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## Comprehensive evaluation research of volleyball players' athletic ability based on Fuzzy mathematical model

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### ABSTRACT

In the confrontation process of volleyball, the key to ultimate victory is athlete's athletic ability; if we can establish a comprehensive evaluation system and model of volleyball players, it helps targeted training and skills improvement of athletes, and wins more honor for Chinese sports circle. This paper studies the technical and tactical characteristics of volleyball players, starts from the physical agility, skills, psychology and intelligence four areas in order to establish a comprehensive evaluation system of volleyball players and explore the scientific, reasonable and workable evaluation methods, and contributes to the targeted training of athletes. The study gives fuzzy set definition with the hundred-mark system and five evaluation grades, and provides algorithm for the quantitative analysis of each index's test results in the index system, finally gives the algorithm steps of volleyball players' comprehensive evaluation based on fuzzy mathematical model, and provides a theoretical basis for the reasonable evaluation of the athlete. © 2014 Trade Science Inc. - INDIA

### KEYWORDS

Volleyball tactics;  
AHP analysis;  
Judgment matrix;  
Fuzzy mathematics;  
Index quantification.

### INTRODUCTION

After nearly a century of development, the modern volleyball has become one of the projects widely used in the world, which is one of the most favorite sports and has the greatest influence. Along with the reform of contemporary volleyball competition system, it makes the sport take the fast change, superb skill and great strength as purposes; it has become the driving force of the development trend of volleyball, but it does not ignore the importance of people; the problem here is the ability of the athlete; only enhancing the comprehensive strength of volleyball players can promote the reform

and development of the project more conveniently. This paper takes volleyball for example, conducts analysis of the athletes' physical ability, skills, psychology and intelligence, explores the core factor that influences the athletes' athletic ability, and provides a basis for the comprehensive evaluation of athletes.

For the research of volleyball players' comprehensive evaluation a lot of people have made efforts; it is these people's efforts that make China lead the advanced level of the volleyball world, some people study the evaluation of athletes from physical fitness; some people study from the technical tactical level, some others study from the physiological parameters; from which

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: Yang yang (2013) took three Universities in Gansu Province for an example to study volleyball players, used literature, Delphi method, mathematical statistics and other methods to construct the level system of special fitness index for Gansu college volleyball players, evaluated the volleyball players' specialized physical fitness, finally established scoring criteria, and provided reasonable suggestions for the upgrade of athletes' special fitness<sup>[1]</sup>; Zhang Xiao-dan (2013) studied specialized sports quality indicators of the Chinese elite female beach volleyball players based on the literature and expert questionnaire, tested the women's volleyball players that are in active service and also the women's volleyball players preparing for the 2008 Olympic, established the target structural model of players' specific quality assessment, and provided a theoretical basis for the training objectives of Chinese women's national beach volleyball team<sup>[2]</sup>; Guo Yu-jie et al (2014) compared the competitive level and differences of aerobic, anaerobic capacity for volleyball players at different positions, and explored aerobic, anaerobic capacity characteristics and laws of excellent women's college

volleyball players, provided a theoretical basis for the athletes' function evaluation and training arrangements before the competition<sup>[3]</sup>.

On the basis of previous studies, this paper analyzes the physical, skill, mental and intellectual characteristics of athletes reflected in women's volleyball tournament, extracts the index to conduct the comprehensive evaluation on volleyball players, and establishes a comprehensive evaluation system; in the late process of the research, it uses the evaluation method of fuzzy mathematical model, provides a theoretical basis for the comprehensive evaluation of volleyball players, and provides guidance direction for the targeted training of athletes.

## STUDY OBJECT AND METHOD

### Study object

This paper takes the 20 players in the women's volleyball team as the study object, and the basic situation of the players is shown in TABLE 1.

TABLE 1: The basic information of the study object

Category	Number of people	Category	Number of people
Master Sportsmen	9	16~18 years old	7
First level athletes	6	18~20 years old	4
Second level athletes	5	20~22 years old	5
14~16 years old	2	22~24 years old	2

### Study method

#### Literature

It searches CNKI database and finds out 30 journal articles and 9 master's thesis on the application of sports training theory, volleyball players' athletic ability and fuzzy mathematics in evaluation of athletes, provides a theoretical basis for the comprehensive evaluation of volleyball players in this article, and provides the basis for the indicators extraction in athletes' evaluation system.

