International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes

Shi Guang
Xi'an Physical Education University, Xi'an, Shaanxi, China
E-mail: 449304571@qq.com, ORCID ID: https://orcid.org/0009-0009-8934-5278

Received 10/11/2023 Revised 28/11/2023 Accepted 05/12/2023

Abstract

Background and Aim: Tennis serve has an absolutely important position on the tennis court. The serving mode of topspin, flat stroke, and side spin cannot be completely distinguished and mastered by most Chinese athletes, and one of the effective ways to improve the technique of serving technology is to measure and analyze the serving technology from the perspective of biomechanics. This study aimed to analyze the biomechanical characteristics of the different service techniques.

Materials and Methods: The participants of the study Xi'an Sports Institute eight secondary athletes, with two high-speed cameras eight two athletes serve three different biomechanical characteristics of image information acquisition, through the APAS data analysis software for video analysis and data processing, get three kinds of athletes serve technology. By comparing the kinematic parameters of the three serving techniques, the regular content of the three serving techniques is revealed.

Result: The height of the highest point of the three serve throws of the eight players are 3.126±0.110m,3.258±0.052m, and 3.167±0.153m. The hit position heights are 2.904±0.044m,3.051±0.131m, and 2.920±0.085m. The center of gravity displacement at the hit position averaged 0.44m,0.474m, and 0.471m. The height of the center of the ball is 1.321±0.030m,1.345±0.035m and 1.325±0.035m. The center of gravity height at the hitting moment is 1.435±0.035m,1.505±0.051m and 1.461±0.049m. At the hitting time, the results of the three serves of the eight players are as follows: The right knee angle was 173.916deg, 140.732deg, and 159.772deg. The right shoulder vertical axis has angles of 87.041deg, 92.867deg, and 86.898deg. The right shoulder angles are 41.09deg,72.847deg and 34.113deg, 77.572deg, 122.674deg, and 131.052deg from the right elbow, 151.894deg, 111.125deg and 129.412deg from the right wrist. The velocity of the right shoulder joint was 1.31m/s, 1.369m/s and 1.483 m/s. The velocity of the right elbow joint was 1.788m/s, 2.443m/s and 2.136 m/s. The velocity of the right wrist was 2.265m/s, 3.257m/s and 3.256 m/s. The velocity of the ball is 17.476m/s, 38.215m/s, and 21.327m/s.

Conclusion: When the same player applies different serving techniques, the smaller the difference between the highest point of the ball and the position of the ball, the better the serve effect. There are some differences between the hitting moment and the body (head) position. The center of gravity displacement trajectory is the same, but the height of the highest, the second side rotation, and the lowest topspin. The Angle of the knee and right shoulder vertical axis vary similarly, and the angular acceleration of the elbow and the minimum Angle of the wrist are almost the same, but the Angle of the shoulder is somewhat different, and the size of the Angle is related to the position of the shot. The speed curves of the right shoulder, right elbow, and right wrist all have the same trajectory, but the speed of the same joint of the three service techniques is somewhat different. Cause a different serve effect.

Keywords: Serving Technique; Tennis Sports; Sports Biomechanics

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

Introduction

Since China's tennis breakthrough in Athens and Beijing Olympic Games, Chinese athletes have had a place in the world tennis, and some even rushed to the top of the world ranking, which can be described as the "outbreak of adversity". But with the "golden age" over, the overall level of Chinese tennis has shown a downward trend. In 2023, Chinese women's player Zhu Lin entered the last 16 of the Grand Slam for the first time, and men's player Zhang Zhizhen also entered the ATP for the first time, ranking in the top 100, and entered the last 16 for the first time at the Madrid Masters, which is a historic breakthrough in Chinese men's tennis. In addition, Wu Yibing defeated Isnell and became the first Chinese mainland player to win the ATP Tour singles title. This good news shows that the tennis stars are rising, and Chinese tennis ushered in new opportunities. The world of tennis is also undergoing unprecedented changes.

The tennis serve is the beginning of the game, is the first to win, to creates the follow-up attack opportunity of the important technical means. The service requires coordination between the lower limbs, trunk, and upper limbs to obtain faster speed or rotation (Yan, et al, 2000; Li, et al, 2017; Fu, & Sun, 2008). Although the principle of whipping technical action (Liu, 2002), this makes the tennis serve technical action more complicated than other actions (Ma & Shi, 2021). Therefore, starting from the perspective of sports biomechanical research, it can help coaches and athletes understand and improve the serve techniques, improve the serve speed, rotation, and threat, and then improve the competitive level and performance (Li, et al. 2020).

The study of sports biomechanics is crucial for the improvement of tennis service technology in China. Through further study of the biomechanical characteristics of the key stage of tennis service technology, it can provide scientific theoretical reference for coaches and athletes, and improve and optimize the service technical movements. At the same time, summarizes the rules of different forms of serving techniques and reveals the action modes of different techniques, which can provide theoretical support for athletes to choose and apply different serving techniques. To sum up, improving the technical level and competitive strength of tennis players in China is of great theoretical and practical significance to the study of sports biomechanics of service technical movements.

Objectives

To Study on kinematic characteristics of tennis serve technology under different serving modes

Literature Review

1. Tennis serve technical action, stage division

The study of serve technical action starts from the division of the action cycle and can be divided into different stages according to the different research purposes. The division of the action cycle is conducive to technical diagnosis (Liu & Yu, 2020). At present, the division of three stages is the mainstream. For example, Liu (2000) divides the tennis serve action into three stages: the technical stage of throwing and swinging, the technical stage of "scratching the back" and the technical stage of swinging and hitting. Similarly, the serve action technique is divided into three large stages and eight small stages: preparation stage (beginning stage, release stage, storage stage, standing stage), acceleration stage (acceleration stage, hitting stage), and accompanying swing phase (deceleration stage

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

and completion stage). In addition to the three stages, there are also four stages (Han, 2017): the preparation stage, the ball throwing stage, the "back scratching" stage, and the stroke stage. Some scholars have divided it into early, middle, and late "back scratching" stages and acceleration stages. Hangge divides the serve action into five stages: the lead stage, the vertical stage, the "back scratching" action stage, the swing action stage, and the subsequent swing stage. There are also six stages (Yan & Li, 2001) and other forms of division.

