KINEMATICS ANALYSIS OF THE LOWER EXTREMITY DURING THE TWO-HANDED BACKHAND GROUNDER STROKE AND DRIVE VOLLEY FOR TENNIS PLAYERS

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This study discussed the motion characteristics of the X-Factor and the role of stance positioning on backhand tennis swing in drive volley and ground stroke. Three elite female tennis players which are training more than 20 hours per week participated in this study. Motion Analysis System with 10 Eagle Digital inferred high speed cameras at 200Hz were used for this study. This study found that the pre-impact rotation mode did not have consistent pattern, but similar trend can be found between the strokes, with the square timing was close at the impact and more trunk rotations on ground stroke in the follow through In the pre-impact stance setting, the ground stroke will adopt a more closed stance, which may be helpful for the hip joint activity. It is suggested that future studies may increase the parameters of the hip joint to establish the reasons for this technical difference**.**

KEY WORDS: stroke, X-factor, stance.

INTRODUCTION: Drive volley is one of the most important scoring techniques for powerful tennis generation. Now, the drive volley was a common net approaching skill for top tennis players, especially femle (Antoun, 2007). Some of the causes from the cognition of domestic tennis coaches, they think that female players use drive volley techniques are higher than male players because their move speed general are slower than male . The top female tennis players in the world use this outstanding aggressive strategy up to 30.8% in the tennis serving term, especially in Venus Williams and Serena Williams even as high as 44.7% and 41.8% (Chen, 2010).

The speed of the swing is the force generated from the lower limbs with the ground, through the lower limbs along the pelvis, torso, upper limbs, racket and finally transmit power to the ball (Elliott, 2006). The past research discover the skilled players showed the high relation in the initial knee position and range of motion with the racket velocity. And the range of motion of hip and trunk was also influenced by the distribution of the body's center of mass (Nesbit, Serrano and Elzinga, 2008). Therefore, the stance setting of the stoke may have big influence to the hitting performance.

The trunk rotation contributes about 10% or more to the swing, and shoulder pre-stretching can advantage the Stretch-Short Cycle (SSC) to produce more moments (Bahamonde, 2003). The X-Factor which is often termed the interaction between the shoulder and hips. It was created by John Andrisani of Golf Magazine (McLean, 1992). Joyce, Burnett and Ball (2010) suggested that the X-factor can increase the speed of the ball when hitting the ball, but more X-factors also have the risk of waist pain.

Therefore, the purpose of this study is to investigate the impact of two-handed volleys and ground impact with the X-factor motion characteristics and the stance projection angle. To understand the hitting characteristics of the two technologies and the potential factors of injury.

METHODS: This pilot study was performed after approved by the Institutional Review Board of Fu Jen Catholic University. Three elite female Taiwanese tennis players who trained more than 20 hours per week participated in this experiment. The experiment was set up on a standard outdoor tennis court. Motion Analysis System with 10 Eagle Digital infrared high speed cameras at 200Hz were used (Motion Analysis Corporation, Santa Rosa, USA), and 48 reflective markers (14.5mm, 3 grams) were placed on each participant and the racket to capture the positions of body segmental joints during the stroke, as shown in Figure 1. The

ball was served from the tennis ball machine to the participants who were standing about 2.5m behind the serve line. The subjects had to hit down-the-line shot back to the target area of 2m x 3m. A global reference system was defined using standard convention with the positive X-axis in the intended direction of ball travel, and the positive Y-axis perpendicular to the intended direction of ball travel and also parallel to the net (positive direction to the right), and the positive z-axis pointing vertically.

Three successful two-handed backhand drive volley and ground stoke of each participants were selected and 0.2s before and after impact of the strokes were analyzed. The results are expressed as the average and standard deviation of three shots. The X-factor is obtained as the vector rotation angle between the shoulder and greater trochanter (GT), as shown in Figure 2. The stance angle is calculated from the projection angle of the vector between the center point of the two ankles and the baseline, as shown in Figure 3.

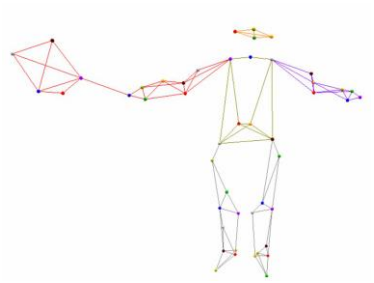

Figure 1: The reflective markers were placed on participant and racket.

Figure 2: The X-factor is the vector rotation angle between the shoulder and GT.

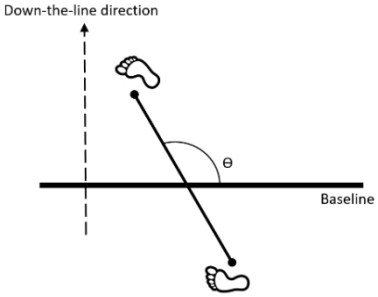

Figure 3: The stance angle is from the projection angle of the vector between the center point of the two ankles and the

RESULTS: Figure 4, 5, 6 show the X-factor angle of the shoulder and greater trochanter (GT) from 0.2 s before and after the impact of ground stroke and drive volley. The results showed a similar trend in the X-factor where the shoulder and GT start to square up around the impact both in ground stroke and drive volley. However, in the follow through phase (after impact), the shoulder starts to rotate and face the target, which starts to increase the angle between shoulder and GT in both ground stroke and drive volley.

