10$ ).

Angle ( $\theta$ )	Descriptive						Mann-Whitney Test						
	Down-The-side line shot two –Handed Backhand			Cross shot two – Handed Backhand			Down-The-side line shot two –Handed Backhand		Cross shot two – Handed Backhand		U	Z	Significance (P)
	Mean	$\pm$	SD	Mean	$\pm$	SD	Mean rank	Sum of ranks	Mean rank	Sum of ranks			
Rt: Shoulder angle	24.50	$\pm$	0.139	39.00	$\pm$	1.219	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Shoulder angle	75.02	$\pm$	1.265	85.66	$\pm$	0.086	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Elbow angle	102.69	$\pm$	4.885	79.21	$\pm$	1.067	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Elbow angle	80.35	$\pm$	0.704	86.06	$\pm$	3.142	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Wrist angle	148.20	$\pm$	4.314	149.47	$\pm$	7.448	9.70	97.00	11.30	113.00	42.000	0.613	0.540
Lt: Wrist angle	161.01	$\pm$	8.505	170.87	$\pm$	2.566	6.40	64.00	14.60	146.00	9.000	3.142	0.002
Rt: Hip angle	154.02	$\pm$	3.058	146.40	$\pm$	1.191	15.50	155.00	5.50	55.00	0.000	3.832	0.001
Lt: Hip angle	148.93	$\pm$	0.261	169.13	$\pm$	1.870	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Rt: Knee angle	138.52	$\pm$	1.696	153.71	$\pm$	0.884	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Knee angle	133.03	$\pm$	3.286	133.51	$\pm$	2.602	9.70	97.00	11.30	113.00	42.000	0.613	0.540
Rt: Ankle angle	109.77	$\pm$	1.161	128.12	$\pm$	0.416	5.50	55.00	15.50	155.00	0.000	3.832	0.001
Lt: Ankle angle	105.76	$\pm$	2.647	106.38	$\pm$	3.851	9.70	97.00	11.30	113.00	42.000	0.613	0.540

Table 3 showed the significance of the differences in the angle joints of the body between Down-The-side line shot and Cross shot two-handed Backhand stroke at ball impact.

Table 3 results reveal that angle differences between Down-The-side line shot and Cross shot two-handed Backhand are: Statistically significant ( $p<0.05$ ) in left elbow, right wrist, left hip, right knee, left knee, and right ankle angles where Down-The-side line shot angles were smaller than Cross shot angles.

Statistically significant ( $p<0.05$ ) in right shoulder, left shoulder, right elbow, left wrist, right hip, and left ankle angles where Down-The-side line shot angles were greater than Cross shot angles.

Table 4 showed the significance of the differences in the angle joints of the body between Down-The-side line shot and Cross shot two-handed Backhand stroke at end of follow through.

Table 4 results reveal that angle differences between

Down-The-side line shot and cross court two-handed Backhand are: Statistically significant ( $p<0.05$ ) in right shoulder, left shoulder, left elbow, left wrist, left hip, right knee, and right ankle angles where Down-The-side line shot angles were smaller than Cross shot angles.

Statistically significant ( $p<0.05$ ) in right elbow, and right hip angles where Down-The-side line shot angles were greater than Cross shot angles.

Statistically insignificant ( $p>0.05$ ) in right wrist, left knee, and left ankle angles.

## 4. Discussion

The results of the statistical analyses showed significant differences between Down-The-side line shot and Cross shot two-handed Backhand in beginning of back swing, end of back swing, ball impact, and end of follow through.

Joint angles in tennis between Down-The-side line shot and

Cross shot two-handed Backhand play an important role in the success of the player.

Cross shot two-handed Backhand the body need to more rotation than Down-The-side line shot two-handed Backhand during end of back swing, ball impact, and end of follow through to hit the ball cross and inside the court.

Change and differences joint angles in Down-The-side line shot and Cross shot two-handed Backhand in beginning of back swing, end of back swing, ball impact, and end of follow through as a result of hitting the ball with a square stance.

Change and differences shoulder joint angles in Down-The-side line shot and Cross shot two-handed Backhand help to transfers linear momentum to the racquet and ball during ball impact.

While the racquet backswing in the two-handed Backhand the range of motion is reduced because both arms are used and tend to be slightly bent [2].

In addition, the legs (Knee angle and ankle angle) should be trained to provide a stable base of support, to properly transfer the force from the ground to the racket, and to provide endurance for long matches [7].

A skilled two-handed Backhand would then essentially be a weight shift with hip rotation, followed by upper body rotation with the arms and racquet rotating with the shoulder especially during cross shot more than Down-The-side line shot.

Some studies accentuate the importance of the body rotation in the two-handed Backhand stroke [9, 10].

The angle of the wrist affects the success of hitting the ball during end of back swing, ball impact, and end of follow through in Down-The-side line shot and Cross shot two-handed Backhand.

There was study showed the important of Wrist angular in the ground stroke in tennis [11].

The two-handed Backhand has a wide variety of follow-through patterns this study result showed significant differences between Down-The-side line shot and Cross shot two-handed Backhand in end of follow through.

A higher internal rotation moment after impact was observed at each Joint [12].

The two-handed Backhand generates greater trunk rotation and external rotation of the arm and forearm [13].

Peak angular velocity was significantly greater for multiple joint rotations at the dominant shoulder and entire non-dominant limb in the two-handed Backhand [14].

In the non-dominant upper limb, elbow flexion was smaller in the continental condition throughout the swing, whilst wrist extension and ulnar deviation was larger in the two-handed Backhand [15].

## 5. Conclusion

This study success to show differences in angles between a Cross shot and Down-The-Side line shot stroke for the skill of the Tow-Handed backhand in beginning of back swing, end of back swing, ball impact, and end of follow through.

Cross shot stroke for the skill of the Tow-Handed backhand need to more rotation in lower and upper body

than Down-The-Side line shot stroke for the skill of the Tow-Handed backhand to hit the ball in cross court successfully.

We may need more research to understand more of the differences between a Cross shot and Down-The-Side line shot stroke for the skill of the Tow-Handed backhand from other sides.

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