A4-5 ID12

EFFECTS OF ONE AND TWO HANDED TENNIS BACKHANDS HIT WITH VARIED POWER LEVELS ON TORSO ROTATION

Hsin-Chen Fanchiang[1], Alfred Finch[2], Gideon Ariel[3]

[1]Georgia State University, Atlanta, Georgia, USA
[2]Indiana State University, Terre Haute, Indiana, USA
[3]Ariel Dynamics, San Diego, California, USA

This study examined hitting one & two hand backhands with moderate and maximal power on the shoulder, hip, and trunk rotations during a tennis groundstroke by collegiate male and female tennis players. Video images from two views at 60 Hz were collected as players hit backhand strokes with a ball launched from a serving stand. Each subject hit 10 trials with moderate and maximal power using one & two hand backhands to a 2x2 m target area. Average ball velocities for stroke conditions were determined and 2 trials closest to the condition average velocity were analyzed with Ariel APAS. ANOVA on the shoulder rotations found significant hand and power factors, where maximal power and two hand backhands used more shoulder motion. The two hand backhand produced greater hip rotation and the female subjects used more trunk rotation with a two handed backhand.

KEYWORDS: tennis backhand technique, torso rotation

INTRODUCTION: Low back pain has been reported to occur in as many as 80 to 90% of tennis players (Pluim & Safran, 2004). This study investigated factors of the backhand groundstroke that may contribute to low back pain. It examined the effects of gender, striking technique, and power level on collegiate tennis players performing backhand strokes on resultant torso rotation. The down line backhand was reported by Elliott & Reid (2002) to produce the greatest amount of shoulder and hip rotation using one and two hand backhands. Therefore by investigating the range of motion of the body alignments utilized in hitting one & two hand backhand tennis strokes at different power levels this may provide insight into potential contributory factors of low back pain of male and female tennis players

METHODS: A total of 10 players, five each, from the Indiana State University Men's and Women's Tennis teams, volunteered to participate and gave informed consent. Each subject performed 10 tennis backhand strokes using either one or two hands, and hit an incoming launched ball with moderate or maximal hitting power from the ad court down the line to a 2 x 2 m area located in the back corner of the court. The subjects had 25 body/racquet data points marked and each stroke was recorded at 60 Hz with a 1/1500 s shutter speed using two Panasonic PV-GS65 video cameras. One camera provided a side view from 5 m away and the other camera provided a left rear view, which was a modification of the filming procedure reported by Elliott & Reid (2002). The ball was delivered using an inclined serving stand similar to the device used by Akutagawa & Kojima (2005) and shown in Figure 1.

