KINEMATICS ANALYSIS OF THE UPPER EXTREMITY DURING THE TWO-HANDED BACKHAND DRIVE VOLLEY FOR FEMALE TENNIS PLAYERS

Mu-Lin Tai[1], Chun-Ju Yang[1], Kai-Lung Chang[1,2], Yi-Chun Lin[1], Wen-Tzu Tang[1]*
Graduate Institute of Athletics and Coaching Science, National Taiwan Sport University, Taiwan[1]
Physical Education Office, National Chengchi University, Taiwan[2]

The purpose of this study was to discuss the motion characteristics of the arms in the two-handed backhand drive volley. Five elite female tennis players participated in this study, their two-handed backhand drive volley strokes were analysed, and all participants are right handed. Motion Analysis System with 10 Eagle Digital inferred high speed cameras at 200Hz were used for this study. The results show a similar elbow and wrist speed strategy in x-axis between two-handed ground stroke and drive volley, our study also found that the rear arm dominates the stroke and mainly provide the topspin that is required for the skill of the drive volley. In order to create better stroke efficiency, the right elbow reached peak velocity first, followed by the right wrist before racket impact with the ball.

KEY WORDS: ground stroke, topspin, elbow, wrist.

INTRODUCTION: Due to the advancements in technology, tennis players can perform diversified skills with modern tennis rackets, therefore, by improving strong strokes tennis players can enhance their performance. Now, the drive volley is a common net approaching skill for top female tennis players (Antoun, 2007). In backhand top spin, most studies aimed at the motion analysis of baseline stroke for single hand or two-handed strokes (Stepien, Bober, & Zawadzki, 2011), but less in the two-handed drive volley in midcourt (Chiang, Hung, & Tang ,2009). Baseline top spin and midcourt top spin (i.e. drive volley) were different in the path and upward/downward direction of ball before impact, and individual performance of players varied. Elbow injuries account for a considerable proportion in tennis damage. The needs to endure the force from the lower limbs with the ground and the load, which can lead to high elbow forces at impact. Effective force transmission can increase the performance at impact and also reduce the chance of injury occurred. Therefore, the purpose of this study was to discuss the motion characteristics of both arms in the two-handed backhand drive volley.

METHODS: Five elite female tennis players participated in this study, the two-handed backhand drive volley stroke were analysed, and all participants are right handed and familiar with the drive volley skill (age 18.8±3.56 years; height 167.4±3.36 cm; weight 63.2±4.32 kg). Motion Analysis System with 10 Eagle Digital infrared high speed cameras at 200Hz were used (Motion Analysis Corporation, Santa Rosa, USA), and 25 reflective markers were placed on each participant and the racket to capture the velocity of elbow and wrist joint during the drive volley stroke. The experiment was set up on a standard outdoor tennis court, the ball was served from the tennis ball machine to the participants who were standing about 2.5m behind the serve line. The participant had to return the ball straight back to the target area of 2m x 3m with drive volley skill. 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.
All data were processed through Evart4.4 software and was smoothed with a Butterworth filter cut off frequency at 10Hz. One success hit of five with good capture quality and maxima ball speed was chosen and analysed for 0.3s before and after impact. The velocity in x-axis and z-axis of elbow and wrist of the leading arm and rear arm were both calculated. The relative velocity of elbow to wrist, leading arm to rear arm were also analysed.

RESULTS AND DISCUSSION: Figure 1 shows the velocity of the elbow and wrist in x-axis 0.3 second before and after the impact. All participants show the same trend with the timing of the peak velocity of the elbow and wrist through the stroke. The right elbow reached the peak velocity and followed by the right wrist, left wrist and left elbow. The right arm shows the traditional kinetic chain, in which the proximal joint reaches the peak velocity and is followed by the distal joint. But the left arm differed from the right arm kinetic chain, the left wrist reached the peak velocity first and is followed by the left elbow. It maybe because the left arm is mainly provides the topspin movement for the drive volley and the left wrist provides the rotation of the racket in x-axis first. When the elbow starts to increase the velocity in x-axis the wrist joint starts going to the direction of the y-axis. Figure 1 also shows that the peak velocity of the right arm occurs before the impact and the left arm occurs after the impact. It may also be due to the left arm mainly providing the topspin movement through the stroke. Stepien(2011) investigated the kinematics of one-handed and two-handed ground strokes. The results show the same result as only right arm had the kinetic sequence with the elbow reaching the peak velocity and followed by the right wrist, while the left side did not show the same kinetic chain. The study conclude that it might because the left extremity plays a role of a dominant extremity. Compared to our study, it shows the similar elbow and wrist speed strategy between the two-handed ground stroke and drive volley.

