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Construction and Discussion of Fuzzy Evaluation System for Tennis Serve Skills

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Keywords: Tennis Teeing Technique, Fuzzy Evaluation System, First Serve, Outer Corner Success Rate, Inner Corner Serve

Abstract: With the general development of sports in the world, people began to pay more and more attention to the tennis service technology. However, there is no better way to effectively analyze the techniques and actions of tennis teeing. In order to effectively analyze the tennis teeing technique, this paper uses fuzzy mathematics method to construct a fuzzy evaluation model to evaluate and analyze, which provides a lot of theoretical basis for training. Through research, we found that the athletes adopt the FB station technology, adopting the back pendulum upwards, and the flexion and extension of the lower limbs are sufficient, increasing the distance between the head and the ball, and obtaining a better posture for the body; the tossing is too high, throwing the ball direction is better. Whether the domestic or foreign offensive athletes are the first choice in the first serve, the outside corner is the first choice, the foreign player's outer corner selection rate is 53.6%, while the foreign player's outer corner selection is 51.2%, in which the domestic player's outer corner success rate is reached 71%, foreign players reached 76%.

1. Introduction

Serve technology has a particularly important position in all tennis skills. It is the only technology that is controlled by oneself and is not restricted by the other party; and the rules stipulate that there are two opportunities for each serve, so the athlete can put the success rate in the secondary position when the first serve, and pursue strength and speed. It is the most difficult to make a serve. Serving is the beginning of every minute. It is the first step in the tactics of the serve. It is the basis for keeping the serve unbeaten. Some research results show that in the tennis match, the score of the serve within two shots (serving and receiving the ball) accounts for 30.33% of the total score; the serve scores within four shots (the serve combined with the third beat) scores the total score. 63.6%. Serve has become a powerful weapon for today's outstanding tennis players to

defeat the enemy.

This paper combines the relevant theoretical basis of tennis teeing technology, using fuzzy mathematics method, constructing fuzzy evaluation system and evaluation system, judging the correlation between the fast strength of tennis players' speed and the training degree of each training method, and can focus on the opinions of different experts. A quantitative analysis of these opinions helps to understand the relationship between the two and provides a large theoretical basis for training.

2. Related Work

There are few special studies on the theory and methods of service training, but there are also some studies that have a strong guiding significance for training practice. In [1], the author determined the characteristics of the ideal serve for men's professional tennis. In the Australian Open, a total of 25,680 first served performed by 151 male tennis players were classified as ace or re-entered. Extract the time and space (influence position, speed, projection angle, landing position and relative player position) and context (score) characteristics of each service from Hawk-Eye data, and used it to construct a classification tree model (with decision rules) for predicting service results. In [2], the authors evaluated the role of the axis of rotation during tennis teeing. The motion capture system was used to evaluate the potential axis of rotation of the four discrete tennis tee stages. Ten top athletes repeatedly conducted a fixed service for the target on the other side of the network. The results showed that in the upper chord stage of the tennis serve, the axis of rotation of the limbs did not necessarily coincide with the minimum inertia axis. In [3], the author developed a computer scorebook for tennis to analyze the duration of the shot. The purpose of this study was to analyze the time factor of a Grand Slam singles game using a computer tennis score book. Due to different strategies, players need to use different service strategies between the French Open and other tournaments. There was no significant difference in ground hitting time between the three matches. These results demonstrated the usefulness of the score book to tennis coaches. In [4], the author's reviewed research showed that the stage of skill learning had different effects on the types of images used by tennis players. In addition, the evaluation showed that athletes with closed skill sports use more cognitive image functions than athletes with open skill sports, and self-efficacy may promote the effectiveness of images used by athletes. From an application point of view, psychological imagery training can be performed on sports psychologists and fitness instructors based on the athlete's level, skill type, expected outcome of image use, stage of learning, and exercise. In [5], the author explored the gender differences in the slam hard tennis ball in terms of batting and kinematics. The authors collated the ball speed tracking data for 102 males and 95 female players during the 2012-2014 Australian Open. When serving the ball, the woman touched the ball close to the net, below the ground, and achieved a flatter trajectory than men. The distance covered by each group when winning or losing points is not related to gender, but men show faster average speed of movement.