#### Expert interviewing method

In order to screen the indicators, conduct authoritative survey of the established system; in order to provide advice for the existing problems and urgent problems in the teaching, it needs the interviews of expert;

considering the authority of the established tactical teaching system, this paper sets up the expert groups by five professors, three associate professors and two coaches.

#### Questionnaire method

It investigates the competitive ability indicators of the excellent women volleyball players; in order to increase the reliability of the survey, this study uses "re-survey method" to test, the time interval of two surveys is 15 days; through the statistics data of the questionnaires, the correlation coefficient of the groups of data is 0.91, and the significance level is less than 0.01.

#### Mathematical statistics

In order to conduct quantitative analysis of the indicators, this paper quantifies the indexes using the fuzzy set method of fuzzy mathematics and data standardiza-

tion methods, and uses EXCEL software and SPSS statistical software for data processing.

### **Analytic hierarchy process**

In order to conduct unified systematic analysis on the quantitative and qualitative analysis, the paper adopts AHP analysis, analyzes the multi-objective and multi-criteria comprehensive evaluation index system for the volleyball players.

## **ESTABLISH THE COMPREHENSIVE EVALUATION INDEX SYSTEM OF VOLLEYBALL PLAYERS**

Athlete's athletic ability refers to the athletes' ability to effectively participate in training and competitions; Volleyball Players' athletic ability in this study can be analyzed from athletes' physical fitness, technical and tactical ability, psychological quality, sports intelligence and other factors; the five abilities exist different levels of fit and constraints; in the tournament players can lay the foundation for the final victory only by applying these qualities scientifically and tactfully.

The establishment of volleyball players' comprehensive evaluation index system can extract from the structure of sportsmen's competitive ability; by the above analysis the structure of the athletic ability is constituted by physical agility, skill, intelligence and psychology four-part; in the following it extracts the comprehensive evaluation indexes of athletes from the above four parts of the structure, conducts expert interviews on the primary indicators after extraction, screens the indicators in line with the principle of scientificity, testability, relative independence, objectivity and simplicity, and ultimately gets the comprehensive evaluation index system for volleyball players; there are four first level indicators, eight second level indicators, sixty-two third level indicators in the index evaluation system.

### **Analysis on factors affecting volleyball player's competitive ability**

The structure of athletic ability is constituted of the physical agility, skill, intelligence and psychology four components; physical agility is mainly reflected in the athletes' special physical fitness, the level of physical function and physical shape characteristics; skills are

mainly reflected in athletes' ability to use volleyball's special technique and tactic; intelligence is mainly reflected in players' tact behavior in training and competition; psychology is mainly reflected in athletes' control ability to psychology; the following analyzes the structural components of volleyball players' athletic ability, in order to provide a theoretical basis for the extraction of athletes' comprehensive evaluation index.

### **1) Physical agility**

As can be seen from the volleyball court, the physical characteristics of athletes shows a higher consistency; from the structures of athletes' body shape, the players are all very tall; this tall body shape can be summarized as height, limb length, short sitting height, thin cortical layer, big physical density, small amount of body fat, wide hand, arm length, narrow pelvis, wide and not long foot, arch height, length of the Achilles tendon and the features of 12 parts; such a body shape helps to improve the offensive effect of serving; from the perspective of physiological function, in the contest process athletes' metabolic mean take the aerobic metabolism function as basis, take the anaerobic metabolism function as the core, the player need to have a good anaerobic metabolism ability; from the perspective of quality features, excellent volleyball players have better movement speed, arm swing speed, flexibility, endurance and jumping ability, these are the athletes' physical characteristics; and health level is the basis of these features.

### **2) Skills**

Technical level of excellent volleyball players is mainly reflected from the proficiency of basic skills, solid degree of basic skills, comprehensive degree of technical level, accuracy degree of the basic skills and prominence degree of the characteristics; in the evaluation process of volleyball players' athletic ability, skills link is the important part that cannot ignore; athletes need continuous innovation in the process of techniques and tactics application, and strive to become a player with complete skill; technical ability is reflected in the grasp situation on the variety of technical movements; and tactical ability is mainly reflected in the individual and collective tactics combination, tactics innovation, tactical theory and many aspects, etc. Therefore specialized training for volleyball players is necessary.