2. Research on the commonality of service technology

Storage is the preparation for the shot, and hitting the ball is the purpose of storage. Players use the power chain by throwing the ball and "scratching the back" to store the power, and in the swing stage to release energy to accelerate the racket (Liu, 2000), which is in line with the principle of whipping action (Liu, 2002). First of all, the position, method, and drop of the throw directly determine the quality of the throw, and the quality of the throw will affect the final serve effect (Yan, et al, 2000). A good throw should have a reasonable position, namely, above the dominant side; a stable way, with the throwing arm straight, using the palm to reduce the ball rotation and keep the upward trajectory stable; and a reasonable drop of about 50cm, and 94cm (Liu, 2000).

Second, no matter which service technique, the power comes from the lower limbs. For example, increasing the angular speed of the lower limbs within a certain range will also increase the ball speed, and increasing the vertical face Angle of the shoulder and hip in the racket lead stage can also increase the ball speed. Therefore, to achieve better service results, athletes need to pay attention to lower limb strength and power chain transmission efficiency. In addition, the changes in lower limb kinematics will also have a certain impact on upper limb kinematics. For example, when the athlete accelerates the movement, the pelvis obtains the maximum upward speed, forming the trunk "surpassing" the racket and the "back scratching" action (Liu, 2000).

Thirdly, no matter what kind of serving technique, special attention should be paid to the position of the hitting point, forearm internal rotation, and footwork during the acceleration stage. Too high or too low the ball is not conducive to improving the head speed, or even causing the net or out of bounds. The internal rotation of the dominant side arm not only reduces the deviation of the racket to the non-dominant side but more importantly, it enables the ideal racket surface Angle, hitting direction, and serve speed of the shot. In addition, the use of footwork can effectively improve the serve speed and threat. Therefore, the reasonable hitting position, the full internal rotation action, and the correct footwork are inseparable from the ideal service effect.

3. Current status of biomechanics of tennis service

According to the racket state of the serve, the serve technical action can be divided into flat serve, side spin serve, and topspin serve. Flat serve is the most commonly used one serve, is the fastest and least rotating serve of all technical movements, is also the most threatening serve, is also an important means of scoring, and is the primary offensive means to maintain the subsequent offensive. The kinematic characteristics of the flat strike serve are different from the other two serve forms. No matter which form of serve, the ball produces a rotation, and the rotation is smaller than the other two flat serve. In terms of kinematic characteristics, Gao & Zhao (2007) proposed that among the world's outstanding tennis players, through observing Federer's service, he found that his service speed is not the fastest, but his service quality is first-class because he perfectly combined the speed, region, and type of service.

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

Tao (2015) pointed out that the serve of tennis is a process of power chain transmission, and only by maintaining the consistency of the serve and the coordination of movements can a high-quality ball be issued. At the same time, Wang, et al (2016) used the high-speed camera test to test the serve speed of the subjects before and after the training and pointed out that the correct serve posture and the order of the body force are the main factors affecting the serve, and strength training is the key to improve the performance of the tennis serve.

To sum up, serving is a technique that does not easy to be disturb the opponent but is most likely to interfere with the opponent. It is also a technology that requires overall coordination and coordination. It not only requires coordination between the lower limbs, trunk, and upper limbs but also requires the muscles to send forces in a certain order to transfer the power to the racket head through the power chain, to obtain a good serve effect. Speed, rotation, and landing point are important factors to evaluate the effect of serve. Higher speed, tricky landing points, and high-speed rotation can often bring considerable points and help athletes to win the game. Want to completely understand the biomechanical characteristics of different service technologies, you need to start from the ball racket stage to explore the source of different serve, the most important is from the hitting stage to explore the various parameters of body joints, and compare them, understand technical differences is conducive to master technical rules, to find out the biomechanical characteristics of different serve. It can optimize its technical movements through scientific training, improve its competitive level, and lay a solid theoretical foundation for the improvement of sports performance.

There are some studies on the 3-D analysis of service technical movements. There are mainly the following characteristics: 1) In the technical analysis, most studies use 100Hz sampling frequency for the serve technical analysis. If the sampling frequency can be increased, more technical details can be captured, which is conducive to a more accurate study of the kinematic indicators of each moment of the serve technical action.2) In the movement link, the body shape and physical ability parameters are the majority, while there are relatively few studies on the body, the service effect, and the ball speed at each moment and stage. To sum up, the high frame rate shooting method can help to understand the detailed characteristics of the technical movements (especially the hitting stage), clarify the relationship between the technical movements characteristics and the serving effect can help the coach optimize the technical movements of the players, and provide scientific data analysis and theoretical guidance for the tennis project.