Because of its high accuracy and high recognition efficiency, the fuzzy algorithm has been applied in many fields by many research teams and has achieved great results. In [6], the author applied fuzzy evaluation to image analysis and established a fusion model of the plantar pressure distribution image, which was expected to contribute to the construction of feature points based on the generation and modification of the last surface of the shoe. First, the time series of the plantar pressure distribution image was preprocessed, including the backlash and the Laplacian of the Gaussian (LoG) filter. Then, discrete wavelet transform and multi-scale pixel conversion fusion

using a Gaussian mixture model (PEO-GMM) optimized by parameter estimation are performed. In [7], the author applied fuzzy evaluation to benefit evaluation. The author proposed a comprehensive research method of relative greenness based on fuzzy AHP-TOPSIS to improve the correlation between the fuzzy ambiguity and the incomplete weight of various mechanical product schemes in environmental design. The paper applied fuzzy AHP and fuzzy TOPSIS to strictly distinguish the quantitative and qualitative indicators of benefit and cost, and established the principle and system of environmental-oriented mechanical product index evaluation based on the whole life cycle. In [8], the author applied fuzzy evaluation to the analysis of learning styles, and determined the best convenient learning method according to individual ability and personality, which was very important for fast, easy and high quality learning. The article developed a rule-based fuzzy logic inference system to determine the best and convenient way to learn engineering staff and students. During the study period, two different learning style models were used in the implementation, targeting 60 and 26 engineering college students and related personnel. In [9], the author applied fuzzy evaluation to image quality assessment, and proposed a new method based on fuzzy interface system called Quality Assessment System (QES), which was used to measure the input of distortion in many cases. The paper proposed nine quality indicators as inputs to three fuzzy logic controller systems and sets their outputs to the input of another fuzzy logic controller system to obtain the TQI of the input video. In [10], the author applied fuzzy evaluation to the development level of power grid, and proposed an adaptive neural fuzzy inference system (ANFIS) based on principal component analysis (PCA). Not only did it have adaptability and learning capabilities, but it also reduced errors because it avoids parameter explosion when too many input variables. In order to verify the validity of the model, this paper established a comprehensive evaluation index system, and then used the principal component analysis method to obtain comprehensive indicators to reduce the dimensionality of the variables. The results showed that the model has better performance than BP neural network.

3. Method

3.1. Conceptual Theory of Tennis Teeing Technology

(1) Characteristics of tennis tee technology project

In tennis, the tennis teeing movement is a sporting feature of the whipping class. It cannot ignore the relevance and integrity of the various parts of the body, and the mobility of the upper and lower limbs. From the perspective of the body kinematic chain, we have a deep understanding of tennis teeing skills, which helps us to improve the training of tennis teeing more rationally and effectively.

(2) The contraction form of the muscles of the body in the tennis teeing technique

There are three types of muscle contraction when the human body moves, namely isometric contraction, centripetal contraction and eccentric contraction. The muscles of different contraction forms are also different. When the muscles are contracted, the muscles are shortened when the muscles are contracted. When the muscles are centrifuged, the muscles are stretched and resisted by external forces, and the muscles are stretched by the same length. The length does not change. These three forms of muscle contraction have varying degrees of application in tennis teeing techniques.

(3) Stretching training in the teaching of tennis teeing skills

According to the characteristics of tennis serve technology, stretch training is an indispensable part of tennis serve. What kind of training method can improve the teaching effect of tennis serve technology? Most scholars have also carried out a lot of research, this part puts forward is a

self-drafting method, but before you can use the training method, you must first understand the science and specificity of the training method. There are a total of 18 types of drafts selected, depending on the muscle group used by the body. Stretching should be carried out during the maximization of muscle movements, which will be more effective.

3.2. Fuzzy Evaluation Model Based on Teeing Technology

(1) Constructing a fuzzy complementary matrix

After establishing the structure of the risk analysis of the event, the affiliation of the risk elements between each level is correspondingly established. After obtaining the weight information of the risk factors set by the experts and the risk factors given by the relevant experts, a hierarchical analysis structure model has been established, which can construct a judgment matrix with fuzzy complementarity between elements.

The relative importance of the fuzzy complementary judgment matrix refers to the fuzzy scale and its meaning table, and the matrix B_{ij} formed according to the fuzzy scale should satisfy:

$$B_{ij} + B_{ji} = 1; \quad B_{ii} = 0.5; \quad 0 < B_{ij} \langle 1, \quad i, \quad j = 1, 2, \quad \text{L L} \ , \quad n) \tag{1}$$

For n-order matrices, we only need to give values to n(n-1)/2 matrix elements.