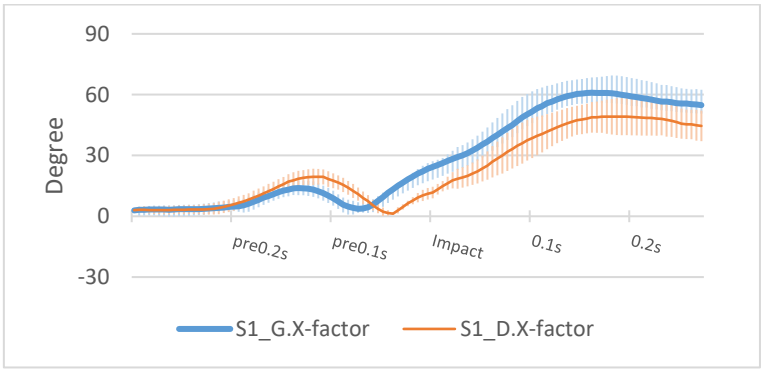

Figure 4: The X-factor of ground stroke and drive volley in subject 1.

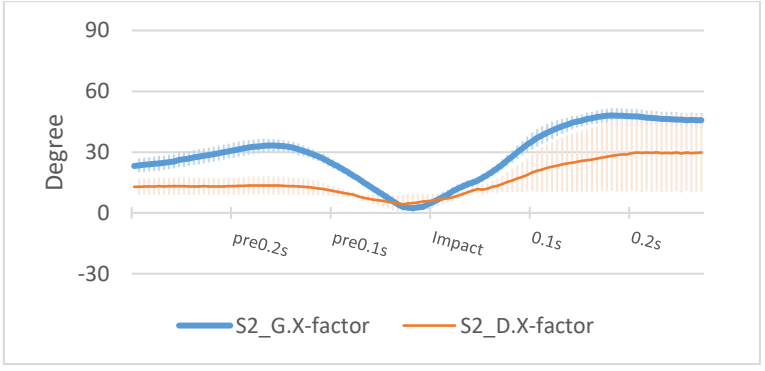

Figure 5: The X-factor of ground stroke and drive volley in subject 2.

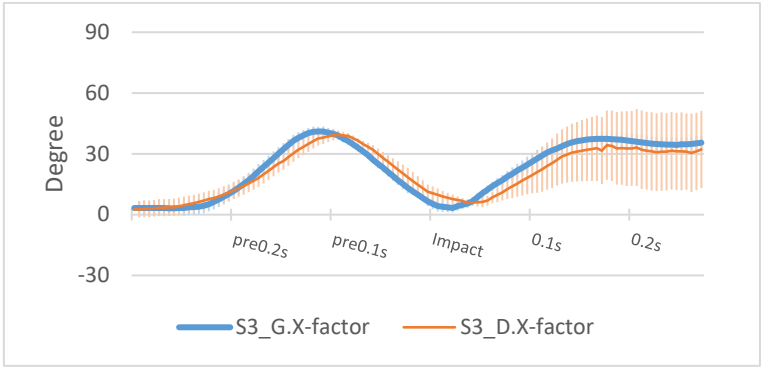

Figure 6: The X-factor of ground stroke and drive volley in subject 3.

Figures 7, 8, 9 show the stance angle of the projection angle of the vector between the center point of the two ankles and the baseline form 0.2 s before and after impact. The results showed that projector angle at stance in all participants showed the same trend where the angle of the ground stroke was greater than the drive volley during the stroke.

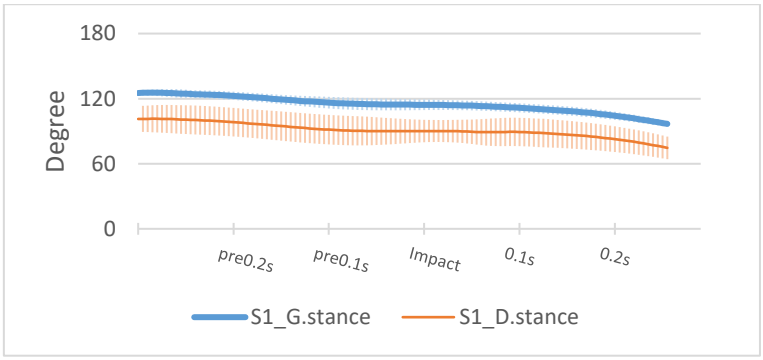

Figure 7: The stance angle of ground stroke and drive volley in subject 1.