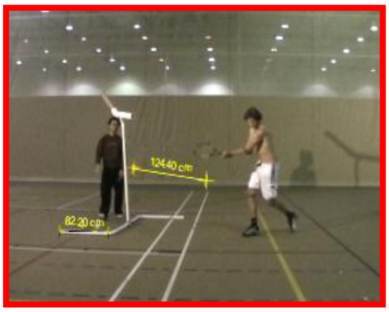

Figure 1: erving stand

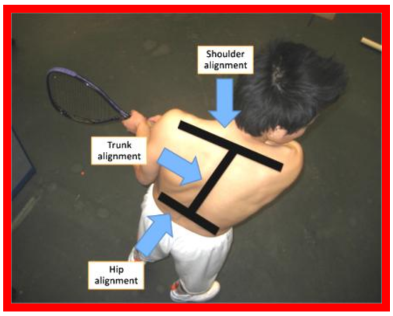

Figure 2: Initial body Alignments

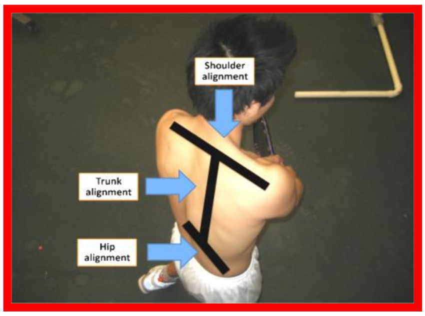

Figure 3: Ball Contact alignments

After five warm-up strokes, the subjects hit 10 backhand ground strokes of each striking technique, and each power level toward the target area. The average velocities for the moderate and maximal strokes were calculated and then the two trials closest to the average velocity for the stroke combination which landed into the target zone were selected. Each of the 10 subjects had at least eight attempts that landed in the target area analyzed and the selected two trials provided the 80 total trials used in the statistical analysis (2 hand conditions x 2 power levels x 2 trials). From the total of 400 trials, the "best average", 80 trials landing in the target zone were selected to be digitized using an Ariel APAS (2008), transformed using the 3D direct linear transformation (DLT), and smoothed using a 2nd order Butterworth digital filter with a smoothing cut-off of 10 Hz (Winter, 2009). The angular alignments of hip, shoulder and trunk rotations were determined at the initiation of forward swing and at ball contact as shown in Figures 2 and 3. Dependent variables of shoulder, hip, and trunk rotation were calculated and analyzed using a 2x2x2x2 ANOVA (gender, technique, power, & trials) with repeated measures on the technique, power and trial factors.

RESULTS: The mean age, height and weight of the subjects were 19.6 ± 0.3 yrs, 1.78 ± 12.0 m, and 73.3 ± 18.5 kg. The tennis players placed 186 out of 400 trials in the target zone which represented a placement accuracy of 46.5%. The male tennis players significantly hit one handed backhand strokes faster than the female players (p=.05), otherwise there were no differences for the other striking conditions. The players tried to strike the moderately stroked ball at approximately 75 to 80% of their maximal effort, and only two male players regularly used two handed backhands when playing and all subjects were right-handed.

Table 1 Average ball velocities expressed as m/s for stroking technique and power

Technique Power	**One handed Maximal** 2 trials each	**One handed Moderate** 2 trials each	**Two handed Maximal** 2 trials each	**Two handed Moderate** 2 trials each
Male (n=5)	31.2 ± 3.6	22.9 ± 2.8	32.3 ± 3.0	26.1 ± 5.0
Female (n=5)	25.5 ± 1.3	21.9 ± 1.5	28.8 ± 2.0	22.9 ± 2.4

The results for the amount of shoulder rotation about the vertical axis found significance for the hand technique (p<.001), power (p<.001), and an interaction of the power*gender factors which approached significance (p=.06). The mean shoulder rotations for the male and female players using one and two handed backhand with two power levels are presented in Table 2 and in Figure 4. A significant main effect for hand technique (p=.003) was found for the hip rotation variable. Subjects performing two hand backhand strokes exhibited a hip rotation of .89 rad and the one hand backhand needed only .50 rad of rotation and this is shown graphically in Figure 5. Post hoc t tests found significant differences in the shoulder and hip rotations for the one and two hand maximal strokes performed by the male players.

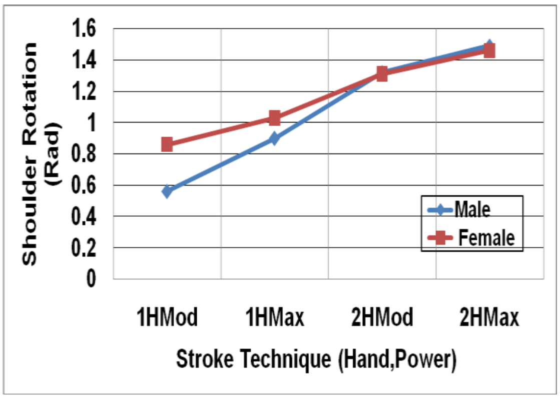

Figure 4: Shoulder rotation used hitting one handed & two backhand with power levels