(2) Ranking of importance of each risk factor

First, calculate the matrix eigenvector and the largest eigenvalue; again, verify the consistency, you need to calculate the consistency index CI,

$$CI = \frac{\lambda \max - n}{n-1} \tag{2}$$

When the judgment matrix has complete consistency, CI =0, the larger max n, the larger the CI, and the worse the consistency of the matrix. In order to test whether the judgment matrix has satisfactory consistency, the CI needs to be compared with the average random consistency indicator RI. When the matrix order is greater than 2, the ratio of the consistency index CI of the judgment matrix to the same-order average random consistency index RI is the random consistency ratio of the judgment matrix, which is recorded as CR.

$$CR = \frac{CI}{RI} < 0.1 \tag{3}$$

At this point, the judgment matrix has satisfactory consistency, otherwise the judgment matrix should be adjusted.

3.3. Feature Extraction Algorithm Model Based on Serve Action

(1) Feature recognition

In the process of camera image capture and conversion, due to various external disturbances and factors of the system itself, the acquired images will inevitably bring in noise, and effectively suppressing and removing noise interference is the basis of subsequent work. For digital images, digital image filtering can be either frequency domain filtering after Fourier transform or spatial (neighbor) filtering of digital images as a two-dimensional plane function, although the form is different but equivalent.

The modification formula at the center point pixel is:

$$r = \frac{1}{9} \sum_{(i,j \in S)} (p_i k_i) \tag{4}$$

Mean filtering is a kind of linear filtering. Because it is the average of the area when filtering out the noise points, the blurred image will lose the detailed information. It is also a kind of linear filtering. The noise point is treated by the Gaussian distribution weight of the neighborhood pixel, which will reduce the blur to a certain extent, but it is still inevitable.

Median filtering model: Median filtering is a kind of nonlinear filtering with median values sorted by neighborhood statistics. The filtering model with template K is:

$$r(i, j) = med_{(r,s \in K)}\{p(i+r, j+s)\} \tag{5}$$

(2) Feature extraction

The target extraction process is a two-class classification problem. The combined color channel m R-nG-B coefficients m, n when the target is best separated from the background is obtained, that is, the direction of the best projection vector of the sample is sought, so that it is within the class. The variance is minimized, and the variance between classes and classes is maximized. Representing a two-class collection as follows:

$$y_i = w^T x_i, \quad i = 1, 2 \tag{6}$$

From the Lagrange multiplier to the extreme value solution:

$$L(w, \lambda) = w^T S_b w - \lambda \left(w^T S_w w - c \right) \tag{7}$$

That is, the coefficient before R, G, and B is -2:1:1, that is, the combined color channel 2R-G-B has better separability.

4. Experiment

4.1. Data Source

According to the research needs of this paper, a questionnaire with 14 factors of rapid strength of the service speed and 27 training methods was designed. The questionnaire is divided into two parts. The first is to ask the experts to supplement and screen the initial indicators of the study, and select the indicators that have a high degree of effect on the speed of the serve. Second, after the experts have revised and supplemented the indicators provided, the empirically determined the degree of correlation between the selected training means and the influencing factors indicators. Set to 3 correlation levels: the relationship is very closely expressed by 1, the relationship is generally closely expressed by 0.5, and the relationship is not closely represented by 0.

Table 1. Questionnaire distribution and collection

	Questionnaire Issue	Questionnaire Recycling	Recovery Rate	Valid Questionaire	Efficient
First Round	20	19	95	19	95
Second Round	20	20	100	20	100

4.2. Experimental Methods

Purpose of the experiment: A total of 2 rounds of experiments were arranged, and then the results of each round were analyzed and tested, and the practicality of the study was verified by comparative experiments.

Experimental time: September 2018 - November 2018, the cycle is 12 weeks.