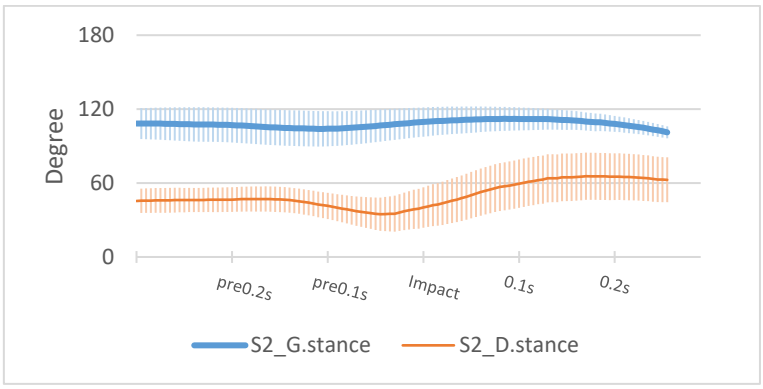

Figure 8: The stance angle of ground stroke and drive volley in subject 2.

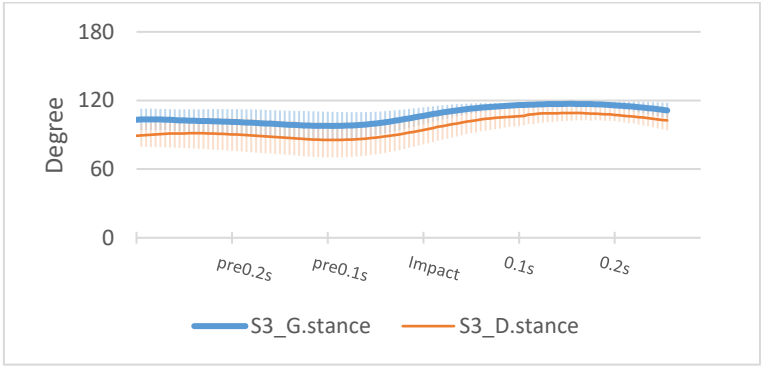

Figure 9: The stance angle of ground stroke and drive volley in subject 3.

DISCUSSION: The X-factor angle of the shoulder and greater trochanter GT in x-axis at 0.2 s before and after the impact between ground stroke and drive volley showed a similar trend, but the upper body rotation was greater than lower body after impact. The figure also shows the movement varied through different players in the square up timing between upper and lower body in these two technique. This indicates that each player may have different hitting strategies.

In Figure 3, the trunk rotation pattern of subject 1 shows the square up timing between shoulder and GT occurred before impact, and the square timing of ground stroke was earlier than drive volley. In Figure 4, subject 2 shows less upper body rotation angle through the stroke in drive volley technique. In Figure 5, subject 3 shows the very similar rotation movement between ground stroke and drive volley, the square up timing between upper and lower body occur just after the impact, and the square timing of ground stroke was a bit earlier than drive volley in follow through.

The results of greater angle of the stance at the setting was found in the ground stroke compared to the drive volley. It indicated that the setting position of the ground stroke is more likely to be a closer stance. The past study pointed out that the semi-open stance may support the rotation of the pelvic (Nesbit et al. 2008; Iino and Kojima, 2001).

CONCLUSION: This study found that the pre-impact rotation mode did not have a consistent pattern, but similar trends can be found between strokes, with the square timing close at the impact and more trunk rotations on the ground stroke in the follow through. In the pre-impact stance setting, the ground stroke will adopt a more closed stance, which may be helpful for the hip joint activity. It is suggested that future studies may increase the parameters of the hip joint to establish the reasons for this technical difference.

REFERENCES

Bahamonde R.E., Knudson D. (1998). Kinematic analysis of the open and square stance tennis forehand. *Journal of Science and Medicine in Sport,* 30(5), 5-29.

Bahamonde, R. (2003). Net work: Trunk biomechanics in tennis. *Biomechanics (Rockville, Md.),* 10(10), 20-22, 24-28.

Chen, Y. (2010). Research on the characteristics of technique and tactics of elite female tennis single player in China. *Sport forum*, 2 (8), pp.53-56.

Cole, M. H. and Grimshaw, P. N. (2009). The X-Factor and its relationship to golfing performance. *Journal of Quantitative Analysis in Sports,* 5(1) article 9.

Elliott, B. (2006). Biomechanics and tennis. *British Journal of Sports Medicine*, 40, 392-396.

Iino Y., Kojima T. (2001) Torque acting on the pelvis about its superior-inferior axis through the hip joints during a tennis forehand stroke. *Journal of Human Moment Studies,* 40, 269-290

Joyce, C., Burnett, A. and Ball, K. (2010). Methodological considerations for the 3D measurement of the X-Factor and lower trunk movement in golf. *Sports Biomechanics,* 9(3): 206–221.

Nesbit, S. M., Serrano, M., & Elzinga, M. (2008). The role of knee positioning and range-of-motion on the closed-stance forehand tennis swing. *Journal of Sports Science & Medicine,* 7(1), 114.

McLean, J. (1992). Widen the gap. *Golf Magazine*, pp. 49-53, December.

Acknowledgement: We would like to express the deepest gratitude to the National Taiwan Sports University Sports Biomechanics and Movement Diagnosis Laboratory and Tainan An Ding Tennis Academy.