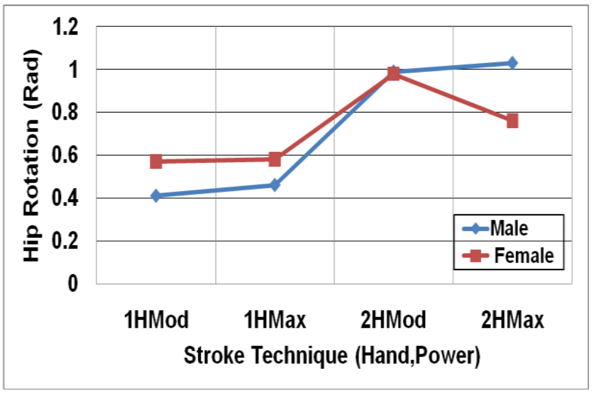

Figure 5: Hip rotation used hitting one & two handed backhand with power levels

Table 2 Body rotations for one & two hand tennis backhand at two power levels with trials factor collapsed

Rotation (Radians) *Males (5), Females (5)*	One H Max (M ± SD)	One H Mod (M ± SD)	Two H Max (M ± SD)	Two H Mod (M ± SD)
Shoulder Rotation Male	.90 ± .29	.56 ± .29	1.49 ± .22	1.32 ± .14
Female	1.03 ± .48	.86 ± .34	1.46 ± .23	1.31 ± .26
Sig. Hand tech. P<.001				
Power level p<.001				
Hip Rotation Male	.46 ± .40	.41 ± .40	1.03 ± .21	.99 ± .19
Female	.58 ± .43	.57 ± .38	.76 ± .26	.98 ± .18
Sig. Hand tech. p=.003				
Trunk Rotation Male	.45 ± .36	.23 ± .17	.48 ± .25	.33 ± .19
Female	.45 ± .17	.28 ± .12	.71 ± .09	.53 ± .23
Sig. Gender p=.010				
Power level p=.007				
Hand tech. p=.050				

The trunk rotation variable was found to have significant main effects for gender (p=.01), power (p=.007), and hand technique (p=.05) factors. There was a significant four way interaction (p=.049) between the technique, power level, trial, and gender factors. The mean trunk rotations for the male and female players using one and two handed backhand with two power levels are presented in Table 2 and graphically in Figure 6. A post hoc t test found significant differences for the trunk rotation when females performed one and two hand maximal strokes. The overall mean trunk rotations for the male and female players using one and two handed backhand with two power levels are presented in Table 2 and graphically in Figure 7. There were no significant main effects found for the trial factor for the shoulder, hip, or trunk rotation variables.

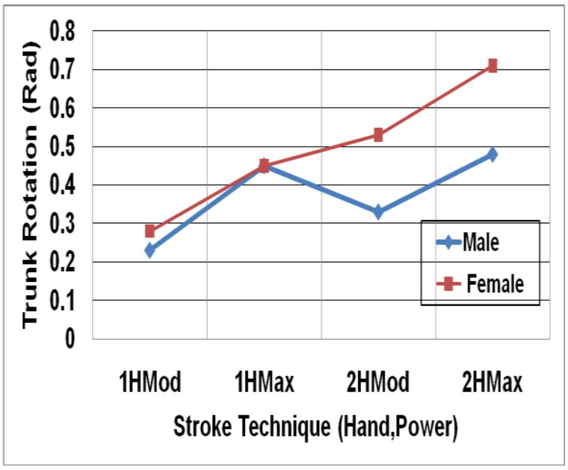

Figure 6: Trunk rotation used hitting one & two handed backhand with power levels

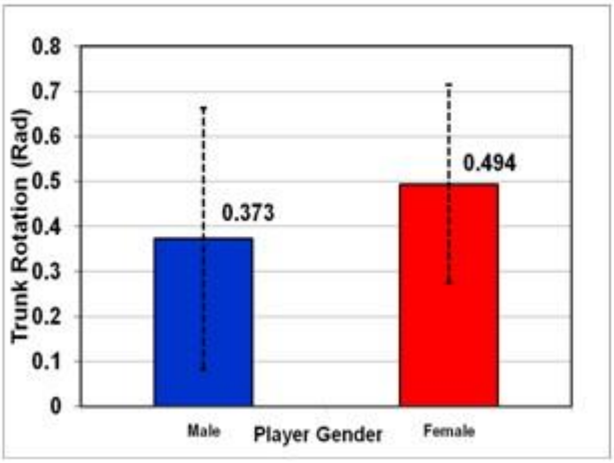

Figure 7: Trunk rotation used by male & female tennis players while hitting backhands