Experiment procedure:

In the first round of experiments, we conducted training experiments with four tennis players, divided into two groups on average, and two in group A and group B. In the experiment, the 14 training methods were selected as the training content of the experimental group, while the control group arranged the training by 12 training methods selected by the experts. Training 3-4 times a week (training the next day), a training time of 90-120 minutes, after a 12-week experiment, the experimental group and the control group were compared to the experimental analysis of the flat shot verify the preferred effect of the training means. In the second round of experiments, another four tennis players were trained in training, each in Group A and Group B. In the course of the experiment, Group A uses the fuzzy mathematics principle to select and match the training methods, and the training content is formulated according to the specific situation of each player, and the selected means are arranged in a certain proportion. The training method of the control group was the same as that of the experimental group, but the normal training was used to match the arrangement of the means and the load. Training 3-4 times a week (training the next day), a training time of 90-120 minutes, after a 12-week trial, the experimental group and the control group were compared to the experimental analysis of the flat shot verify the feasibility of applying fuzzy mathematics to training.

Group A and Group B were tightly controlled during the training to ensure that the two groups were subjected to comparative experiments under the same conditions. It is required that the training content arranged should be as consistent as possible during training, such as preparation activities, intensity of load, number of times, etc., and training can not interfere with normal tennis training tasks.

4.3. Evaluation Criteria

(1) Determination of "weight coefficient"

Among them, 3 provincial coaches and 1 national coach are independently selected from the index set X={X_1, X_2, X_3, X_4,...X_{20}} as the five most important indicators that they consider to be the most important. 20 sets of indicators, which are recorded as:

$$\begin{aligned} X^{(1)} &= \{X_1, X_5, X_7, X_8, X_{10}\} \\ X^{(2)} &= \{X_2, X_6, X_7, X_9, X_{10}\} \\ &\cdots\cdots \\ X^{(20)} &= \{X_3, X_4, X_6, X_7, X_8\} \end{aligned} \tag{8}$$

(2) Calculation of quantitative scores

The model is the sum of the standard score values of all the evaluation indicators affecting the sports quality and the respective weight scores, and the value of the comprehensive evaluation is obtained. Its mathematical model is:

$$W = \sum_{i=1}^{n} k_i x_i \quad \left(\sum_{i=1}^{n} k_i = 1 \right) \tag{9}$$

In the formula, W is the comprehensive evaluation value of athletes' sports quality, n is the number of evaluation indicators, x_i is the value of each evaluation index, and k_i is the weight of each evaluation index.

(3) Evaluation of the balance of special sports quality

Firstly compare the performances of each athlete's special sports quality in the sample, and find out the corresponding standard scores, and subtract the lowest two scores from the average of the two highest scores (B_{max}) of each indicator of each test subject. The average of the "difference (B_n)" of the value (B_{min}) is the reference value, and the standard deviation is the discrete distance, and the evaluation criteria are divided according to the principle of normal distribution.

$$B_n = B_{max}{}^{-} B_{min} \tag{10}$$

B_n - the standard score of the balance of the development of each special sports quality; the average of the highest two standard scores corresponding to the B_{max} -11 test scores; the average of the lowest two standard scores corresponding to the B_{min}-10 test scores.

5. Results and Discussions

5.1. The Influence of Body Center of Gravity on Tennis Teeing Skills

The speed of the body's center of gravity is very unstable due to the depression, the torsional force of the body and the change of body posture and the waving of the arm (see Figure 1). Analysis of the body center of gravity speed curve of 8 servings, we can find that from the end of the throwing shot to the end of the hitting, the body's center of gravity speed has four peaks, the second peak is the moment of the feet off the ground, the first 4 peak value is the start time of the shot.

The body center of gravity velocity curve combined with the three-dimensional effect diagram comparison analysis, it is speculated that the appearance of the four peaks may be caused by the following reasons: the rise of the first peak is due to the extension of the two legs, the body obtains the ground reaction force, and the center of gravity accelerates. The decline period is due to the gradual extension of the knee and ankle joints, the strength of the depression gradually decreases, the body is subjected to gravity and the ground reaction force, the body is subjected to the external force direction downward, and the center of gravity has a downward direction.

