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Effects of lower limb position on ball speed in tennis ground strokes

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ABSTRACT

According to Schoenborn (2002) groundstrokes are 62% of all tennis strokes in competition. The forehand is considered the main "weapon" in modern tennis, along with the serve, and 74% of top 100 male players use a two handed backhand. This percentage rises to 92% in women. The forehand drive is of great importance in the male professional tennis and it is considered the most important stroke after the serve (Reid, Elliot, & Crespo, 2013).

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INTRODUCTION

The placing of the lower limbs (more exactly of the feet), relative to the direction of the ball, during the preparation phase of a groundstroke in Tennis, as always been somewhat controversial. With the game getting much faster, players need to be able to react more quickly, adopting more frontal positions (Bahamonde, 2001). Elliott (2007) refers that modern tennis is more based on open stances, high rotation strokes and effective use of elastic energy can increase ball acceleration by 20%. However, most of the top players seem to assume a more closed position to look for a winner. Although there seems to a clear shift in the latter years towards the open stance position, the debate goes on.

The more closed stances seem to be linked to more power and precision. Bahamonde & Knudson (2003) found that closed stance players produce larger moments of force and consequently more power and joint loading. Analyzing the stances, Knudsen (2004) affirms that square (or closed) stances promote larger hitting zones. Also, the open stances produce lower (-6%) racquet speeds in college level players, than closed stances. Main advantages of open stance are considered to be quick reaction after the stroke and the use of more elastic energy. The shoulder rotation over the hips, and the position of the upper limbs when related to the trunk and core muscles on the preparation phase, creates the perfect condition for pre stretching (Elliot, 2006).

As these are aspects that influence the way the technique is taught and are quite important in advanced players, it is of the foremost importance to accurately measure the two techniques (open and closed stance) and determine their characteristics.

METHODOLOGY

A group of 5 male players, all with a best ranking within the top 100 ATP where selected for the study. All were right handed and used a two handed backhand except one left-handed with a one hand backhand.

	Height	Weight	Age
Mean	1,834	78,6	31,2
SD	0,07893	6,0663	7,328028

Table 1. Group characterization, height in meters, weight in kg and age in years.

The test protocol included the execution of a series of 4 sets of 5 shots at maximum speed, with the players instructed to execute forehands and backhands both in closed stance and open stance. For each stroke a full series was executed. The 10 best shots were selected, eliminating the inaccurate shots (in foot placement, racket impact and precision), according to preliminary trial studies.

Two preparation tests were conducted with each player, ensuring adequate learning of the test protocol and environment.

Each series was captured using a QualisysTM motion capture system, with 1100 frames per second, 3 megapixel resolution and full field of view. Impact point was captured with Photron Fastcam SA4, at 12000 frames per second, at 1080p (Full HD) resolution. A Stalker ATS 2 radar gun was used as a redundancy speed measurement.

Paired samples T-Test was used for comparison and Pearson correlation coefficient for reliability, as well as average and standard deviation for characterization of results. Confidence level was maintained at 0,05.

RESULTS

Data seems to indicate a small speed advantage for the closed position in both strokes. The small difference (3,06km/h for the forehand and 3,38km/h for the backhand) is statistically significant ($p \leq 0,01$). The results also reflect the expected difference in ball speed between the forehand and the backhand (13,2km/h for the open stance and 12,88km/h for the closed stance, $p \leq 0,001$).

Stroke	Forehand		Backhand	
Stance	Open	Closed	Open	Closed
Mean	117,16	120,22	103,96	107,34
SD	3,649769	4,067240	2,71774	3,12076

Table 2. Ball speed scores for the forehand and backhand in both stances, in km/h.

Kinematic analysis permitted to evaluate the angle of shoulder rotation during the backswing for both strokes in each stance. We verify that there is statistically significant difference ($p \leq 0,001$) in shoulder rotation in favor of the forehand and the closed stances. Although small, the higher rotation of the shoulder probably promotes a longer acceleration path for the racket during the acceleration phase on to the impact point.

	Forehand		Backhand	
	Open	Closed	Open	Closed
Mean	100,68	105,15	78,14	83,54
SD	5,443363	5,994257	9,458847	8,259095

Table 3. Angle of the shoulder rotation for the forehand and backhand in both stances, in degrees.

In the graphical representation seems to be clear the consistency of the scores, inferring a possible relationship between the two variables.

