KINEMATICAL ANALYSIS OF FOREHAND STROKE TECHNIQUE OF EXCELLENT WOMEN'S TENNIS PLAYER SHARAPOVA

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Forehand stroke is one of the most important and basic tennis techniques, with the highest rate of utilization. Good forehand stroke technique may serve as a powerful offensive weapon for a player, it can have a profound impact on the tennis game result and lay a solid foundation for learning other tennis techniques. In virtue of three-dimensional photograph analytical method, this research presents a kinematical analysis on key links of forehand stroke technique by Maria Sharapova, the champion of women's singles in 2014 China Open, so as to obtain kinematical parameters of forehand stroke technique by the world excellent women's tennis player, reveal kinematics characteristics of forehand stroke technique and offer theoretical instructions to coaches and athletes for proper understanding and mastery of such a technique during training.

KEY WORDS: Tennis, Forehand stroke, Kinematical analysis.

INTRODUCTION: Tennis is a highly technical sport event. To some extent, forehand stroke technique is one of the most important tennis techniques and can be regarded as the very life of each tennis player. The power of forehand stroke lies in reasonability of technical actions and its outstanding and distinct technique style (Yanming et al., 2014). So it is of great importance for a tennis player to improve his or her technical actions; while reasonable actions must be subject to sports biomechanical principle of a stroke, which is a key factor determining the level of tennis forehand stroke. As a result, it is especially significant to take kinematical analyses on key links in forehand stroke technique of a tennis player (Huifang 2014). Accordingly, three-dimensional photograph analytic method in this paper is adopted to carry out a kinematical analysis of key links in forehand stroke technique of the world excellent women's tennis player Sharapova, in order to understand and master kinematical characteristics and parameters of her forehand stroke technique and provide theoretical bases for tennis players in improving their forehand stroke techniques.

METHODS: three-dimensional photograph analysis. 2014 China Open employed two made-in-Japan JVC9800 cameras (shooting frequency:50fpSat a constant speed) in the form of three-dimensional fixed point to shoot the entire forehand stroke of Sharapova from different angles，with No.1 camera right behind the side line of the tennis court, No.2 camera right in front of the base line, showing an included angle of about 95° between main optical axes of the two cameras. Both of the cameras were arranged in the right serve court of the athlete, where 24 control points were placed to demarcate the space in a three-dimension scale so that entire action of the athlete were kept within the frame. To ensure the reliability of analytic data and dotting accuracy of the frame during analysis, staff members moved horizontally or rotated the frame before formal shooting according to the locations of two cameras so as to reduce any unnecessary error due to overlapping of individual poles.

To facilitate the synchronization of camera starting points, the selected videos were cut at first by Boilsoft Video Cutter which was cutting software, and then imported into star high titanium 3-D Signal TEC V3.2HDC analysis system developed by Beijing Senmiaoxing Science and Technological Development Co., Ltd, so as to analyze the shot videos via such steps as spatial model, space demarcation, video analysis, calculation and so forth, with available original data processed smoothly by low-pass digital filtering method and cutting frequency up to 8Hz. When defining the synchronization point, the starting point was pushed 5 frames forward while the end point 5 frames backward in the premise that characteristic pictures had been determined in order to reduce the smooth filtering processing error.

RESULTS AND DISCUSSION: (1) Backswing: at the end of backswing, Sharapova made her left and right hip angles of 158.8° and 142.2° respectively, left and right knee angles of 149.8° and 135.7°, left and right shoulder angels of 43.3° and 106.6°, left and right elbow angles of 158.2° and 127.8°, and the angle between racket and her arm up to 116.9°. During the backswing, the speeds of her right shoulder, right elbow, right wrist joint, racket head and center of gravity were 0.53m/s, 1.65m/s, 2.04m/s, 8.98m/s and 1.12 m/s respectively.

Table 1
Analysis of Joint Angle Parameters of Sharapova at the End of Backswing

Name	Angle
Left hip angle	158.8°
Right hip angle	142.2°
Left knee angle	149.8°
Right knee angle	135.7°
Left shoulder angle	43.3°
Right shoulder angle	106.6°
Left elbow angle	158.2°
Right elbow angle	127.8°
Angle between racket and arm	116.9°
Angle between shoulder and hip	62.5°

analyses on kinematical parameters above show that: Sharapova made a comparatively sufficient body turning during backswing, in which main muscle group participating in the stroke stretched in advance. At the end of the backswing, both her hip joint and knee joint were flexed so that the center of body weight lowered (Jifang et al., 2013). Shoulder joint and elbow joint angles can reflect the extension state of racket and the arm relative to the trunk of an athlete at the end of backswing. Sharapova swung back the racket farther away from her trunk to lengthen the distance of body work and improve the effect of a stroke. Keeping arm joints at a certain speed, and the wrist joint and racket head at a faster speed at the end of backswing will benefit the generation of faster racket head speed at the moment of stroke (Jian 2009).