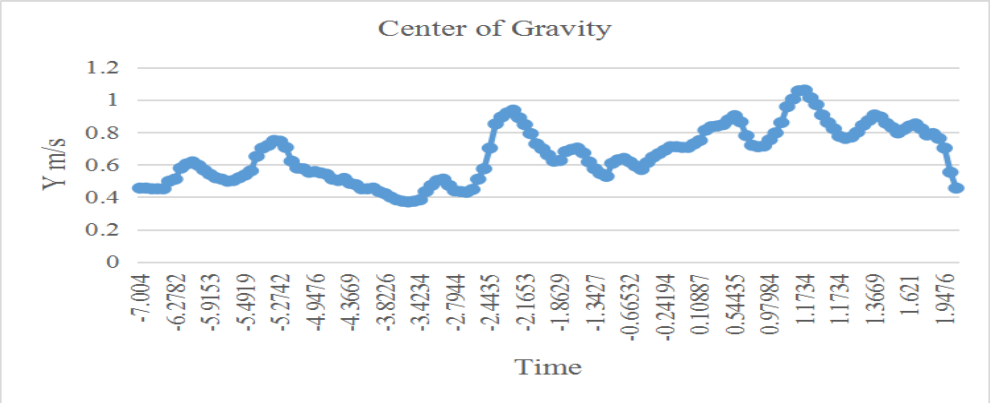

Figure 1. Curve of the center of gravity of the body without the hem

Table 2. List of the center of gravity of the left foot off the ground

Number	1	2	3	4	5	6	7	8	9	10
Speed	2.64	3.01	2.91	2.99	2.57	2.46	3.16	2.67	2.08	3.03
Y speed	1.33	1.46	1.25	1.66	1.71	1.19	2.06	2.05	1.31	1.42

The 10 test subjects were left foot and finally left the ground to complete the jump. Table 2 lists the time of the left foot of the 10 test subjects, the center of gravity speed value. The 1st serve has a center of gravity and speed of 0.18 m/s compared to the 6th serve, and the forward speed is 0.14 m/s. The service on the 2nd is 10.5 meters slower than the service on the 7th, and the forward speed is 0.6 meters. Compared with the average of 3 times of serving with hem and 3 shots, the center of gravity is 0.32 meters faster and the forward speed is 0.42 meters.

5.2. Knee Joint Motion Feature Extraction Analysis

Table 3 is a random selection of 2 subjects for data analysis. Figure 2 shows the height reached by the two athletes. Both athletes showed obvious knee-squatting movements during the throwing stroke. In the first serve, the maximum flexion angle of the left knee was 87.16 °, and the maximum knee flexion angle was 131.29 °. The maximum flexion angle of the left knee in the second tee was 99.28 °, and the maximum flexion angle of the right knee was 151.06 ° (Table 3). The maximum flexion angle of the left knee angle of the athlete's first serve in the first serve is 100.23 °, and the maximum knee flexion angle of the right knee is 125.71 °.

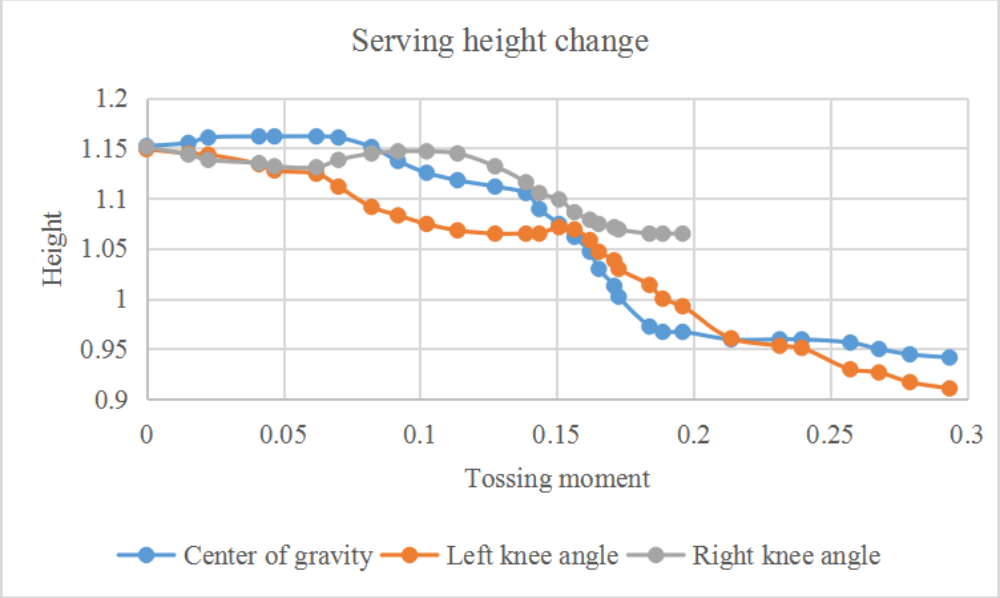

Figure 2. The decrease in the center of gravity of the athletes on the 2nd and the height change of the knee joint

If the knee flexion is too large or too small, it will not produce the best amount of force, which is not conducive to the entire tee movement. Excessive knee flexion will cause excessive load on the extensor muscles, affecting the speed of knee extension and the other parts of the body. The knees are too small to fully stretch the knee muscles, affecting the reserve of elastic potential energy, and thus affecting the knee extension strength. Make the body unable to get a good vertical speed.