Figure 2 shows the velocity of the elbow and wrist in z-axis 0.3 second before and after the impact, compared to the velocity of the x-axis, the velocity in z-axis is about 2/3 smaller than the x-axis. In the vertical direction, the pattern has less consistency in the timing of the peak velocity between participants. However, with the peak velocity in the x and z-axis, the left wrist always shows the highest velocity, followed by the right wrist, left elbow and right elbow.

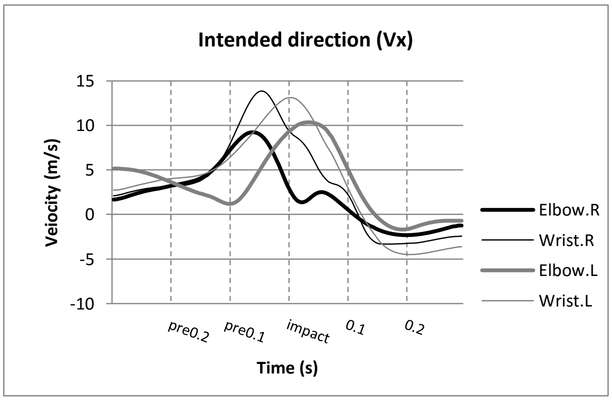

Figure 1: A typical pattern of elbow and wrist velocity in the vertical direction (x-axis) for both arms

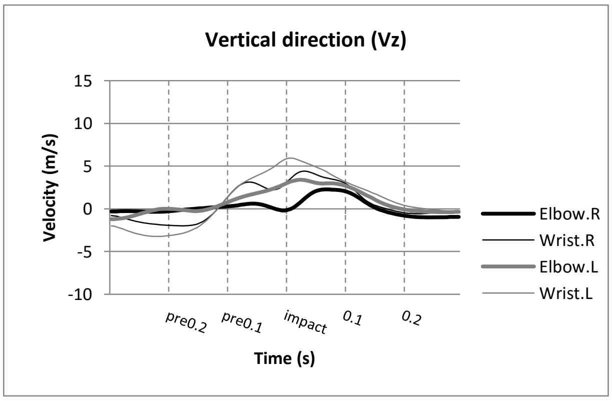

Figure 2: A typical pattern of elbow and wrist velocity in the vertical direction (z-axis) for both arms

Figure 3 and 4 show the relationship between elbow and wrist during the stroke. The figure shows that with both arms, at about 0.2 second before impact, the velocity between the elbow and wrist are very close. With the right arm, the velocity sequence transition from proximal to distal joint can be found on the right elbow and wrist. The wrist starts to increase the velocity about 0.1 second before impact and reaches the peak at the impact. But with the left arm, the wrist starts to decrese the velocity before the ball was striked. The left were reached the peak velocity before impact, and the wrist start to slow down in x-axis. The velocity of the left elbow speed up about 0.05 second before impact and until 0.1 seconds after impact. The reason that the elbow increase the velocity before impact may because the arm was doing the internal rotation for the topspin that is required for the skill of the drive volley, which turns the wrist in to the y-axis.

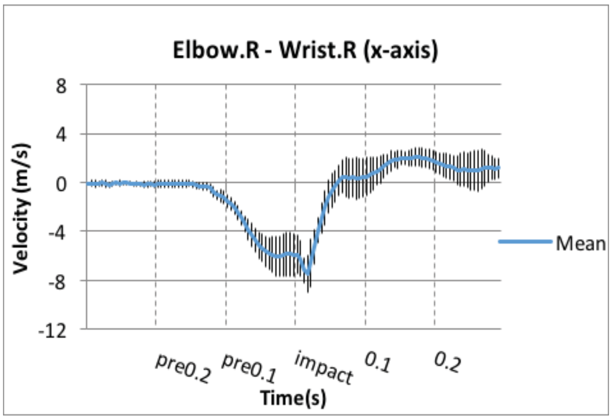

Figure 3: Average velocity pattern of the relationship between right elbow and wrist during the stroke (x-axis)

