Kinematical Analysis on Karen Khachanov’s Tennis Serve Technology

Qi Lin Qin and Ji He Zhou

Abstract: Kinematical analysis was made on the 2016 ATP250 Chengdu Tennis Open men's single’s champion, Karen Khachanov’s serve technology. Using the three-dimensional video analysis method to analyze Karen Khachanov’s serve technology, then relevant kinematic parameters was got, thus can provide some data reference for coaches and athletes to improve serve technology. During the throw the ball to take the stage, Karen tossed high quality ball, with large range of truncus twist and relatively fully lateral stretch of the upper truncus muscle; during the back swing stage, Karen’s holding arm was fully flexed the shoulder and elbow, and the fully flexed shoulder can help to serve with force; during the swing the batting stage forward, Karen’s holding arm and truncus were fully stretched, and the force order was in line with whipping action technology principle, from the proximal joint to the distal joint, thus the speed was increasing in order. Analysis and comparison find out that Karen Khachanov’s serve technology was normative and reasonable and it is worthy of imitating for tennis players.

Keywords: Karen Khachanov, tennis serve, three-dimensional video analysis method, kinematics

1 INTRODUCTION

During the tennis competition, the only non-opponent-influential technology, entirely the athletes initiative attacking the other, is the serve technology. From the current development trend of tennis all over the world, it has gradually become the main means of scoring. Serve is the beginning of every point, and a good serve can not only be a directly score, but also can control the opponent to get the best of the tactical intentions.

This paper mainly uses the three-dimensional video analysis method to make kinematical analysis on the 2016 ATP250 Chengdu Tennis Open men’s singles’ champion Karen Khachanov’s serve actions, and kinematic parameters of the service technology are obtained to provide technical reference.

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2 RESEARCH OBJECT AND METHODS

2.1 Research Object
The Russian excellent tennis player, Karen Khachanov, was born in Moscow in May 1996; with his height 198cm, weight 88kg; right hand shooting; the 2016 ATP250 Chengdu Tennis Open men's singles’ champion, ranking 51 in ATP singles.

2.2 Research Methods
Three-dimensional video analysis method: On the 2016 ATP250 Chengdu station scene, two JVC GC-PX10AC high-speed camera was hired to shoot three-dimensional video of Karen Khachanov’s serve action, with 50 frames / sec speed. One camera was set diagonally behind the base line and the other set in diagonally front of the side line, with the angle of optical axis of about 90°. The being chosen technical action is the successfully first serve with the speed of 199km / s.

3-D Signal TEC V3.2HDC parsing software was used to analyze Karen Khachanov’s serve action, and the European dempster human model (16 links, 21 joints) was chosen. Due to the research needs, the head of the racket and tennis were added as two test points for analysis. The resulting datas were smoothed with low-pass digital filtering with a cutoff frequency of 8 Hz.

3 RESULTS AND ANALYSIS

3.1 Action Stage Division
Karen use foot-up stance technology while serving, which means at the end of Karen’s right holding racket arm raising racket stage, his right foot took a step forward. And actually in this process, Karen’s right foot moves forward along with his body moving forward in the serve process, to get close to the left foot. After tossing the ball and raising the racket, when the body posture nearly in a “trophy” shape, the rear foot also completed the step forward action, standing beside the front foot.

In order to analyze the action of Karen’s serve, this paper divided the action into three stages, with four moments. The four moments were following: T1: the ball from the moment, T2: left knee bend maximum moment, T3: head in the back of the lowest point, T4: racket touch the ball at all times. (T1-T2), backward swing stage (T2-T3), swing the batting stage (T3-T4) forward.