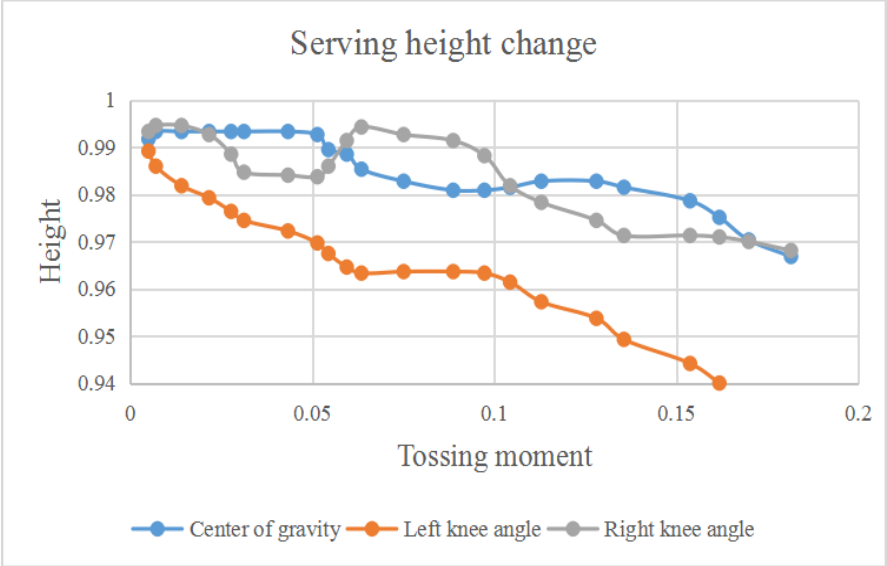

Figure 3. The lowering of the center of gravity of the athletes on the 7th and the height change of the knee joint

Table 3. Bending angle of knee joints of two athletes

	Angle of Throwing Time	Minimum Knee Angle	Bending Time	Bending Angle	Center Lowest Point Angle
First Time on the 2st	172.22 °	87.16 °;131.29 °	0.53	81.29 °	151.23 °
Second Time on the 2st	169.38 °	99.28 °;151.06 °	0.62	77.16 °	149.21 °
First Time on the 7st	166.58 °	100.23 °;125.71 °	0.49	89.21 °	140.58 °
Second Time on the 7st	169.34 °	110.1 °;144.26 °	0.51	90.28 °	144.27 °

5.3. Analysis of the relationship between the angle of the serve and the success rate

Combined with Table 4, we can see that the average success rate and standard deviation of the athletes in the middle of the road are (0.63±0.21), the average and standard deviation of the internal angles are (0.62±0.33), and the success rate and standard deviation of the outer corners. The success rate of the player in the middle of (0.58±0.29) is significantly higher than the success rate of the inner corner, slightly higher than the success rate of the outer corner.

Table 4. Descriptive statistics on the success rate of domestic players from different angles

Angle	Average	Standard Deviation
Middle Road	0.63	0.21
Inner Angle	0.62	0.33
Outer Angle	0.58	0.29

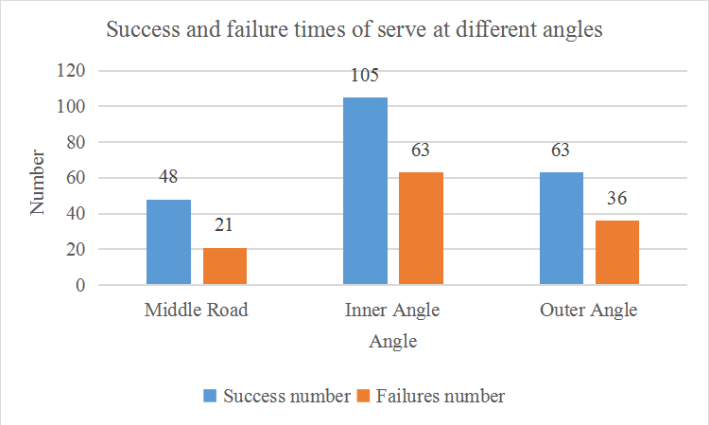

Figure 4. Number of successes and failures of domestic players at different angles