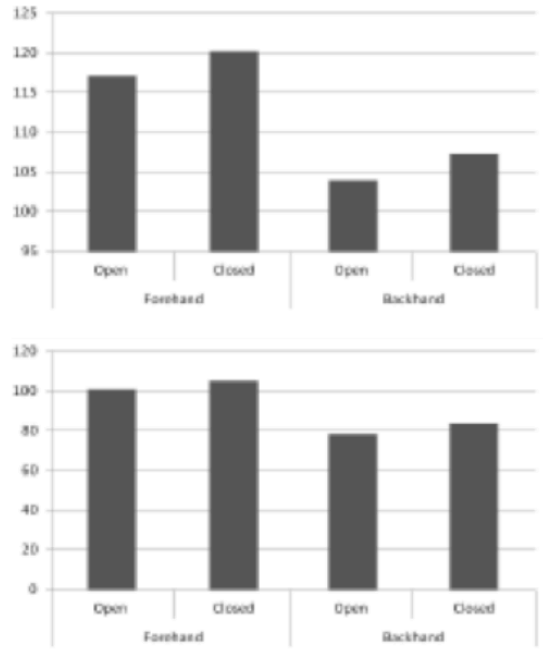

Table 3 & 4.Graphical representation of the ball speed scores (km/h) and the angle of the shoulder rotation (degrees).

DISCUSSION

The scores seem to indicate a slight advantage in speed of the closed stances in both the backhand and the forehand. There are a few differences in the two techniques that can probably explain these results.

It has been mentioned that the leg drive and probable weight transfer in the closed stance can be a determining factor, and also a slightly better balance can affect both speed and precision. However the clear preference for the open stance cannot be underestimated. The movement advantage is great and the difference is speed is slight, which probably explains why most players prefer the open stance in most situations.

In any case, it's important to remember that match play speeds can be different (lower) because of precision, mental pressure and opponent constraints. Hawkeye data from Australian Open 2012 to 2014 as show that average shot speed from top level players was 95,6km/h (Whiteside, Bane & Reid, 2015).

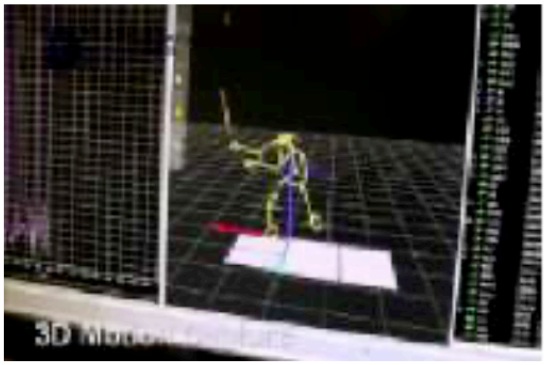

Image 1 & 2. Motion capture renderings using skeletal joints calculation algorithms, with force plate data.

Closed stances also seem to promote a higher shoulder rotation during the backswing. The difference is also slight (4,47° for the forehand and 5,4°, p≤0,001) but can also be an important factor to explain the speed difference. The higher shoulder rotation will probably promote a longer acceleration path for the racket, resulting in higher racket speed at impact point and consequently a higher ball speed. One of the main reasons for performing the backswing in tennis is to increase the distance at which acceleration can develop during the forward swing (Aleksovski, 2015).

The results of shoulder rotation seem to be close the literature findings. It is although interesting to verify that, for this group, the rotation was higher for the closed stances in both strokes and much higher for the forehand (21,61° for the closed stance strokes and 22,54° for the open stance strokes, p≤0,001).

Image 3 & 4. High speed impact point tracking, showing clearly the deformation on the ball and strings, at 10000 fps.

We can also see clearly the limitation imposed by open stance on trunk rotation in the backhand, with a average score of 78,14°, significantly lower than the other strokes.

The higher degree of shoulder rotation can be a determining factor in the increased speed observed in closed stance however other factors can be in play. Other probable advantage for the closed stance in forehands and backhands is precision. Muhamad, Golestani & Razak (2015) demonstrated a higher accuracy for closed stance strokes with intermediate players.

This probably explains why normally top players use more often open stance during rally but seem to prefer the use of closed stance, especially in the forehand, to go for the winner shot. However we can also argue that the winner shot appears in response to shorter balls with the necessity to "step in" for the shot.

It is very important to continue the debate and research on this topic, to provide the best possible information to coaches and assist them to better develop performance players.

CONCLUSIONS

With this study we aim to contribute for the characterization of the open and closed stance position in the groundstroke's, mainly focusing on their advantages. In this context we can state that in our study we found:

1. There seems to be a small ball speed but statistically significant advantage for the closed stance position, both in forehand and backhand;
2. As expected, forehand strokes produced higher ball speed than backhands;
3. Shoulder rotation was higher in closed stance strokes;
4. Open stance backhand shoulder rotation was especially limited achieving the lowest average scores, as expected;

Summarizing, although there is a clear movement reaction advantage in open stance strokes, closed stance seem produce more power probably associated accuracy mainly due more shoulder rotation and larger hitting zones in the direction of travel. Therefore closed stance is probably a best choice for pressure/winner forehand shots, especially combined with the necessity to step in.

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