KINEMATIC ANALYSIS ON SERVE TECHNIQUE OF WORLD'S ELITE FEMALE TENNIS PLAYER

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The purpose of this study was to obtain the kinematic parameters on serve technique of WTA (Women's Tennis Association) top two Serena Williams and Simona Halep. The study selected WTA top two players' first serve in 2014 China Open, which was held in Beijing, China. This paper makes analysis on serve technique between two elite players through the method of three-dimensional video analysis. The kinematic technical feature has been obtained through this study, resulting in not only providing referential statistics for the technical training of the players, but also enriching the technical theory of tennis.

KEY WORDS: toss, backswing, hitting, whiplash movement.

INTRODUCTION: In recent years the speed of the serve has increased considerably. For instance, the fastest serve speed of professional female players is 211km/h. Serve is the main mean of scoring to win the match, especially the first serve, which is an offensive weapon. The quality of the first serve indeed directly influences the set of serves for player and high quality first serves make difficult for opponent from the start. Therefore, it is the start of the game and the start of attack. A large number of documents shows that the statistics collected about kinematic research of first serve is mostly focused on training professional and amateur athletes. Besides, it is rare to collect data of world's elite tennis players by the application of 3D video analysis. Owing to the widespread application of first serve in tennis matches, this paper will explore WTA (Women's Tennis Association) top two players' serve technique by 3D video in 2014 China Open.The purpose of this study was to obtain the kinematic parameters on serve technique of world's elite female tennis players.

METHODS: *Three-dimensional video analytic method:* We use two JVC9800 cameras to record research objects serve technique in the game of 2014 China Open. The camera has a length of 1.25m, and their main axis angle is about 95°. One of them is located about 20m behind the player to the right. Another is placed in front of her about 20m to the right. 3D Signal TEC V1.0C software has been adopted for the analysis of the video recorded, and the study uses the 3D Signal TEC V1.0C software to analysis frame by frame. The Dempster's human model is used (21 joints, 16 links).The original data are smoothed by a low pass filter, which the cut off frequency is 8 Hz. Meanwhile, the process will be studied one motion after another with the purpose of obtaining reliable statistics. Furthermore, in order to satisfy the need of this research, three measuring points are added which cover the top of racket, the tennis and the projected angle of shoulder and hip.

RESULTS AND DISCUSSION: According to the technical characteristics of the tennis serve action, the paper divided the serve process into three stages: the tossing stage, the backward swing stage and swinging forward swing stage. Williams and Halep are using step up stance when serve, it can let player obtain a larger upward force from the ground. It is found that the higher the hitting point, the higher the successful rate. Through analyzing the important technology link of tossing, the average heights of the ball away hand of Williams and Halep are 1.70m and 1.58m respectively. Due to the player's height difference, the height of the ball away hand will be different. Relative researches showed that it is reasonable to throw the ball from head. The average height of tossing of Williams and Halep are 3.12m and 3.53m respectively. At the end of the first stage of tossing, Williams' left knee average angle is +108°and the right is +114°, Halep's left knee average angle is +113°and the right is +120°. The knees keep bending in a certain degree when serve, it will produce

linear momentum by bending to stretch up of knee, then transferred the ground reaction force to the trunk. The average angle between shoulder and hip of Williams is +32°and Halep is +37°, their trunk with a great range of rotating, therefore, it can save more energy for hitting (Cristina & Enrique, 2009). Williams and Halep's right elbow bend degree is reasonable at the end of this stage. Williams' right elbow average angle is +87°and Halep is +90°.In backward swing stage, Williams' left knee average angle is +175° and the right is +173° at the end of this stage, Halep's left knee average angle is +177° and the right is +176° at the end of this stage.Williams' stretch range of left and right knee is +68° and 59° respectively, Halep's stretch range of left and right knee is +64° and 56° respectively. We found that it is considered that players' stretch range of knee should increase moderately, through rapid extending of lower limbs to obtain more energy (Duane, 2006). Athletes keep larger right shoulder joint angle at the end of backward swing stage, it can increase the working distance (Williams & Schmidt, 2006). Williams' right shoulder average angle is +82° at the end of this stage and Halep' s right shoulder average angle is +76°.The research shows that reasonable elbow flexion can have good effect to final acceleration. At the end of backward swing stage, Williams and Halep's right elbow average angle is +61°and 67°respectively. In swinging forward swing stage, the average hitting height of Williams and Halep are 2.61m and 2.55m respectively. The hitting height is 1.49 times to Williams' height and Halep is 1.52 times to her height.Relative researches showed that world's elite tennis players' hitting height is 1.50 times to their height. By analysing the difference from the highest point of ball to the hitting point, Williams' difference is 0.46m and Halep is 0.91m. In contrast, Williams' difference is 0.45m smaller than Halep, small difference is beneficial to players' judgment, in order to insure the success of serve and reduce mistakes. Because serve is a typical whiplash movement, therefore the maximum speed of body segments are present from lower to upper limbs in turn in the stage of swinging forward swing. The calculation results show that, while hitting the ball, the average speed of Williams' right shoulder joint is 2.56m/s, the right elbow joint is 3.68m/s, the right wrist joint 6.40m/s and the head of racket is 22.30m/s. The average speed of Halep's right shoulder joint is 2.39m/s, the right elbow joint is 3.49m/s, the right wrist joint 5.60m/s and the head of racket is 20.60m/s.

CONCLUSION: The paper shows that serve is a typical whiplash movement. Through the analysis and discussion of Williams and Halep's serve, we found that the kinematic parameters have reference value.Williams and Halep's main indications are as follow:
(1) In contrast, Williams has high stability in tossing. With a good tossing, player can make the ball has stable movement route. Moreover, it will make sufficient preparation for hitting. In addition, two elite players' trunk with a great range of rotating when backswing, it can save more energy for hitting.
(2) In back forward swing stage, the data showed that two elite players' left and right knee stretching in large range, through rapid extending of lower limbs to obtain more energy. At the end of back forward swing stage, two elite players' right shoulder keep a large angle, it can let players have a larger range movement and form a good initial state for next action. In swinging forward swing stage, two elite players have higher hitting height. The higher hitting height, the higher success rate of serve.Williams' difference from the highest point of ball to the hitting point only 0.46m,small difference is beneficial to players' judgment, in order to insure the success of serve and reduce mistakes. Through the speed of two elite players' body segments in swinging forward swing stage, we found that the speed of shoulder, elbow, wrist and the head of racket are increase gradually, it is accord with the technical principles of whiplash movement.

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