Through these data, we know that the selection of the landing point of Chinese tennis players is concentrated in the outer corner, and the success rate of the outer corner is between the success rate of the inner corner and the middle road, and the success rate of the inner corner is the lowest. From the communication with these offensive players, it is found that these players are biased towards the outer corner of the service in the daily training. The inner corner is generally chosen as its unconventional drop point, so the success rate is not guaranteed.

Table 5. Descriptive statistics of the success rate of foreign players from different angles

Angle	Average	Standard Deviation
Middle Road	0.62	0.33
Inner Angle	0.59	0.35
Outer Angle	0.59	0.39

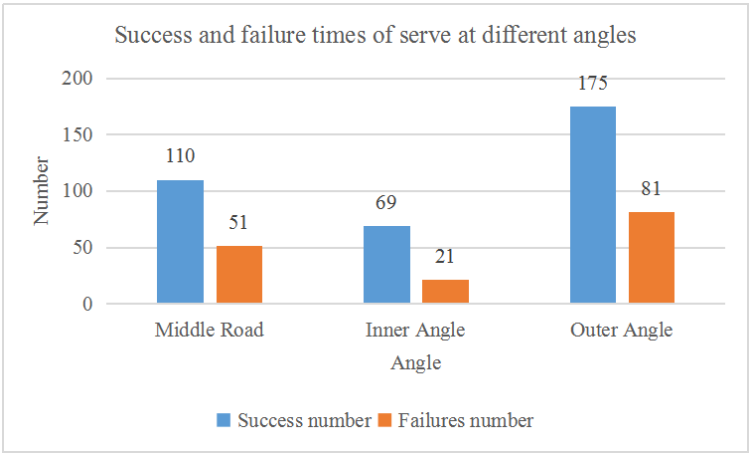

Figure 5. Number of successes and failures of foreign players in different angles

From these data, it can be seen that the ability of the inner, middle and outer corners of foreign offensive athletes is relatively average, and there is not much difference. In combination with Figure 5, it can be seen that the total number of times the foreign athletes serve in the outer corner is 256 times, the number of successes is 175, the number of failures is 81, the total number of calls in the middle is 161, the number of successes is 110, the number of failures For 51 times, the total

number of servings in the inner corner was 95, the number of successes was 69, and the number of failures was 26. It can be seen that the foreign players' outer corners are the first choice when they are in the game. The success rate can be seen that the outer corner is also their most sure point.

Compared with the serve success rate of the other two regions, the domestic player's internal corner serve success rate has a certain gap with foreign players, the difference is 8.6%. In the three regions of foreign players, the serve is relatively average, and the success rate of domestic players should be improved. We all know that the serve in the game can not always maintain the same habits and routines, and should be selected in the choice of placement. In terms of diversity, this requires players to have a balanced ability to serve in each area, so increasing the success rate of the inside corner should be the focus of their training.

6. Conclusion

In order to effectively analyze the tennis teeing technique, this paper uses fuzzy mathematics method to construct a fuzzy evaluation model to evaluate and analyze the relationship between the rapid strength of the tennis player's serve speed and the relevance of each training method. Expert opinions and quantitative analysis of these opinions help to understand the relationship between the two and provide a large theoretical basis for training. Through research, we found that the athletes adopt the FB station technology, adopting the back pendulum upwards, and the flexion and extension of the lower limbs are sufficient, increasing the distance between the head and the ball, and obtaining a better posture for the body; the tossing is too high, throwing the ball direction is better. Whether the domestic or foreign offensive athletes are the first choice in the first serve, the outside corner is the first choice, the foreign player's outer corner selection rate is 53.6%, while the foreign player's outer corner selection is 51.2%, in which the domestic player's outer corner success rate is reached. 71%, foreign players reached 76%. Compared with the serve success rate of the other two regions, the domestic player's internal corner serve success rate has a certain gap with foreign players, the difference is 8.6%.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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