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### 3) Intelligence

In volleyball confrontation process, teammates and coaches are not allowed to enter the venue; players need to control the court's environment and competitive features, athletes need to have a higher intellectual level for the confrontation project that have fast ball speed and more changes; this ability allows players be flexible and improvise, thus the players can deal with a variety of unexpected complexity in the game; the athletes' reaction speed and intellectual level influence the play effect of the sport's techniques and tactics.

### 4) Psychology

Volleyball sports require a higher mental qualities for players; in the confrontation, when the point loss, no good fighting awareness and self-control ability appear due to the players' own technical movement fault; when the situations of these psychological characteristics arise, it will have a significant impact on the competition results; psychological quality characteristics of volleyball players is reflected in aspects of decisive degree to deal with the problem, the degree of tacit understanding to collaborate with other team members, the ability to mutually encourage and increase the confidence.

According to the relation between the elements of athletes' athletic ability, it builds the model structure to reflect the economic capacity, which is the process to generalize, conclude and abstract athletes' athletic ability; This is the only way to reveal the overall level of volleyball players from a deeper level. At the beginning of establishing the comprehensive evaluation system of volleyball players, we need to screen the evaluation indicators in accordance with the principles of the scientific, testability, relative independence, objectivity and simplicity.

### The screening process and results of volleyball players' comprehensive evaluation index

Screening process of indicators is built on the basis of the primary indicators; the study conducts questionnaire survey of 90 primary single indicators and divides the importance degree of each indicator into five grades; the evaluation language from excellent to poor are respectively: "very important", "more important", "important", "general" and unimportant; and set the weight

$\alpha_i (i = 1, 2, \dots, 5)$  scores of five grades as in formula (1) below.

$$(\alpha_1 \ \alpha_2 \ \alpha_3 \ \alpha_4 \ \alpha_5) = (5 \ 4 \ 3 \ 2 \ 1) \quad (1)$$

The corresponding evaluation language of each single indicator has the above five grades; each member of the expert group votes the importance degree of indicators in accordance with his own understanding, and then it conducts the data normalization process by row, the number of votes corresponding to index  $i$  is represented by  $n_{ij} (i = 1, 2, \dots, 90; j = 1, 2, \dots, 5)$ , the corresponding evaluation language level to  $j$ , the degree of importance reduces gradually from 1-5; the score of the index  $i$ 's importance degree is shown in formula (2) below.

$$\begin{cases} N_i = \sum_{j=1}^5 n_{ij} \\ \text{Mark}_i = \left( \frac{n_{1j}}{N_i} \quad \frac{n_{2j}}{N_i} \quad \frac{n_{3j}}{N_i} \quad \frac{n_{4j}}{N_i} \quad \frac{n_{5j}}{N_i} \right) \\ \cdot (\alpha_1 \ \alpha_2 \ \alpha_3 \ \alpha_4 \ \alpha_5)^T \end{cases} \quad (2)$$

Using this method the  $\text{Mark}_i$  means the importance degree of this index; in order to further refine the comprehensive evaluation index system of volleyball athletes, it is divided into four first-level indicators as physical agility, skill, psychology and intelligence; according to the importance degree of the primary elected indicators, it uses the indicators whose importance degree is more than 4.0 points; the name, the importance degree and the standard deviation of the filtered second level indicators are shown in TABLE 2.

After screening there are total fifty-two remaining third level indicators, divide the index symbols according to the second level indicators, its importance degree and index names are as shown in TABLE 3.

### Establish the comprehensive evaluation system for volleyball players

According to the indicator screening results in accordance with the above importance degree, the study conducts simple treatment on it, and we can draw the volleyball player's comprehensive evaluation system as shown in Figure 1.

The structure of the comprehensive evaluation sys-

**TABLE 2 : The screening results of the second level indexes under the Volleyball Players' comprehensive evaluation first level index**

First level indexes	Second level indexes	The corresponding importance degree of the index after screening	Standard deviation of the findings
Physical agility-A	Body Shape -A1	4.69	0.947
	Body functions -A2	4.38	0.768
	Sports quality -A3	4.77	0.439
	Healthy level -A4	4.77	0.599
Skill -B	Technical capacity -B1	5.00	0.000
	Tactical level -B2	4.58	0.555
Psychology -C	Mental ability -C1	5.00	0.000
Intelligence-D	Exercise intelligence -D1	4.77	0.439