(2) Racket swinging at the ball: Sharapova made the horizontal shoulder-hip projected angle of 62.5°at the end of backswing and 16.1° at the moment of stroke, with a rotation

of 46.4° at the angle between shoulder and hip. It took 0.18s from the end of the backswing to the moment when the ball touched the racket. At the moment of touch, left and right knee joint angles were 155.4° and 161.5° respectively, left and right hip joint angles of 163.2° and 174.6°, right shoulder joint angle of 38.9°, right elbow joint angle of 142.1° and the angle between racket and the arm up to 132.3°. While, at the moment of stroke, the speeds of Sharapova's right shoulder, right elbow, right wrist, right hand joint and racket hand were 1.84m/s, 3.28m/s, 5.06m/s, 6.02m/s and 17.56 m/s respectively.

Table 2
Analysis of Joint Angle Parameters of Sharapova at the Moment of Touch

Name	Angle
Left hip angle	163.2°
Right hip angle	174.6°
Left knee angle	155.4°
Right knee angle	161.5°
Right shoulder angle	38.9°
Right elbow angle	142.1°
Angle between racket and arm	132.3°
Angle between shoulder and hip	16.1°

During swinging the racket at the tennis ball, a player should employ a full shoulder and hip turning and his or her lower legs should extend towards the ground forcefully, with shoulder joint as axis so that the swinging of the upper arm drives the lower arm which drives the wrist, namely the arm holding the racket delivers force successively (Wenlin et al., 2012). Kinematical parameters obtained from racket swinging at the tennis ball, Sharapova could make a full shoulder and hip turning and keep a certain center of body weight and reasonable shoulder & elbow joint angles, which would play an important role in giving a fast and powerful forehand stroke. Due to shorter time for swinging the racket at the ball, the right elbow joint angle increased gradually and the speed of joints of the arm holding the racket from near side to far side of her body had a gradual progressive increase, with racket head, hand and wrist joint speeds reaching the maximum. During the stroke, thereout, Sharapova moved smoothly at a heat. The inward turning of Sharapova's elbow joint drove the joggling of her wrist so as to generate more spins of the ball and improve the stability of stroke while she swung at the ball forward (Marchar et al., 2013).

(3) Follow-through: at the end of follow-through, Sharapova's speeds for her center of body weight (Vx, Vy and Vz) were 0.04 m/s, 0.36 m/s and 0.56m/s respectively, with her left and right shoulder angles of 43.1° and 112.8° as well as left and right elbow angles of 45.2° and 91.8°. A follow-through action is the continuity of a racket-swinging action and plays an important role in keeping integrity and consistency of a stroke, improving the stroke effect of the stroke and preventing any injury (Rogowski et al., 2011). Sharapova maintained her body balanced throughout the follow-through, with her trunk and all links at a good rotating speed and a satisfactory buffering effect. The change in shoulder and elbow joint angles indicated that Sharapova significantly lifted

her elbow and swung her arm forward during the follow-through to prolong the action time of the racket to the ball, resulting in a fast and powerful stroke with a fast spin .

CONCLUSION: In conclusion, forehand stroke technique of Sharapova in stages ranging from backswing, racket swinging at the racket to follow-through conforms to the theory of sports biomechanical principle. Actions, including shoulder turning and body inclining for prepareing a stroke and completing the stroke, are smooth and extended comparatively, with stroke technique being reasonable and normative. Her kinematical technical parameters at each stage are worth of learning by tennis coaches and athletes.

REFERENCES:

Sun Yanming & Chang Chunfang. (2014). Kinematical Analysis of Technical Characteristics of Forehand Topspin in Tennis. *Journal of Capital University of Physical Education and Sports*, 02, 189-192.

Wang Huifang. (2014). Kinematical Analysis of Forehand Topspin Technique of Male Athletes in ATP Chengdu Open, Chengdu Sport University,.

Wang Jifang, Zhou Jihe, Gao Zhanle & Li Yirong. (2013). Kinematical Analysis of Forehand Topspin Action of Thomas Enqvist [A]. Sports Biomechanics Branch of China Sport Science Society. Thesis Collection for the 16th National Academical Communication Conference of Biomechanics in Sports (CABS 2013) [C]. Sports Biomechanics Branch of China Sport Science Society.

Guo Jian. (2009). Biomechanical Analysis and Evaluation of Forehand Stroke Technique. *Bulletin of Sport Science & Technology*, 12, 53-55.

Hu Wenlin, Zhou Jihe & Cheng Liang. (2012). Kinematical Analysis of Forehand Receiving Technique of Moya [A], Sports Biomechanics Branch of China Sport Science Society; Collection of Abstracts of the 15th National Academical Communication Conference of Biomechanics in Sports (CABS2012) [C], Sports Biomechanics Branch of China Sport Science Society.

Reid Machar, Elliott Bruce & Crespo Miguel. (2013). Mechanics and Learning Practices Associated with the Tennis Forehand: A Review. *Journal of sports science & medicine*, 122.

Rogowski Isabelle, Rouffet David, Lambalot Frederic, Brosseau Olivier, & Hautier Christophe. (2011). Trunk and upper limb muscle activation during flat and topspin forehand drives in young tennis players. *Journal of Applied Biomechanics*, 271.