JOINT ANGLE PRODUCTION DURING SQUASH FOREHAND AND BACKHAND STROKE

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The paper discusses the production of joint angles at the upper limb joint of forehand and backhand strokes during contact phase. There are eight significant joint anatomical profiles that were investigated namely; trunk flexion, trunk lateral flexion, trunk rotation, shoulder adduction, shoulder rotation, elbow flexion, wrist flexion and wrist pronation.. A female intermediate squash player participated in this study and data were collected using a 250 Hz VICON MX motion analysis system. The results show that the extension of the elbow joint and pronation/supination of the wrist played important role in generating racquet head velocity during contact.

KEYWORDS: upper limb joint angle, forehand stroke, backhand stroke, squash.

INTRODUCTION: Squash is a moderate to high-intensity intermittent exercise. In squash, it will be of great interest to study the mechanics involved in all the movement of squash activities, particularly in identifying the key contributors to a powerful stroke. The forehand and backhand strokes are fundamental movements of squash. It is necessary for the player to develop an accurate and powerful stroke to achieve any degree of success in playing the game. The forehand stroke resembles a sidearm throw or a skimming the stone action where the forearm rotates. The backhand stroke resembles the throwing of a frisbee, where the forearm rotates, except control of the wrist movement which when swinging will control the racket head.

The sequencing of movements of the trunk, upper arm, forearm and hand segments have been described as key ingredients of high-velocity stroke production (Hunt, 1974; Elliott, Champion, & Morrison, 1984; Khan, 1992). 90% of the variance in post-impact ball speed has been shown to be accounted for by the angular velocity of the racket at impact (Chapman, 1986). The importance of forearm pronation and wrist flexion was further emphasized by Woo and Chapman (1991). There are very few studies that have assisted sports scientists in understanding the biomechanics of upper limb of squash strokes. Therefore, the objective of this study was to determine the joint angle production of forehand and backhand squash strokes during the contact phase.

METHODS: A female intermediate squash player participated in the study, using her own racquet. The player was required to perform three forehand and three backhand trials. She was told to perform the forehand and backhand stroke as if under match conditions. Only one trial from each stroke type was selected for analysis. Data was collected using a 250 Hz VICON MX motion system analysis which consisted of seven MX-F20 2 megapixel cameras. Thirty-nine markers were affixed to the player representing joints and segments of the body according to full-body VICON Plug-in gait model. Data collected were then analysed using VICON Nexus software. Variables analysed during forehand and backhand strokes were: trunk flexion, trunk lateral flexion, trunk rotation, shoulder adduction, shoulder rotation, elbow flexion, wrist flexion and wrist supination/pronation. All of these angles were measured during the contact phase of the forehand and backhand strokes. Ie. the racket was touching the ball.

RESULT AND DISCUSSION: Table 1 summarizes the anatomical joint angles obtained during the forehand and backhand strokes during contact. Figures 1 and 2 illustrate the forehand and backhand strokes respectively during the contact phase.

Table 1: The anatomical joint angles of forehand and backhand stroke at contact.

Joint Angle	Angle (rad)	
	Forehand	Backhand
Trunk flexion	0.399	0.145
Trunk lateral flexion	0.281	0.128
Trunk rotation	0.079	0.244
Shoulder adduction	0.327	0.332
Shoulder rotation	0.412	0.411
Elbow flexion	0.630	0.536
Wrist flexion	0.210	0.250
Wrist supination	2.629	2.892

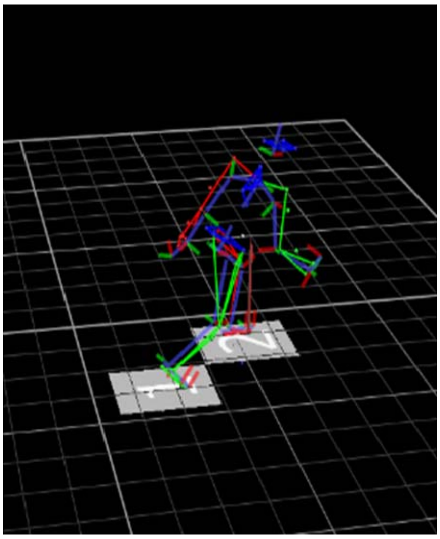

Figure 1: Forehand stroke.

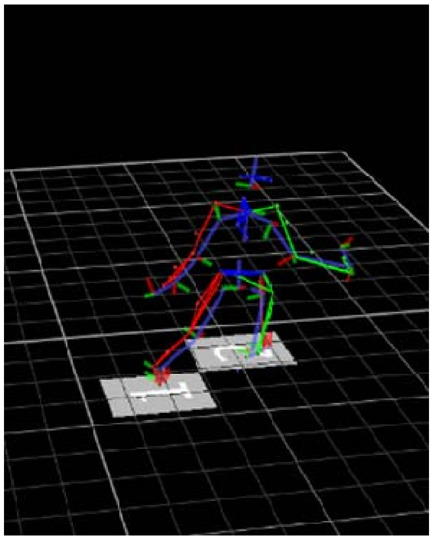

Figure 2: Backhand stroke.

During the contact phase, rapid forearm pronation and shoulder internal rotation accelerate the racquet. Longitudinal rotations about the trunk and upper arm segments, shoulder adduction and wrist flexion were the segmental movements that primarily contributed to racquet motion at contact. Forearm pronation was responsible for maintaining proper orientation of the racquet head at contact. Elbow and wrist adduction played important roles in maintaining the vertical position of the racquet head (Woo, 1993).

Through the value of the angles shown in Table 1 for both strokes, there are actually not many differences in the values of joint angle during contact phase. The angle of the trunk for both strokes are slightly decreased as the trunk straightened at the time of ball contact. The majority of the trunk movement was rotational movement which for the forehand stroke the trunk was continually rotated to the left while for the backhand stroke, the trunk was continually rotated to the right. The upper arm was continuously adducted horizontally and slightly rotated internally through contact phase for both strokes. This movement was accompanied by upper arm rotation which is outward rotation for the forehand stroke and inward rotation for the backhand stroke. The upper arm was continuously rotated until it reached the next phase which is the follow through phase. Rotation of the upper arm is important in this phase as it is one of the primary sources of racket speed for forehand and backhand overhead shot (Elliott, Marshall, & Noffal, 1996). The elbow joint rapidly extended as the upper arm reached its maximum rotation at an angle 0.63 rad for forehand and 0.536 for backhand. This is actually establishing the vertical height of the racquet head for the ball (Woo, 1993). The elbow was remained extended until right after ball contact. During contact, racquet head speed was at its maximum because of forearm pronation or supination (Elliott et al., 1996). At the wrist joint, the hand/racquet segment was slightly extended. During the forehand stroke, the wrist joint was supinated extensively while during the backhand stroke, the wrist joint was pronated extensively. During this phase, the wrist joint was slightly adducted to establish the vertical height of the racquet head in concert with the elbow angle (Woo, 1993).

CONCLUSION: Joint angles in forehand and backhand stroke play an important role in the success of the player. From the angles, the angular velocities and angular acceleration of the joint can be measured to determine the racquet head speed as well as post impact ball speed. During both strokes, the body should be moved in a well developed kinematic chain in order to generate the necessary power (Göktepe, Ak, Söğüt, Karabörk, & Korkusuz, 2009). Small changes in angle can cause the players to lose the game or lose points to their opponents. The result from the study showed that extension of the elbow joint and pronation/supination of the wrist played important roles in generating racquet head velocity during contact.

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