**TABLE 3 : The screening results of the third level indexes for the Volleyball Players' comprehensive evaluation system**

Index Symbol	Index Name	Importance degree	Index Symbol	Index Name	Importance degree
A11	Height	4.75	A31	30m	4.65
A12	length of upper limb	4.69	A32	60m	4.85
A13	length of lower limb	4.38	A33	V-Movement	4.69
A14	Hand length	4.62	A34	M-movement	4.85
A15	Span - Height	4.15	A35	Prone and 20m running	4.46
A16	Shoulder rotation distance	4.00	A36	The touch height when both Feet take-off	4.46
A17	Achilles tendon length	4.38	A37	Mean value of ten consecutive touch height	4.85
A18	Foot-shape	4.38	A38	Run-up touch height	4.77
A19	Body fat ingredient	4.00	A39	Standing long jump	4.46
A21	Morning Pulse	4.31	A310	Badminton throw	4.69
A22	Maximum heart rate	4.77	A311	Deep squat	4.77
A23	Maximal oxygen uptake	4.54	A312	1min straight leg sit-ups	4.62
A24	Blood testosterone	4.31	A313	30s double rock jump	4.08
A25	Blood lactic acid BLA	4.15	A41	Past medical history	4.08
A26	Hemoglobin	4.54	A42	Sports Injuries	4.38
A27	Vision	4.54	B11	Serve Technology	4.92
A28	Body function	4.38	B12	Passing Technology	4.77
B21	The application of offensive tactics	4.62	B13	Ball digging technology	4.92
B22	Ability to improvisation	4.92	B14	Spike Technique	5.00
B23	Defensive and offensive tactics	4.85	B15	Comprehensiveness of technical grasp	4.85
C11	Competition mood	4.92	B16	Effectiveness of technical sports	4.85
C12	Game motivation	4.38	B17	Proficiency of technical action	4.92
C13	Volitional quality	4.92	D11	Pay attention to the quality	4.15
C14	Self-confidence level	4.85	D12	Intelligence	4.77
C15	Central nervous fatigue	4.08	D13	Cultural level	4.38
C16	Sensory perception ability	4.23	D14	Professional knowledge	4.15

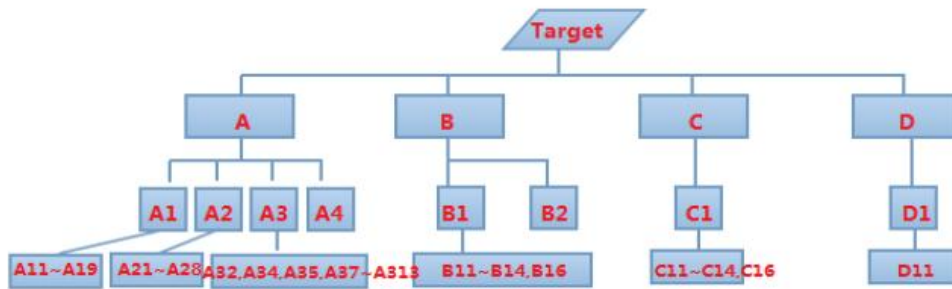


Figure 1 : Hierarchical chart of volleyball players' comprehensive evaluation index system

tem in Figure 1 shows that the third level indicators after simple treatment changes from the previous 52 to the remaining 39; so this study can be simplified that A1, A2, A3, A4, B1, B2, C1 and D1 as the first level indicators, the corresponding third-level indicators are the structure of second level indexes; according to the importance degree the computing method of weight distribution for the indexes at all levels are shown in formula (3), the formula (3) takes to the first level indicators as an example.

$$\begin{cases} \text{Mark} = \text{Mark}_{A1} + \text{Mark}_{A2} + \dots + \text{Mark}_{C1} + \text{Mark}_{D1} \\ (\beta_{A1} \ \beta_{A2} \ \dots \ \beta_{D1}) \\ = \frac{1}{\text{Mark}} (\text{Mark}_{A1} \ \text{Mark}_{A2} \ \dots \ \text{Mark}_{D1}) \end{cases} \quad (3)$$

According to equation (3) we can calculate the weight distribution condition of the eight first-level indicators after the simplicity, similarly we can obtain the weight distribution condition of each second level index under the first level indexes; so you can get the weight distribution results of all levels of indexes as shown in TABLE 4.