The throwing stage (T1-T2): the ball from the hand to the left knee bend maximum moment

Backward Swing Stage (T2-T3): Left knee bend maximum moment to the beat at the lowest point behind

Swipe the ball before the stage (T3-T4): the head in the back of the lowest point to the time when the ball into the ball

3.2 Results and Analysis

3.2.1 Throw the Ball to Take the Stage
The stage of the throwing stage, that is, from the moment of the ball from the moment of the left hand to the left knee bend, the purpose of this stage is that
the player's player can throw the ball into his right and stable batting position and the complete shot action, where the athletes have the appropriate height of the shot, the appropriate speed of the hand and the arm of the full extension of the arm and the full extension of the lower limbs in order to facilitate the next phase of the smooth progress. The throwing stage mainly analyzes and discusses this stage from the point of time, the angle of the elbow, the height of the hand, the speed of the hand and the angle of the knee at the time of T2. At this stage of the higher throws off the hands of the height of the hand to control the distance of the ball longer, you can strengthen the control of the ball on the ball, so that the ball is relatively stable line. The height of the ball is too low, on the one hand is not conducive to the acceleration of the ball, on the other hand is not conducive to control the ball after the direction of movement [1]. T1 time, Karen's left shoulder angle of 120.3°, left elbow angle of 169.7°, indicating that the shoulder, elbow extension is more fully, lengthened the ball from the hands of the height of the hand, help hand to control the distance of the ball, so that The world's high level of tennis players shot about 5.0-6.0m / s, at the moment Karen's shot speed of 5.8 m / s, with the previous study is more close; some scholars to study the ball when the ball off hand Height average of 0.92 times the height of [2], at the moment Karen's shot height of 1.869m, with its height ratio of 0.944, shot height is more reasonable. Studies have shown that: excellent professional players in the center of gravity to the lowest point when holding the knee side of the knee angle of about 100° [3], T2 time Karen's knee angle were 89.2°, 92.5°, compared with its research Close to. This stage of the ball thrown to the highest point of the height of 3.404m, indicating that Karen knee joint bend larger, high height of the ball, knee bend for the action as well as the next stage of the fast pedal to do a good job fully prepare. At this stage, Karen's hip and hip projection angle of 40.2°, indicating that Karen's torso twist a larger range, the upper trunk muscle lateral stretch is more adequate for the direction of the swing to increase the elastic potential energy.

3.2.2 Backward Swing Stage
Backward swing stage, that is, the left knee bend maximum moment to the head in the back of the moment after the stage. The purpose of this stage is to make the athlete to make full lower limbs pedal stretch, and convergence on the trunk and holding the arm to do back to shoot, so that the shoulder arm muscles and abdominal muscles fully stretched, back arch posture, with its Before the swing stage to form a complete "scratch back" action for the forward swing stage to increase the work distance. T3 time Karen's left knee angle is 137.5°, the left ankle angle is 100.0°, the left hip angle is 167.8°, compared with the T2 angle of the left knee bend angle, the pedal extension amplitude of 48.3°, indicating that the lower limb has Full of pedal and hip extension, to improve the height of the center of gravity, there is sufficient time to do back bow posture, is conducive to high hit the ball, increase the attack range of the batting; have to study the lowest point of the height and the height of the center of gravity is reflected Athletes scratching the action in the trunk and holding the shoulder of the muscle stretch of the important basis [4]. At the moment the right shoulder angle of 132.8°, the right elbow angle of
58.0°, the right wrist angle of 147.3°, the height of the center of gravity of 1.312 m, back to the back of the lowest point of the head position height of 1.269, the lowest point of the head is lower than the body center of gravity Height 0.043m, indicating that its holding the arm full flexor elbow, the shoulder has been fully stretched, access to a certain degree of elastic potential, for the swing shot a lot of energy reserves, easy to serve.