Conceptual Framework

The conceptual framework for this research is as follows:

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

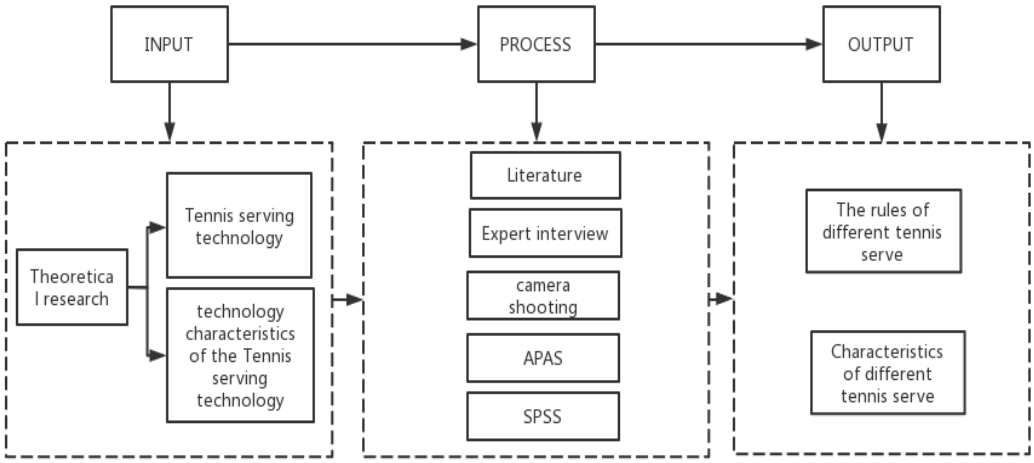

Figure 1 Conceptual Framework

Methodology

1. Type of research

Test research

2. Population and sample size

In this study, 8 male tennis players from Xi'an Sports University were selected as the research and test subjects (right-handed rackets). Each player needs three forms of serving, comparing the three serve forms for each player, and the same serve form between the players.

3. Research tools

Three-dimensional DLT calibration framework, two high-speed cameras (Casio FX-FH 100), APAS data analysis software, and SPSS statistical software.

4. Data Collection

Using a three-dimensional DLT calibration frame, two high-speed cameras (Casio FX-FH 100) record the movements of the player while serving.

The sampling frequency was recorded at 120 frames / s. The videos were analyzed and processed using APAS data analysis software to obtain the movement biomechanics of the athletes while performing the three serve techniques.

By comparing the biomechanical parameters of the three service techniques by SPSS statistical software, we revealed the regularity of the three service technique characteristics.

-Test Method

The two cameras（A with B） have about 110. As in Figure 2.

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

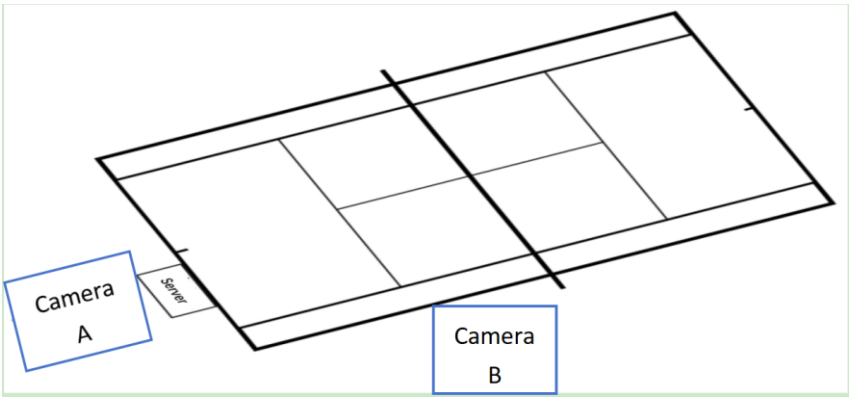

Figure 2 Tennis Serving Test Site Schematic Figure

-Stage division

The serve technique (right-hand position) is divided into three moments: the serving moment, the highest point of the rising moment, and the hitting moment. Before the formal test, the players are fully prepared and tracking service. ① Each player can serve the topspin, flat shot, and side spin 7 times, and choose the best serve and the best serve and the best tennis serve 2 times as the sample.

-Sample selection

Before the formal test, the athletes are fully prepared and try to serve.① The serve times of each player are topspin, flat shot, and side spin 7 times, and the best serve and the best shot effect twice are selected as the sample.② The subject attempted to send the ball to the designated service area.

-Classification of serve

Upspin serve, where the upper rotation is the main rotation of the ball, is assisted by side spin. Flat service, namely strong and strong rotation serve. Side spin serve, that is, the right-handed serve as the main rotation of the ball.

5. Data Analysis

By comparing the biomechanical parameters of the three serving techniques, the regularity of the characteristics of the three serving techniques is revealed.

-Analysis of Sports Biomechanics

Statistics are collected according to the serving times and successful times of top-spin, flat strike, and side-spin balls, as recorded in Table 2.

Table 2 Statistics of the Success Rate of Three Kinds of Serving of 8 Athletes

Name	Top-spin Success Rate%	Flat-shot Success Rate%	Side-spin Success Rate%	Total Success Rate%
Tian x	71.4	57.1	85.7	71.4
Zhang XX	71.4	71.4	85.7	76.1
Yang XX	85.7	71.4	85.7	80.9
Zhou XX	71.4	71.4	85.7	76.1
Zhang X	71.4	57.1	71.4	66.6

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

Name	Top-spin Success Rate%	Flat-shot Success Rate%	Side-spin Success Rate%	Total Success Rate%
Zhang XX	71.4	57.1	71.4	66.6
Shi X	57.1	71.4	85.7	71.4
Li XX	71.4	71.4	85.7	76.1

From Table 2, we can get all the success rates. We will exclude the athletes with lower total success rates from the data. To ensure the rationality of the data and reduce the error. The success rate of Yang XX's three kinds of serving is 80.9%, which is the highest among the eight male tennis athletes. Table 3 shows the success rate of top-spin-serving, flat-serving, and side-spin-serving of 8 tennis athletes.