DISCUSSION: Although, statistically non-significant the female tennis players utilized about 10% more shoulder rotation than the male players in generating their racquet head velocity while using the same striking technique. The two handed backhand required a significant increase of 12% shoulder rotation which could have some implications on facet or lower back discomfort. The one hand backhand tended to leave the left arm to lag behind the trunk whereas the right arm in the two hand backhand provided the momentum of the stroke. This study reported results similar to a study by Elliott (1989) where it was found that shoulder rotation was a major contributor to racquet head velocity. Also, the present study found that 20% more shoulder rotation was used to hit with maximal power shown in Figure 4. The significant hand technique for the hip rotation variable might have been the result of different mechanics used in the two swing techniques. This finding was consistent with the results reported in a study by Akutagawa & Kojima (2005). In the two hand backhand, the left hand gripping the racquet facilitates the left shoulder and left hip to carry the momentum throughout the forward movement. Additionally, there was a significant ($p=.05$) interaction between technique and gender for the hip rotation variable. Males used less hip rotation than females in the one handed stroke but males used more hip action in the two handed stroke in order to generate the higher ball velocities when using the two hand backhand. This study found that the players utilized more trunk rotation when maximal power (.52 rad) was used instead of moderate power (.35 rad). Also, it was found that greater trunk rotation of .51 rad was utilized when the players used two hands for their backhand rather than one hand (.35 rad). Ranges of motion of this magnitude were reported by Toren (2001) to result in limited muscle involvement occurring when trunk rotation movement was in the range of .17-.26 rad either side from anatomical mid-sagittal plane (neutral position). It was suggested that, if trunk rotation movement approached the end of range of motion (ROM), it might load the structures (disks, joints, ligaments) which are more sensitive, cause discomfort or pain, and have the risk of spinal disorder.

CONCLUSIONS: Greater shoulder rotation occurred when subjects performed a two handed backhand, which in turn increased the trunk range of motion and may be a contributing factor in low back problems in tennis players. Also, when hitting with maximal power the players used more shoulder rotation to generate the racquet head velocity. Hip rotation was significantly increased when using two hands in the backhand. Female subjects had greater shoulder rotation but less hip rotation, thus producing more trunk rotation while the male players used the hips and shoulders to generate racquet head velocity which in turn created less trunk or torso rotation/torque. Both the male and female players utilized trunk rotation that exceeded the .17 to .26 rad ranges that were reported by Toren (2001) to be associated with potential vertebral facet impingement. All the female tennis players used a two hand backhand and when they hit for maximal power, the trunk rotation ranges increased up to .71 rad which would place them at an elevated risk of loading the spinal structures. The greater trunk rotation demonstrated by females could possibly place them at higher risk of low back injuries while using a two handed backhand, that increased the trunk rotation as compared to a one hand stroke, and the higher power level further increased the amount of trunk rotation.

REFERENCES:

Akutagawa, S., & Kojima, T. (2005). Trunk rotation torques through the hip joints during the one- and two-handed backhand tennis strokes. *Journal of Sports Sciences*, 23, 781-793.

Ariel, G. (2008). *Ariel Performance Analysis System (APAS with WIZARD & RENDERER}, motion analysis system, 2008 version*, Ariel Dynamics, Inc., San Diego, CA.

Elliott, B., Marsh, T., & Overheu, P. (1989). A biomechanical comparison of the multisegment and single unit tospin forehand drives in tennis. *International Journal of Sport Biomechanics*, 5, 350-364.

Pluim, B. M., & Safran, M. R. (2004). *A practical guide to optimal tennis health and performance.* California: Racquet Tech Publishing

Reid, M., & Elliott, B. (2002). The one- and two-handed backhands in tennis. *Sports Biomechanics,* 1, 47-68.

Toren, A. (2001). Muscle activity and range of motion during active trunk rotation in a sitting posture. *IPC science and Technology Press*, 583-591.

Winter, D. A. (2009). *Biomechanics and motor control of human movement*. 4nd ed., 65-78.