

A KINEMATIC ANALYSIS OF A TOP 10 WTA TENNIS PLAYER'S FIRST SERVE

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The purpose of this study was to provide valuable information of the tennis serve, through a three-dimensional (3D) cinematographic analysis of Li Na's flat serve. Two high-speed cameras operating at 200Hz placed around the baseline recorded her flat service motion. The direct linear transformation (DLT) method was used. The ball was hit at a distance of 1.11 m below a peak ball toss height of 3.65 m. In backswing, the minimum knee flexion angle was about 110°. The lowest point recorded by the racket head was about 0.21 m lower than the height of the body center of gravity during the early drive phase. The velocity of the racket head was 38.2 m/s at impact and the height of the impact point was 2.5 m which was 1.48 times the height of her body. Like other elite tennis players in the world, Li Na has her own tennis strokes and swing style.

KEY WORDS: flat serve, DLT method, three-dimensional analysis, Chinese player.

INTRODUCTION: The serve, a closed skill which players have total control over, may be the most important shot in tennis. However, it is also a difficult stroke to master. Not only do the arms prescribe different movement patterns and rhythms, but they must coordinate with the movement of the lower limbs and the trunk. Because of its importance and complexity, the tennis serve becomes a closely watched issue, especially the flat serve which is the fastest of all the service types and is also probably the most intimidating and fearsome weapon a player can have. Many kinematic studies of tennis serving have been done, focusing on the upper-limb movements (Elliott, Marsh, & Blanksby, 1986; Elliott, Fleisig, Nicholls, & Escamilla, 2003b; Reid, Elliott, & Alderson, 2007), or the patterns of the lower-limb (Elliott & Wood, 1983; Girard, Micallef, & Millet, 2005), or the function of trunk (Chow, Shim, & Lim, 2003; Chow, Park, & Tillman, 2009). However, there are few studies on tennis serve of the world-class players. Li Na, the first Chinese player to win a Grand Slam event and reach the WTA top 10, was the subject in this research. This study described selected kinematic variables of the first serve of a top 10 WTA tennis professional and provided both the players and coaches with a better understanding of the flat serve.

METHODS: Li Na was filmed using a two-camera, 3D direct linear transformation (DLT) set-up. Two high-speed cameras were placed around the baseline and used to record the calibration frame, which was necessary for calculating 3D coordinate data using DLT method (Figure 1). After an adequate warm-up, Li Na performed three flat serves as fast as she could from the right service court, while serving motion was recorded by the two cameras operating at 200 Hz. According to the estimates by a coach of Chinese national tennis team, the best serve was selected for analysis. Data were processed using the Shi Xun Analysis System (Beijing Sport University, China). A 16-segment biomechanical human model proposed by Zatsiorsky was used to capture movement data. The 3D coordinates were filtered through a Butterworth digital filter at a cut-off frequency of about 15 Hz. Linear velocities of joints, linear velocity of ball, joint angles and so on were then calculated.

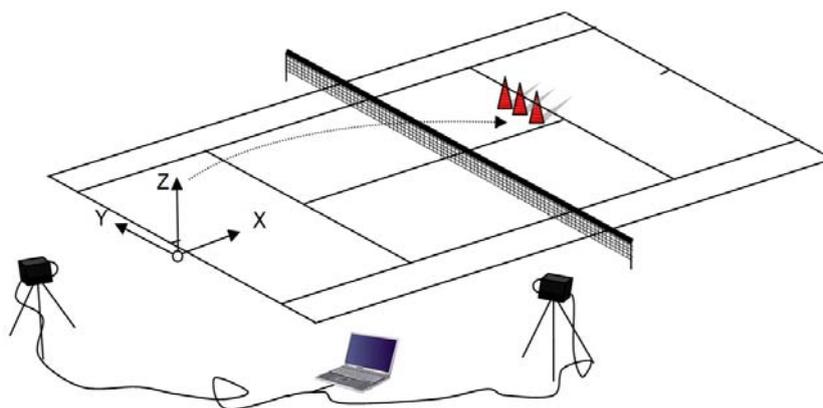


Figure 1: The experimental set-up.

RESULTS: Li Na using a foot-back (FB) technique (Figure 2) propelled the ball from the hand with an upward initial velocity of 6.2 m/s, 0.3 m/s in the fore-and-aft direction and 0.2 m/s in the right-to-left direction. The ball was hit at a distance of 1.11m below a peak ball toss height of 3.65 m. During the backswing phase, the minimum left and right knee flexion angles were 110° and 109° respectively. The lowest point of racket head was about 0.2 m lower than the height of the body center of gravity during the forward drive to the ball. The velocity of the racket head was 38.28 m/s at impact and the velocity of the ball was 42.6 m/s after impact. The height of the impact point was 2.5 m which was 1.48 times the height of her body. During the forwardswing, the trunk leaned forward about 29° to the vertical.



Figure 2: Beginning of lower limb extension.

DISCUSSION: Li Na used the FB technique which was reported by Elliott and Wood (1983) to produce a larger horizontal ground reaction forces while the foot-up technique was characterized by bigger vertical ground forces. Thus, each has their own advantages. Li Na tossed the ball 'under control' as it moved only marginally in the right-to-left direction. However, the peak ball toss height was a larger than impact height, which led the ball dropping at impact. This might affect the accuracy of the stroke, while research has shown it aids the ability to hit the 'flat' serve with some forward rotation. During the backswing, Li Na's lower limbs flexed sufficiently. The approximate 110° of flexion in both legs will allow a good leg drive (Elliott, Reid, & Crespo, 2003a). At the end of backswing, Li Na shifted her hips sideways towards the net. This position may have 'unbalanced' her, reducing her ability to push off the ground. During the forwardswing, Li Na didn't lean forward enough. The trunk

flexing forward is needed to develop angular momentum (reference). Since forwardswing starts with the stretching coxa, and trunk is the transportation hub of movement chain. We suggest her to take more core strength training, such as abdominal and abdominal oblique exercises. These data provide valuable information of performance characteristics of an elite player. However, we can not decide whether or not Li Na's technique is the best, unless more biomechanical details are examined and compared with between the top players, particularly when body anthropometry is taken into account. In addition, because of the limitation of testing outdoor, we only got the kinematic data which was not enough for understanding the cause of any movement. Therefore, further studies are needed.

CONCLUSION: In this study, we examined kinematics of Li Na's flat serve including the velocity of the racket head at ball impact. Like other elite tennis players in the world, Li Na has her own tennis strokes and swing style.

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