Table 3 The Success Rate of Top-Spin-Serving, Flat-Serving and Side-Spin-Serving of 8 Tennis Athletes

Serving type	Tian X	Zhang XX	Yang XX	Zhou XX	Zhang X	Zhang XX	Shi X	Li XX	X±SD
Top spin	71.4	71.4	85.7	71.4	71.4	71.4	57.1	71.4	71.4±7.64
Flat-shot	57.1	71.4	71.4	71.4	57.1	57.1	71.4	71.4	69.612±9.16
Side-spin-ball	85.7	85.7	85.7	85.7	71.4	71.4	85.7	85.7	82.125±6.62

From Table 3, we can tell that the success rate of side-spin-serving and top-spin serving is generally higher than that of flat-shot-serving, and the standard deviation of the success rate of flat-serve is significantly higher than that of top-spin-serve and side-spin-serve, indicating that the stability of flat-serve of the same person is lower than that of top-spin-serve and side-spin-serve.

Results

1. Sports Biomechanical Analysis of Tennis-serving Technique

1.1 Research on the Relationship Between the Highest Point of Serving the Ball and the Height of Striking Position

The height of the highest point of serving the ball affects the height of the striking position. When the throw is too high or too low, the quality of serving will be affected. Measure the highest point of the ball and the height of the striking position when the athlete throws the ball, as shown in Table 4.

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

Table 4 Statistical Table of the Highest Point of the Ball and the Height of the Striking Position When Serving the Ball

Serving type	Number of samples (n)	The highest point of the ball when serving (m)	Striking position height (m)
Top-spin-shot	8	3.126±0.110	2.904±0.044
Flat-shot	8	3.258±0.052	3.051±0.131
Side-spin-shot	8	3.167±0.153	2.920±0.085

It can be concluded from the data in Table 4 that the highest point and striking position of the flat-serve of each experimental object are generally higher than that of the side-spin-serve and the top-spin-serve. The difference between the highest serving point and striking position of athlete Yang XX's flat-serve is 0.321m, the difference between the highest serving point and striking position of side-spin-serve is 0.27m, and the difference between the highest serving point and striking position of top-spin-serve is 0.326m. On the other hand, the difference between the highest serving point and the striking position of athlete Zhang XX's flat-shot-serve is 0.613m, the difference between the highest serving point and the striking position of side-spin-serve is 0.564m, and the difference between the highest serving point and the striking position of top-spin-serve is 0.552m. The higher the level of Ming, the smaller the difference between the height of the ball rising to the highest point and the height of the striking position, the more stable the ball is, and the success rate also increases accordingly.

1.2 Research on the Relationship Between Striking Position and Body Position at Striking Time

In the cases of different serving skills, the position of the ball at the time of being struck is different from that of the body. The position of the ball and the position of the body (head) at the time of striking the ball in three kinds of serving techniques are represented by the X, Y, and Z axes respectively. The X-axis is perpendicular to the bottom line of the serving, and the direction of the court is positive; the Y-axis is the direction of the left toe in the preparation posture, and the extension direction of the toe is positive; the Z-axis is the height perpendicular to the ground and is positive upward. As shown in Table 5.

Table 5 The Relationship Between the Position of the Ball and the Position of the Body (head) at the Time of Striking

Serving type	Position	X-axis	Y-axis	Z-axis
Top-spin-shot	Position of the ball (m)	-0.858	-0.567	1.876
	Head position (m)	-0.554	-0.785	1.087
	Difference (m)	0.314	-0.218	0.789
Flat-shot	Position of the ball (m)	-0.623	-0.717	1.959
	Head position (m)	-0.482	-1.079	1.018

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

Serving type	Position	X-axis	Y-axis	Z-axis
	Difference (m)	0.141	-0.362	0.941
	Position of the ball (m)	-0.95	-0.201	1.96
Side-spin-shot	Head position (m)	-0.534	-0.631	1.118
	Difference (m)	0.416	-0.43	0.842

In Table 5, from the Z-axis we can tell, the difference between the head of the top-spin-serve, the head of the flat-serve, and the head of the side-spin-serve and the striking position is 0.789m, 0.941m, and 0.842m respectively. The difference between the head of the top-spin-serve and the striking position is lower than that of the flat-serve and side-spin-serve, which indicates that the Z-axis height difference between the head of the top-spin-serve and the striking position is smaller when at the striking time. On the Y-axis, the differences between the head of the top-spin-serve, the head of the flat-serve, and the head of the side-spin-serve and the striking position are 0.218m, 0.362m, and 0.43m respectively. The difference between the head of top-spin-serve and the striking position is also lower than that of flat-serve and side-spin-serve, which indicates that the difference between the head of top-spin-serve and the striking position in the Y-axis direction is small at the striking time; On the X-axis, the difference between the head of top-spin-serve, the head of flat-serve and the head of side-spin-serve and the striking position is 0.314m, 0.141m and 0.416m respectively. The horizontal direction of flat-serve almost coincides with the head at the striking time, while the horizontal direction of top-spin-serve and side-spin-serve is far away from the head, and the head of three kinds of serve is slightly ahead of the ball at the striking time.

1.3 Study on the Angle of Right Knee, Elbow and Wrist Joint and the Angle of Right Shoulder Vertical Axis at Striking Time

The angle of some joints of different serving techniques should be different when striking the ball. The angle of the vertical axis of the right knee, right shoulder, right elbow, and right wrist determines the different types of serving, as shown in Table 6.

Table 6 Statistics of Vertical Axis Angle of Right Knee, Right Shoulder, Elbow, and Wrist Joint at the Time of Touching the Ball

Serving type	Number of samples (n)	Right knee joint angle (deg)	Right shoulder vertical axis angle (deg)	Right elbow angle (deg)	Right wrist angle (deg)
top-spin	8	162.479±10.084	81.680±1.505	110.389±6.739	130.974±14.601
Flat-shot	8	155.574±13.249	89.956±2.934	143.237±16.014	105.774±13.822
Side-spin	8	158.444±7.916	86.299±3.044	147.385±14.653	99.240±24.441

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

From the perspective of the right knee joint, the average knee joint angles of top-spin-serve, flat-serve, and side-spin-serve are 173.916 deg, 140.732 deg, and 159.772 deg. Taking the knee angle of Yang XX's serving as an example, the angle curve is shown in Figure 2.