TABLE 3 shows that there are 42 evaluation indexes as height, arm length, length of lower limb, span-height, shoulder rotation distance, the Achilles tendon length, foot-shape, body fat ingredient, morning pulse, heart rate, maximal oxygen uptake, blood testosterone, blood lactic acid, hemoglobin, vision, body function, 60m, m-movement, 20m run starting from prone, the run-up touch height, average value of ten consecutive touch height, standing long jump, badminton throwing, deep squats, one minute straight leg sit-up, 30 seconds double shake jump, serving technique, ball digging technology, passing techniques, spiking technique, technical sports results, competitions mood, game motivation level, volitional quality, confidence level, sensory perception ability, central nervous fatigue, health level, the tactical level and intelligence level.

### COMPREHENSIVE ASSESSMENT METHOD OF VOLLEYBALL PLAYERS BASED ON FUZZY MATHEMATICAL MODEL

#### The fuzzy set definition of volleyball player's evaluation index

The fuzzy set is divided into five levels, respectively very good L1, good L2, general L3, poor L4 and very poor L5; the centesimal system stipulates that the score range of very good is (90-100), the score range of good is (80-90), the score range of general is (70-80), the score range of poor is (60-70), the score range of very poor is below 60 points; the to be tested indicators in this article are divided into two types, one is the result of the questionnaire survey, one is the result of test data; to quantify the investigated indicators results, it uses principles of evaluation language and corresponding scores, namely the corresponding value to very good is 100 points, the corresponding value to good is 90 points, the corresponding value to general is 80 points, the corresponding value to poor is 70 points, the corresponding value to very poor is 60 points.

The treatment way of measurable indicators can take the 0.5 times standard deviation, sigma, 1.5 times standard deviation, 2 times standard deviation, 2.5 times standard deviation and more than 2.5 times standard deviation as the evaluation criteria; take height for an example, the height mean of excellent women volleyball athletes is 175.71 cm, the standard deviation is 4.76cm, then the corresponding evaluated language for the athletes with different heights is shown in formula (4) below.

$$L = \begin{cases} L1, [(\bar{x} - 0.5 \times s), (\bar{x} + 0.5 \times s)] \\ L2, [(\bar{x} - 0.5 \times s), (\bar{x} - s)] \cup [(\bar{x} + 0.5 \times s), (\bar{x} + s)] \\ L3, [(\bar{x} - 1.5 \times s), (\bar{x} - s)] \cup [(\bar{x} + s), (\bar{x} + 1.5 \times s)] \\ L4, [(\bar{x} - 2 \times s), (\bar{x} - 1.5 \times s)] \cup [(\bar{x} + 1.5 \times s), (\bar{x} + 2 \times s)] \\ L5, [(\bar{x} - 2.5 \times s), (\bar{x} - 2 \times s)] \cup [(\bar{x} + 2 \times s), (\bar{x} + 2.5 \times s)] \end{cases} \quad (4)$$

TABLE 4 : The weight distribution results of all levels of indexes according to importance degree

First level index	Second level index	Weights	First level index	Second level index	Weights	First level index	Second level index	Weights
A1	A11	0.13	A3	A32	0.12	C1	C11	0.21
	A12	0.11		A34	0.12		C12	0.20
	A13	0.10		A35	0.09		C13	0.23
	A14	0.12		A38	0.10		C14	0.18
	A15	0.11		A37	0.12		C16	0.18
	A16	0.10		A39	0.11		A3	0.13
	A17	0.12		A310	0.08	A4	0.13	
	A18	0.11		A311	0.09	B1	0.14	
	A19	0.10		A312	0.08	B2	0.13	
	A21	0.12		A313	0.10	C1	0.14	
A2	A22	0.14	B1	B11	0.23	A1	D1	0.13
	A23	0.13		B12	0.23			
	A24	0.12		B13	0.16			
	A25	0.12		B14	0.25			
	A26	0.11		B16	0.23			
	A27	0.13		A1	0.09			
	A28	0.13		A2	0.11			

In formula (4)  $L$  represents the corresponding evaluation language to the index data of certain athletes,  $\bar{X}$  means that the average value of the index,  $S$  means that standard indicators of test index data; there are many indicators with high priority, also there are many indicators with low priority; during volleyball exercise, the mean value herein taken in this paper is the

data mean of the national excellent volleyball players; we take these data as a standard to evaluate other athletes, namely we take the data indicators of elite volleyball players as a reference substance, and take the mean and standard deviation of different multiples as boundaries of level classification.