3.2.3 Forward Swing the Batting Stage
Forward swing the batting stage, that is, the head in the back of the moment until the time when the ball into the ball at the moment. The purpose of this stage is to make a larger swing speed, the lower limbs of the line can be effectively converted into the hip joint angular momentum, and then combined with the upper limb reasonable whipping action, do an effective shot. The study shows that the use of FU skills of the athletes hit the height of the average height of 1.43 times the use of FB technology hit the height of the average height of 1.38 times [2], the study of the use of FU technology players hit the height of the height of the average height 1.52 times, using FB technology hit the height of the average height of 1.38 times [5], indicating the use of FU technology can be relatively high vertical height, thereby increasing the height of the batting, increasing the range of attack. Comparison can be seen, Karen's hitting point height of 2.920m, with its height ratio of about 1.47, in line with Hui Liu and Yuliang Sun study of the FU technology. Some studies have shown that the maximum point of the drop above the hitting point should be around 0.5m, and some even in the 0.2m range [3], Karen's drop to reach the highest point and the hitting point of the gap is 0.484m. In the batting moment has a larger angle and elbow angle, the distal link to the shoulder for the axis, around the shoulder rotation radius of lengthened, thereby increasing the swing speed. At the time of hitting the Karen left hip angle is 169.1°, the right shoulder angle is 146.5°, and the right elbow angle is 165.4°. This shows that Karen's holding arm and torso have been fully stretched, holding the arm quickly swing the ball, the ball to obtain a larger initial speed. Tennis action is a whipping class action, so a reasonable action rhythm should be the body from the lower joint to the upper joint speed increases in turn, the greater the rate of increase between the speed of each link, indicating that the action of the momentum of whipping the better [1]. The speed of the shoulder joint, elbow joint, wrist joint is 3.21 m / s, 6.94 m / s, 13.14 m / s and 30.49 m / s. This shows that Karen's order of force in line with the proximal joint to the distal joint transmission, the speed was increasing the situation, in line with the principle of whipping technology action.

4 CONCLUSIONS
4.1 Throw the Ball to Take the Stage
At the moment of T1, Karen’s left humeral angle was 120.3° and the left elbow angle was 169.7°, indicating that the shoulder and elbow joints were more fully stretched; the release speed of (5.8 m / s) and the release height of (1.869m) were reasonable; the quality of throwing the ball is high. At T2 time,
Karen’s left and right knee angle were 89.2°, 92.5 respectively, indicating that the bend range of knee joint was larger, which made full preparation for the knee joint to do the bend action at the next stage. The projected angle of Karen’s hip was 40.2°, showing that the torsion range of trunk twist was larger, and the lateral stretch of upper trunk muscle was more adequate, which increased the elastic potential for swing at the direction of hitting the ball.

4.2 Backward Swing Stage
At the time of T3, Karen’s left knee angle was 137.5°; the left ankle angle was 100.0°, and the left hip angle was 167.8°. Compared with T2 moment, the pedal extension of the knee was 48.3°, indicating that the lower limbs pedaled and stretched fully, which improved the height of the center of gravity, allowed him to have sufficient time to do the posture of round the back, which was conducive to hit at the high point, increasing the range of attack; through the analysis on Right humeral angle (132.8°), right elbow angle (58.0°), right wrist angle (147.3°), the center of gravity height (1.312 m) and the height from the back of the racket to the lowest point of the racket head (1.269m), the lowest point of the racket head is lower than the body center of gravity height for 0.043m, indicating that the shoulder and elbow of the holding arm were fully flexed and the shoulder was fully stretched, obtaining a certain degree of elastic potential energy, reserving a lot of energy for the swing and batting, convenient for driving serve.

4.3 Swing the Batting Stage Forward
At the moment of T4, Karen’s hitting height was 2.920m, and the specific value with his height was about 1.47. The hit point was relatively high. The left hip angle was 169.1°; the right shoulder joint angle was 146.5°, and the right elbow angle was 165.4°. These showed that Karen’s holding arm and trunk were fully stretched, well ready for the ball to get a larger initial speed. The speeds of the shoulder joint, the elbow joint, the wrist joint, and the racket head were 3.21 m/s, 6.94 m/s, 13.14 m/s and 30.49 m/s, which indicated that the order of the Karen’s power generation was in line with the transmission from proximal joint to far joint. The speed trend was progressive increasing, in line with the principle of whipping technology action.

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