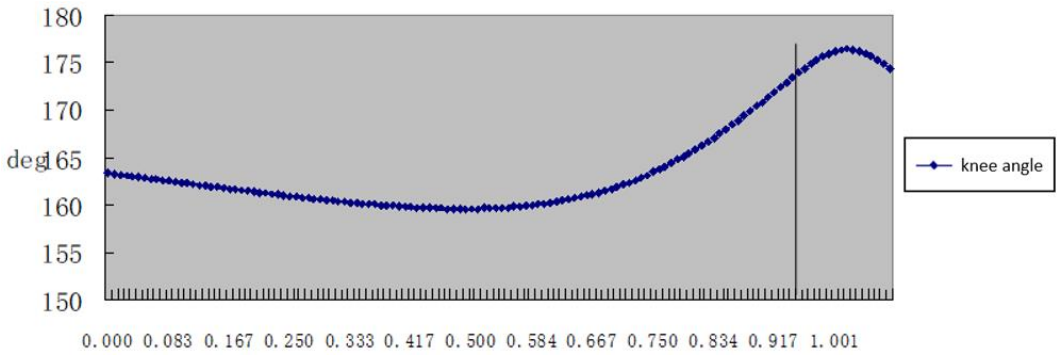

Figure 3 The Curve of the Angle Change of the Knee Joint When the Athlete Serves
(Note: the line parallel to the Y-axis in this figure represents the striking time)

At the moment of striking, the knee joint angle of the top-spin-serve is the largest, and the knee joint angle of the flat-serve and side-spin-serve is similar, which indicates that the knee joint tension of the top-spin-serve is the largest at this time. In the striking position, the knee joint flexes first and then extends, which indicates that the reaction force between the lower limbs and the ground produces the explosive force of striking the ball, which prepares the power base for the next power chain. It also indicates that the three kinds of serving techniques need the knee joint's push and extension as the power base, which is also the main power source of serving the three kinds of balls.

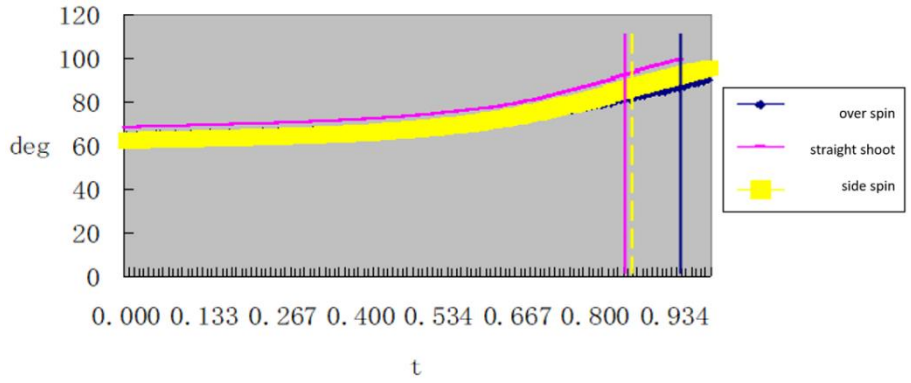

Figure 4 The Curve of the Angle Change of the Right Shoulder Vertical Axis of the Athlete's Serving
(Note: the line parallel to the Y axis from left to right in the figure is the striking time of the flat-serve, the striking time of the side-spin-serve and the striking time of the top-spin-serve in turn)

From the angle of the right shoulder vertical axis, when at the time of striking, the average angle of the right shoulder vertical axis of top-spin-serve, flat-serve, and side-spin-serve is 87.041 deg, 92.867 deg and 86.898 deg respectively, and the angle of top-spin-serve and side-spin-serve is slightly lower than that of flat-serve, which also proves that the striking position of front flat-serve is higher than that of top-spin-serve and side-spin-serve, as shown in Figure 3. During this period, the vertical angle of the

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

right shoulder is constantly increasing, and the right shoulder of the three kinds of serving techniques extends upward.

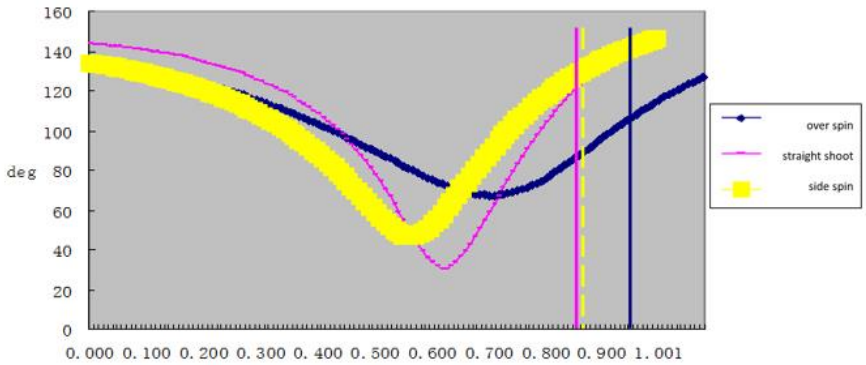

Figure 5 The Curve of Elbow Angle Change of Serving the Ball (Note: the line parallel to the Y-axis from left to right in the figure is the striking time of flat-shot-serve, the striking time of side-spin-serve and the striking time of top-spin-serve)

From the perspective of the right elbow joint, the average elbow joint angles of top-spin-serve, flat-serve, and side-spin-serve are 77.572deg, 122.674deg, and 131.052deg. The elbow joint angles of the flat-serve and the side-spin-serve are similar, but the elbow joint of the top-spin-serve is relatively small, which is related to the lower striking position of the top-spin-serve. As shown in Figure 4. The angle of the elbow joint increases almost uniformly from the lowest point to the moment of striking. It can also be seen that the elbow joint of the top-spin-serve is generally lower than that of the flat and side-spin-serve, but the angle increases almost uniformly after striking, which indicates that the elbow joint of top-spin-serve extends from the time of striking position to the time when the ball leaves the racket surface, while the elbow joint angle of flat-shot and side-spin-serve is larger and almost no longer increases at the time of striking, It means that the elbow almost stops stretching.