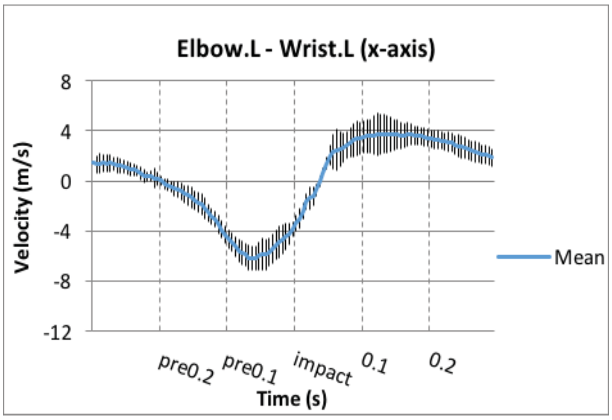

Figure 4: Average velocity pattern of relationship between left elbow and wrist during the stroke (x-axis)

Figure 5 and 6 shows the average pattern of the relationship of the elbow and wrist between arms. Both elbow and wrist shows a very similar pattern with the leading arm (right side) has higher speed at 0.1 second before the impact, and the transition from leading arm to rear side arm happened at about 0.1 second before the impact. After impact the leading arm dominate the swing again.

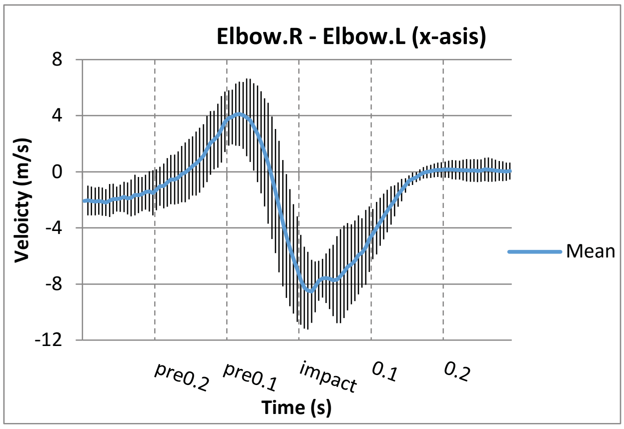

Figure 5: Average velocity pattern of the relationship between right and left elbow during the stroke (x-axis)

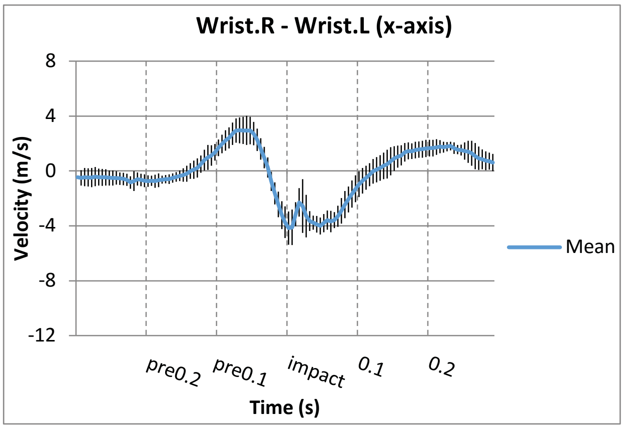

Figure 6: Average velocity pattern of relationship between right and left wrist during the stroke (x-axis)

When the ball was very close to being struck, the left side speeds up in order to create the topspin for drive volley technique. After impact the leading arm starts to speed up, possibly due to the subject being asked to hit down the line. Therefore, the right side switched back to taking control of the accuracy.

CONCLUSION: Through studying upper extremity movement of the drive volley, it shows the similar elbow and wrist speed strategy in x-axis between two-handed ground stroke and drive volley. Our study also found that the rear arm dominates the stroke and mainly provide the topspin that is required for the skill of the drive volley. In order to create better stroke efficiency, the leading arm uses the kinetic chain. The right elbow reached the peak speed first and was followed by the right wrist, reaching peak velocity at the time of impact.

REFERENCES

Antoun, R. (2007). Women's tennis tactics. *Champaign IL: Human Kinetics.*

Chiang, J.Y., Hung, T.Y., Tang, W.T. (2009). Kinematics tennis drive volleys of for muscle analysis. *2009 Asia Pacific International Symposium on Biomechanics cum Taiwan Society of Biomechanics*, 169-170.

Eygendaal, D., Rahussen, F. T., & Diercks, R. L. (2007). Biomechanics of the elbow joint in tennis players and relation to pathology. *Br J Sports Med, 41*(11), 820-823. doi:10.1136/bjsm.2007.038307

Stępień, A., Bober, T., & Zawadzki, J. (2011). The Kinematics of Trunk and Upper Extremities in One-Handed and Two-Handed Backhand Stroke. *Journal of Human Kinetics,* 30, 37-47.

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.
.