To divide the fuzzy level of the test data, this paper obtains the mean value and standard deviation of each

TABLE 5 : The mean and standard deviation of testability index data for excellent women’s volleyball athletes

Index	Mean	Standard deviation	Index	Mean	Standard deviation	Index	Mean	Standard deviation
A11	175.71	4.76	A26	13.11	0.76	A313	62	3
A12	77.81	1.67	A27	73.14	3.53	B11	8.24	1.22
A13	104.10	4.96	A28	3.25	1.57	B12	9.34	0.34
A14	18.32	0.85	A32	8.52	1.41	B13	8.91	0.58
A15	5.24	2.64	A34	8.64	0.76	B14	9.33	0.32
A17	24.92	2.87	A35	3.44	0.23	B16	8.79	1.07
A19	15.67	3.51	A37	2.98	0.14	C11	52.83	2.67
A21	54.51	4.21	A38	2.96	0.25	C12	7.27	0.65
A22	186.12	6.83	A39	2.42	0.38	C13	38.13	4.21
A23	4.51	0.46	A310	8.32	1.76	C14	8.83	0.95
A24	93.64	5.47	A311	86.07	10.32	D11	55.94	24.60
A25	9.25	1.46	A312	47.5	4.5	D12	73.65	17.32

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testability index data for excellent women's volleyball athletes as shown in TABLE 5.

### Fuzzy evaluation step

STEP1 According to formula (4) the fuzzy evaluation grade of the test index data can be obtained;

STEP2 According to the survey results the fuzzy evaluation grade of the investigative index can be obtained;

STEP3 Conduct assignment on to be measured indicators in accordance with the standard of formula (5);

$$\text{Mark} = \begin{cases} 100, L1 \\ 90, L2 \\ 80, L3 \\ 70, L4 \\ 60, L5 \end{cases} \quad (5)$$

STEP4 According to equation (6) calculates the score of volleyball player's higher level index;

$$G = (\text{Mark}_1 \quad \text{Mark}_2 \quad \dots \quad \text{Mark}_n) \begin{pmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_n \end{pmatrix} \quad (6)$$

And so we eventually obtain the volleyball player's comprehensive evaluation scores in turn, and then need to compare the number of athletes, or the evaluation grade of individual athletes provides reference for targeted training of athletes.

## CONCLUSIONS

- 1) This paper first analyzes the required skills, character and qualities of volleyball players in the confrontation process, sums up the characteristics of four aspects as physical agility, skill, psychology and intelligence, provides a basis for the extraction of athletes' comprehensive evaluation index.
- 2) By analyzing the four aspects of physical agility, skill, psychology and intelligence, this paper obtains the primary second level indexes and third level indexes under the four first level indexes, and screens the primary indicators according to the importance degree of the survey data obtained in interviews with experts, and then uses simple principles to conduct a secondary screening for the

indicator system, obtains eight first level indicators and thirty-nine second level indicators, and through analysis there are total forty-seven measurable indicators; during this period also obtains corresponding weights distribution of each index, and provides a basis for the rear fuzzy evaluation.

- 3) It gives fuzzy set definition with the hundred-mark system and five evaluation grades, and provides algorithm for the quantitative analysis of each index's test results in the index system, finally gives the algorithm steps of volleyball players' comprehensive evaluation based on fuzzy mathematical model, and provides a theoretical basis for the reasonable evaluation of the athlete.
- 4) Key content of this study is the analytical method on the index system establishment, index data quantitative method and quantitative indexes of volleyball players' competitive evaluation; the quantization process of indicators can be divided into the indicator quantization process of measurable data type and survey indicators; the quantization process of measurable data uses the 0.5 times standard deviation as the way of level nodes, and combines the index data with the hundred-mark system; and finally by associating the index data after quantization with the previous weight allocation results, we can calculate the final score of players, and then we evaluate the athletes according to the range of the score. Advantages of this paper is to extract the index and establish the index system taking the instance as object, and provides a method for the establishment of athletes' comprehensive evaluation system, divides the quantification process of indicators into two categories, and gives the comprehensive evaluation algorithm based on the fuzzy mathematical model.

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