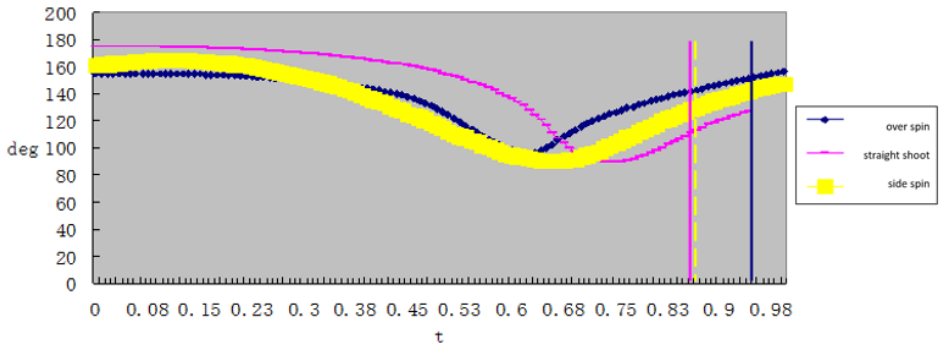

Figure 6 Curve of Wrist Joint Angle Change of Serving the Ball (Note: the line parallel to the Y axis from left to right in the figure is the striking time of flat-serve, the striking time of side-spin-serve and the striking time of top-spin-serve)

From the perspective of the right wrist joint, the average wrist joint of top-spin-serve, flat-serve, and side-spin-serve is 151.894 deg, 111.125 deg, and 129.412 deg. As shown in Figure 5, at the moment

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

of striking, the wrist angle of top-spin-serving is higher than that of flat-shot and side-spin-shot. The different striking positions lead to the wrist of top-spin-serving being more outstretched than that of flat-shot, which makes the racket face more open and can better increase the top-spin. The minimum angle of the wrist joint of the three kinds of serving is similar, which indicates that they all need to increase the internal rotation of the wrist joint through abduction and flexion.

1.4 Research on the Velocity of the Right Shoulder, Elbow, and Wrist Joint and the Velocity of the Ball at the Time of Striking

The speed of different serving techniques at the time of striking should be different. The different angles of the right shoulder, right elbow, and right wrist result in the different speeds of striking the ball, as shown in Table 7.

Table 7 Speed of Right Shoulder, Right Elbow and Right Wrist Joint and Ball Speed V (m/s) of Athletes at Striking Time

Serving type	Number of samples (n)	Right shoulder Joint (m/s)	Right elbow joint (m/s)	Right wrist joint (m/s)	ball (m/s)
Top-spin	8	1.403±0.095	1.829±0.061	2.455±0.172	20.492±3.290
Flat-shot	8	1.468±0.145	2.112±0.290	3.024±0.222	35.071±3.108
Side-spin	8	1.644±0.231	2.330±0.211	3.315±0.068	23.109±2.526

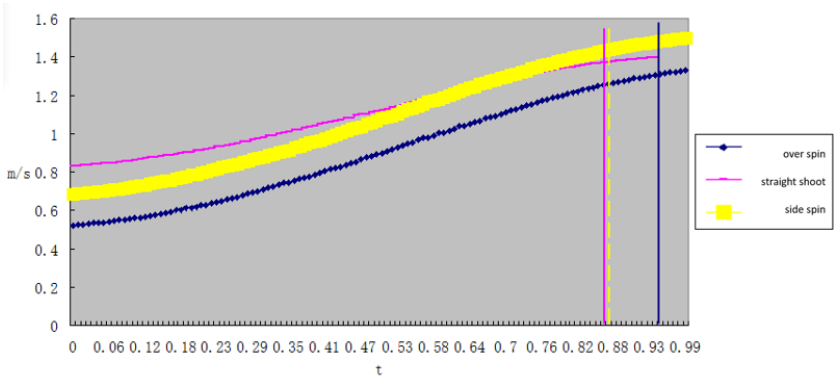

Figure 7 Velocity Curve of Right Shoulder Joint of Serve (Note: the line parallel to the Y-axis from left to right in the figure is the strike time of flat-serve, the strike time of side-spin-serve and the strike time of top-spin-serve)

From the speed of the right shoulder joint, the average speed of the right shoulder of the athletes' top-spin-serve, flat-serve, and side-spin-serve is 1.31m/s, 1.369m/s, and 1.483m/s. As shown in Figure 6, the speed of the right shoulder of the side-spin-serve is relatively higher than that of the top-spin-

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

serve or even higher than that of the flat-serve, and the acceleration of the shoulder joint of the side-spin-serve is significantly higher than that of the flat and top-spin-serve, which indicates that the side-spin-serve needs a lot of acceleration, resulting in the phenomenon that the speed of the right shoulder of the side-spin-serve is higher than that of other serve.

