LOWER TRUNK KINEMATICS AND MUSCLE ACTIVITY DURING DIFFERENT TYPES OF TENNIS SERVES

John W. Chow, Soo-An Park, Mark D. Tillman and Guy B. Grover

Center for Exercise Science, University of Florida, Gainesville, FL, USA
E-mail: jchow@hhp.ufl.edu

INTRODUCTION

Lower back injuries are common among competitive tennis players. Players may be at a greater risk of lumbar disc pathology from rotational and hyperextension shearing effects (Hainline, 1995). Previous studies of the tennis serve have focused on the muscular activity and kinematics of the hitting arm and shoulder region. Limited data regarding lower trunk muscular activity and kinematics during the tennis serve are available (Chow et al., 2003).

The purpose of this study was to examine the relative motion of the middle and lower trunk and muscular activity of the lower trunk during 3 different types of tennis serves – flat, topspin, and slice – performed by skilled players.

METHODS

Twenty male tennis players were recruited as subjects (mean age 24 years, height 180 cm, weight 766 N) in two skill groups [Advanced Intermediate (AI) group: *N* = 9, NTRP rating 4.5-5.0; Advanced (AV) group: *N* = 11, NTRP rating ≥ 5.5]. Electromyographic (EMG) and kinematic data were collected separately in 2 sets of trials . Each set consisted of 7 trials for each of the 3 serve types. The order of the serve type was randomized for each set.

Surface EMG techniques were used to monitor the activity of 8 muscles on the left and right sides of the body: rectus abdominus (LRA, RRA), external and internal oblique (LEO, REO, LIO, RIO), and erector spinae (LES, RES). Maximum effort isometric trials were conducted for maximum EMG levels.

To obtain kinematic data, two reflective marker sets, each consisting of four markers in an inverted “T” pattern, were placed on the middle and lower back of the subject. Four gen-locked cameras (60 Hz) were used to record the serving motions. Marker locations were used for estimating the anatomical joint (AJ) angles (Vaughan et al., 1999) between the middle and lower trunk. Kinematic data were not available in 5 AV subjects.

For each subject, the 2 highest self-rated EMG and kinematic serves for each serve type were analyzed. The maximum AJ angles (expressed as the angular deviation from the AJ angle at the standing posture) for 4 trunk motions (extension, left lateral flexion, and left and right twisting) and the average EMG levels for each muscle during the four phases of a tennis serve (ascending and descending windup, acceleration, and follow-through phases) were determined.

For each muscle, the EMG parameters were compared using a 2 x 3 x 4 (Skill x Serve type x Phase) MANOVA with repeated measures on the last two factors. A 2 x 3 x 4 (Skill x Serve type x Trunk motion) ANOVA with repeated measures on the last two factors was performed on maximal AJ angles (alpha = .05).

RESULTS AND DISCUSSION

For most muscles tested, the largest average EMG levels were observed in either the descending windup or acceleration phases. When comparing overall muscle activation during a tennis serve between the two skill groups, the subjects in the AV group generally exhibited greater muscle activation than the subjects in the AI group.

The MANOVA revealed significant main effects for skill level in LRA (p = .008) and phases in all muscles (p < .001). The average EMG level of the AV group for LRA was significantly higher than that of the AI group. Two trends were observed – the AV group exhibited higher EMG levels than the AI group in the LEO (p = .055) and RES (p = .069).

The activation patterns clearly demonstrate a high degree of co-contraction during a tennis serve, especially in the descending windup and acceleration phases. In addition to the compressive load, the hyperextension and lateral flexion of the trunk during various phases of a tennis serve may cause shear loads on the lumbar spine.

The ANOVA revealed no significant main effects for serve type and skill level. However, significant differences between the two skill levels were found for the maximal AJ angles for extension (p = 0.018) and left lateral flexion (p = 0.038). The AV group had significantly smaller extension and greater left lateral flexion angles than the AI group (Table 1). It is possible that, instead of relying on lumbar hyperextension like the AI subjects did, the subjects in the AV group relied more on the hyperextension of the upper trunk (i.e., thoracic spine) to achieve the overall trunk hyperextension needed for an execution of a tennis serve.

The significantly greater maximal left lateral flexion AJ angle exhibited by the AV group indicates that highly-skilled right-handed players can reach for a greater height during a tennis serve because of the greater left lateral flexion. This result corresponds to the significantly greater LRA activity found in the AV group and implies that highly-skilled players are subjected to greater asymmetric loads on their lumbar spines due to the greater lateral flexion.

In conclusion, there was no significant variation in lower trunk motion and muscle activation among the three serve types and relatively large lumbar spinal loads are expected during the acceleration phase because of the hyperextension posture and profound front-back and bilateral co-activations in lower trunk muscles.

REFERENCES

Chow, J.W. et al. (2003). *J. Sci. Med. Sport*, **6**, 512-518.
Hainline, B. (1995). *Clin Sports Med*, **14**(1), 241-265.
Vaughan, C. et al. (1999). *Dynamics of Gait*.

ACKNOWLEDGEMENTS

United States Tennis Association (USTA).

Table 1. Means and (standard deviations) for different maximal AJ angles.

Serve Type	**Flat**		**Topspin**		**Slice**	
Motion \ Skill	**AV**	**AI**	**AV**	**AI**	**AV**	**AI**
Extension	19.3 (11.9)	27.5 (10.9)	19.3 (10.6)	31.9 (17.2)	20.0 (10.1)	26.9 (7.6)
Left Lat Flexion	16.0 (4.1)	12.3 (5.2)	15.5 (5.4)	10.9 (4.8)	15.4 (5.3)	12.4 (8.4)
Left Twisting	7.9 (4.3)	6.8 (3.8)	6.8 (4.1)	5.4 (0.9)	5.5 (3.8)	4.3 (3.1)
Right Twisting	5.6((4.5)	4.2 (1.8)	6.1 (6.9)	4.13 (0.6)	11.2 (12.7)	4.1 (3.1)