

MOMENTUM TRANSFER OF TRUNK AND UPPER EXTREMITY IN TENNIS BACKHAND STROKE

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INTRODUCTION

Backhand stroke is a frequently used tennis technique and the improper backhand is believed as a major factor leading to tennis elbow. The effective integration of the whole body segments as a kinetic chain transferring the momentum to the racket via the trunk and upper extremity is essential. The purposes of this study were to develop a kinetic chain model of the upper extremity in one-handed backhand stroke, and to analyze the momentum transfer from the trunk, upper extremity to racket in order to provide valuable information about the mechanisms of tennis backhand stroke.

METHODS

Six right-handed elite male tennis players (age: 26 ± 2.71 yrs, height: 175 ± 7.74 cm, body mass: 73 ± 7.25 kg) with many years tournaments experience were recruited in this study. The skill level of tennis players were rated as 5.5-6.0 according to the United States Tennis Association. The Expert Vision motion system with six cameras (Motion analysis Corp., Santa Rosa, CA, USA) was used to collect the tennis one-handed backhand motion at sampling rate of 60 Hz. Sixteen markers were attached on the selected anatomic landmarks unilaterally, and three attached on the racket to define the coordinate system of the trunk, upper arm, forearm, hand, and racket. Ten trials of backhand stroke were collected with a 3-minute rest between trials. Linear momentum (L) is the product of the segment mass (m) and velocity (v) in the gravitational segment centre of mass position. Angular momentum in the segment coordinate system (H') is defined as the product of the principal moment of inertia (I) and angular velocity in segment coordinate system (ω'). The calculation of three components of moment of inertia relative to the segment centre of mass was also adapted from the previous study [1]. The racket's moment of inertia about three orthogonal axes (longitudinal, frontal, and transverse) were computed using the pendulum method [2]. In order to obtain the segmental contribution of the upper extremity to backhand drive performance, we transferred linear and angular momentums from segmental coordinate system into the court coordinate system, in which the opposite of driving (leading) direction is X-axis, right hand side of the court as the Y-axis, and upward direction as Z-axis.

RESULTS AND DISCUSSION

The results showed the time periods of 0.40 seconds (0-24 frames) before impact and 0.27 seconds (25-40 frames) after the impact during the one-handed backhand stroke. Our results showed that the trunk has larger influence on linear momentum than angular one during the backhand stroke. Considering the resultant linear momentums of the backhand stroke, the trunk demonstrated the largest magnitude followed by the racket, forearm, upper arm, and hand. The largest trunk contribution

was supported by Field and Altchek [3]. The forward, leftward, and upward trunk movements were essential for generating the racket linear momentum and stabilization of the trunk is also considered to be very effective for the sequential transfer the high force and energy through trunk. However, the insufficient angular momentums of trunk and upper arm external rotation, the potential weak links in the kinetic chain, may predispose the forearm and hand segments to the increased loads (Figure 1). The players relied on the elbow joints to generate the racket velocity and might increase the loads as well as the potential injury to this region [4]. The hand segment had a small resultant angular momentum may suggest that the players keep the hand segment stably throughout the backhand stroke. The possible explanation may be that the skilled players maintained their wrist in a relatively fixed and extended position. The small magnitudes of linear and angular momentums in hand segment may indicate the hand keeps stably in extended position for the momentum transfer rather than power generation throughout the backhand for the prevention of tennis elbow.

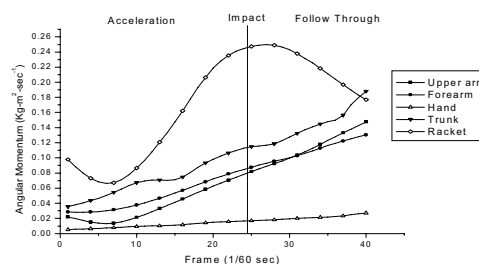


Figure 1: The resultant angular momentums of the segments.

CONCLUSIONS

The efficient kinetic chain of backhand stroke successfully transferred the momentum from proximal trunk to distal hand segments. The segment dropout or kinetic chain breakage decreases the ultimate force and energy available to the racket-ball, and puts abnormally large strains on the surrounding segments. The coaches and clinicians need to advise the tennis players to use the advantage of large trunk muscles and to improve the strength of shoulder rotator cuff muscles to generate the racket momentum for reducing the tennis-related injuries.

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