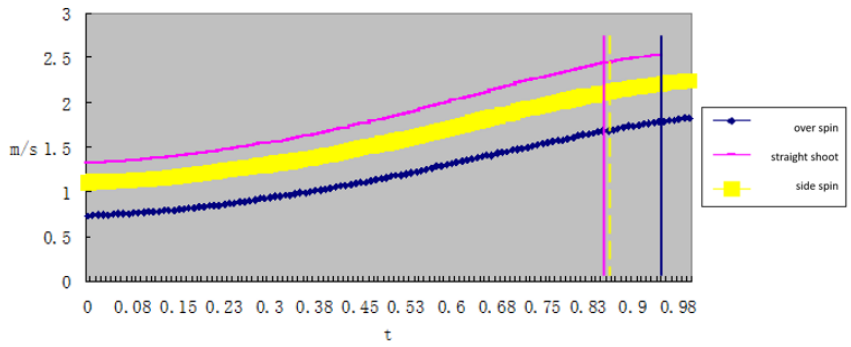

Figure 8 The Curve of the Speed Change of the Right Elbow Joint of the Athlete's Serving (Note: the line parallel to the Y-axis from left to right in the figure is the striking time of the flat-serve, the striking time of the side-spin-serve and the striking time of the top-spin-serve in turn)

From the speed of the right elbow joint, the average speed of the right elbow of the top-spin-serve, flat-serve, and side-spin-serve is 1.788m/s, 2.443m/s, and 2.136m/s. As shown in Figure 7, the speed of the right elbow of the flat serve is significantly higher than that of the top spin serve and the lateral serve, while the elbow speed of the top spin serve is the lowest. The speed curves of the right elbow of the three serving techniques are almost parallel. In other words, from the beginning to the end, the elbow joint is the link of the conduction velocity from the trunk to the shoulder joint.

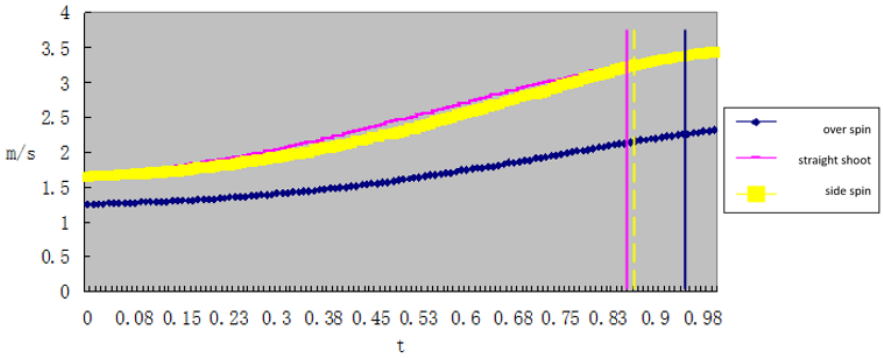

Figure 9 The Curve of the Speed Change of the Right Wrist Joint of the Athlete's Serving (Note: the line parallel to the Y-axis from left to right in the figure is the striking time of the flat-serve, the strike time of the side-spin-serve and the strike time of the top-spin-serve in turn)

In terms of the speed of the right wrist, the average speed of the top-spin-serve, flat-serve, and side-spin-serve is 2.265m/s, 3.257m/s, and 3.256m/s. As shown in Figure 8, the speed of the right wrist of the top-spin-serve is lower than that of the side-spin-serve and the flat-serve, while the speed of the right wrist of the side-spin-serve is very close to that of the flat-serve, indicating that the right wrist of

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

the flat-serve and the side-spin-serve accelerates more forward. Put the right shoulder, elbow, and wrist statics of the three serving techniques together for comparison. As shown in Figure 9-11.

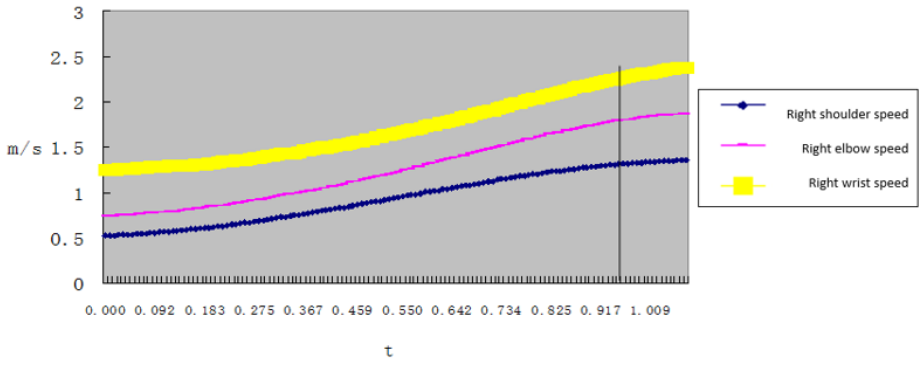

Figure 10 The Curve of the Speed Change of the Right Shoulder, Elbow and Wrist of the Athlete's Top-spin-serving Technique (Note: the line parallel to the Y-axis in the figure is the striking time)

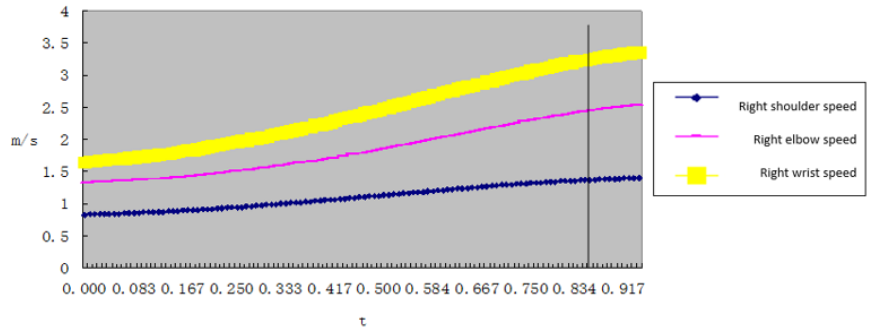

Figure 11 Speed Curve of Right Shoulder, Elbow, and Wrist of Athlete's Flat-serving Technique (Note: the line parallel to the Y-axis in the figure is the striking time)

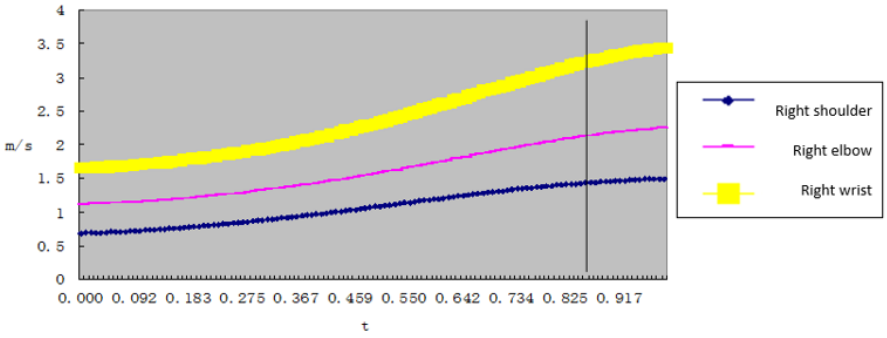

Figure 11 Curve of Speed Change of Right Shoulder, Elbow, and Wrist of Athletes' Side-spin-serving Technique (Note: the line parallel to the Y axis in the figure is the striking time)

The right shoulder, the right elbow, and the right wrist of the three serving techniques have the same characteristics, which are, the speed of the right shoulder joint is the lowest, the right elbow joint is the second, and the right wrist joint is the highest. It shows that the speed of the shoulder is the starting point from the serving position to the striking time, then the elbow joint accelerates, and finally, the wrist speed reaches the maximum. The speed of the ball, and the average speed of top-spin-serve, flat-

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

serve, and side-spin-serve are 17.476m/s, 38.215m/s, and 21.327m/s respectively. The speed of the flat-serve is higher than that of the top-spin-serve and the side-spin-serve. This is because the flat-serve flies almost in a flat line without strong rotation of the side and topspin. The speed of the right shoulder, right elbow, and right wrist of the top-spin-serve is the lowest, so the speed of the ball is the lowest.

Conclusion

When the same player applies different serving techniques, the smaller the difference between the highest point of the ball and the position of the ball, the better the serve effect.

There are some differences between the hitting moment and the body (head) position. The center of gravity displacement trajectory is the same, but the height of the highest, the second side rotation, and the lowest topspin.

The Angle of the knee and right shoulder vertical axis vary similarly, and the angular acceleration of the elbow and the minimum Angle of the wrist are almost the same, but the Angle of the shoulder is somewhat different, and the size of the Angle is related to the position of the shot.

The speed curves of the right shoulder, right elbow, and right wrist all have the same trajectory, but the speed of the same joint of the three service techniques is somewhat different. Cause a different serve effect.

Recommendation

In the training of different services, the highest point of the serve and the height of the ball should be clear, so that the distance is as close as possible to ensure the stability of the service.

According to the different biomechanical characteristics of the service, the corresponding training to strengthen and improve the service technology.

References

Fu, R., & Sun, S. (2008). Establishment and application of hard field women's tennis doubles competition. *China Sports Science and Technology*, 4,79-83. doi:10.16470/j.csst.2008.04.018.

Gao, S.D., & Zhao, W. (2007). Analysis of the latest tennis service technique and training. *Journal of Anhui Normal University (Natural Science Edition)*, 4, 516-519.

Han, G. (2017). *Master thesis on successful and error serve of tennis players of different levels*. Master thesis: Guangzhou Institute of Physical Education.

Li, B., Bao, Q., Miao, L., & Li, Y. (2017). Summary of the biological characteristics of tennis sports. *China Sports Technology*, 5,69-83. doi:10.16470/j.csst.201705008.

Li, H., Liu, J., Ye, K., Yu, B., & Liu, H. (2020). Effect of speed rhythm on hammer ball performance: a case study of elite players. *Journal of Beijing Sport University*, 9,108-115. doi:10.19582/j.cnki.11-3785/g8.2020.09.012.

Liu, H. (2000). Sports biomechanical principle of tennis vigorous service technique. *Journal of Beijing Sport University*, 2,173-180. doi:10.19582/j.cnki.11-3785/g8.2000.02.013.

Liu, H. (2002). *PhD thesis on biomechanics research of upper limb whipping technique.* Beijing Sport University.

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871

International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 2: March-April 2024: ISSN 2985-2730
Website: https://so07.tci-thaijo.org/index.php/IJSASR/index
DOI: https://doi.org/10.60027/ijsasr.2024.3871

Liu, H., & Yu, B. (2020). Biomechanical analysis methods for action techniques. *Sports Research* (05), 64-70.

Ma, X., & Shi, B. (2021). Mechanics of tennis service: Research progress and trend. *Journal of Chengdu Institute of Physical Education*, 2,122-127. doi:10.15942/j.jcsu. 2021.02.020.

Tao, Z. (2015). Application of biomechanics in tennis serve. *Exercise*, 24, 34-35.

Wang, H., Ji, Z., Jiang, G., &Zhang, H. (2016). Biomechanical study of the influence of tennis training on tennis service. *Journal of Beijing Normal University (Natural Science Edition)*, 5,658-662. doi:10.16360/j.cnki.jbnuns.2016.05.021.

Yan, B., & Li, Z. (2001). Tennis Serve movement and basic technical mode. *China Sports Technology*, 10, 37-41. doi:10.16470/j.csst.2001.10.013.

Yan, B., Wu, Y., Yuan, T., & Lu, J. (2000). Biomechanical analysis of the tennis ball serve technique. *Sports Science*, 4, 80-85.

Citation: Shi, G. (2024). Study on Kinematic Characteristics of Tennis Serve Technology under Different Serving Modes. International Journal of Sociologies and Anthropologies Science Reviews, 4 (2), 225-240; DOI: https://doi.org/10.60027/ijsasr.2024.3871