Development of Optimal Performance Indicators for Chinese Youth Badminton Players

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Abstract

Background and aim: The badminton program is one of the strongest sports in China. In recent years, it has been faced with two challenges, such as the problem of cultivating Chinese junior badminton athletes and the pressure of international competition brought by the rapid progress of junior athletes from Thailand, Denmark, India, and other countries. This study aims to establish the evaluation system of youth badminton performance is crucial to providing scientific, systematic, and comparable data and suggestions for the General Administration of Sport of China and the development of badminton in China.

Methods: This study used the questionnaire method to investigate and analyze the factors affecting the performance of Chinese junior badminton athletes. The whole population sampling method was used to sample the youth badminton athletes and coaches in Guangdong Province, China. A total of 420 questionnaires were distributed and 400 questionnaires were valid, including 265 males and 135 females. The Delphi method was used to screen and construct the evaluation indexes of the best sports performance of Chinese youth badminton athletes. 19 people, including professors, national coaches, and high-level athletes, formed a panel of experts, and the evaluation indexes were discussed and screened in two rounds.

Results: The results showed that the factors affecting the performance of Chinese junior badminton athletes were five aspects, including the length of athletes' training, the level of coaches' training, the level of athletes' grades, the athletes' best performance, and the athletes' situation. The evaluation indexes of Chinese youth badminton athletes' best performance include three primary indexes: physical quality, competitive strength, and game performance; seven secondary indexes: body form, physical function, physical quality, technical ability, tactical ability, psychological ability, and motor intelligence; and seventy-one tertiary indexes, such as lung capacity, one-minute pull-ups, badminton slamming, and self-control ability.

Conclusion: The factors affecting the performance of Chinese junior badminton athletes are complex and diverse. A three-level multidimensional evaluation index of the best sports performance of Chinese junior badminton athletes was constructed to provide a scientific basis for the training of Chinese junior badminton athletes and to provide reference data for the General Administration of Sport of China to formulate badminton development policies.

Keywords: Chinese Junior Badminton Athletes; Influencing Factors; Best Performance Indicators

Introductory

The Badminton program is one of the strongest sports in China. In recent years, the development of Chinese badminton has faced two challenges: firstly, the retirement of the old generation of legendary athletes has made the cultivation of young Chinese badminton talents a key issue. Secondly, the rapid progress of junior badminton athletes from Thailand, Denmark, India, and other countries has also brought unprecedented challenges to Chinese badminton.

For China, the athletic performance of young badminton athletes is a key part of talent cultivation (She & Xu, 2021), and the establishment of an evaluation system for the athletic performance of young badminton athletes is imminent in China (Journal of Guangzhou Sports Institute, 2021).On September 2, 2019, the Outline for the Construction of a Strong Sporting Nation, formally issued by the General Office of the State Council of China, explicitly proposes to comprehensively promote the popularization

of badminton, improve the scientific level of training and competition (Central Committee of the Communist Party of China and the State Council, 2019), and actively explore the development road with Chinese characteristics to improve the level of training and competition. The scientific level of the race. China's State General Administration of Sports (SGAS) established nine projects to build a strong sports nation, stating that "we should comprehensively implement a project to cultivate youth sports talents and youth sports coaches, and build a new pattern for cultivating youth reserve talents". Subsequently, in 2020, the State General Administration of Sports and the Ministry of Education jointly issued the Opinions on Deepening the Integration of Sports and Education to Promote the Healthy Growth of Young People, which put forward the opinions of vigorously developing youth sports clubs and improving the system of sports events. These relevant official documents provide very clear guidance for the development of youth badminton clubs and also show that the state is constantly promoting the development and progress of youth sports.

For this reason, this study thoroughly researches the nature and laws of badminton, analyzes the factors affecting the performance of Chinese youth badminton athletes, and establishes an evaluation system of the performance of Chinese youth badminton athletes, to provide the General Administration of Sport of China and the development of China's badminton industry with scientific, systematic, and referenceable data and suggestions.

Objectives
    1. To study the factors affecting the performance of Chinese junior badminton athletes.
    2. To develop the best performance indicators for Chinese junior badminton athletes

Literature Review
    The focus of this study was on the "Development of Optimal Performance Indicators for Chinese Junior Badminton athletes" and reviewed the following literature and studies:
    1. Theories related to the construction of the indicator system
       1.1 Relevant research on the evaluation index system of various sports programs
       Using the questionnaire survey method, expert interview method, and other screening to get the kinematic indicators that can reflect the strength of youth race walking athletes, and divided them into two kinds of stable indicators and sensitive indicators, to construct the evaluation standard of different speed interval race walking technology, and to analyze and evaluate the competitive strength of youth race walking athletes. The expert questionnaire survey method to construct a comprehensive evaluation system of physical fitness, and found that the key indicators of physical fitness of adolescent soccer athletes are special technology and body movement ability, and morphology is the basic guarantee of physical fitness level. (Zhao, 2017). The expert interview method was used to screen the cross-country skiing athletes' cross-selected indicators, including morphology, quality, function, and coach evaluation, and the athletes were tested, and one-way ANOVA and factor analysis were used to determine the key indicators of each level and the weight of each indicator, and to finally determine the corresponding evaluation standard. (Lu & Yan, 2020).

       1.2 Related research on the evaluation index system of badminton athletes' sports performance
       So far, several scholars have studied the sports performance evaluation index system of badminton athletes, Yin Hongzhou's study, established the sports quality evaluation system and evaluation standard of male badminton athletes in Sichuan colleges and universities, and the evaluation system consists of three first-level indexes (strength quality category; speed and sensitivity category; speed and endurance category) and 12 second-level intuitive indexes. (Nie & Liu, 2011)

In the study, through the analysis of the special characteristics of badminton and the influencing factors of badminton athletes' competitive ability, 13 indicators were selected to build the structural model of badminton athletes' selection index system, and the weights of the indicators were calculated by using hierarchical analysis and fuzzy mathematics, and finally the evaluation scale of badminton athletes' selection was formulated, which was obtained by experimental testing and other methods. The comprehensive score of the athlete is obtained through experimental testing and other methods, to scientifically and quantitatively realize the badminton athletes's late selection (Su & Gao. 2013).

In the study, 10 special physical quality indexes of excellent male badminton athletes in Shaanxi Province were tested, 6 typical indexes affecting the special quality of athletes were identified, the indexes were comprehensively analyzed, and the weight values were calculated, so that a comprehensive evaluation system of the special quality of excellent male badminton athletes was initially set up (Zhao & Ma, 2014).

In the study, through expert interviews, index optimization, and on-site testing, 3 first-level indicators (strength quality, speed, and sensitivity, speed and endurance) and 12 second-level indicators were screened out from a large number of indicators, and the evaluation index model and evaluation standard of special physical training of young male badminton athletes were initially established, which provides a good opportunity for the young badminton coaches to diagnose, check and evaluate the level of the athletes' special quality and even the Athletic level. It provides a reference for youth badminton coaches to diagnose, check, and evaluate the special quality level and even the competitive level of athletes (Que, 2014).

2. Factors that contribute to the excellence of young badminton athletes

In terms of physical fitness, the article "Physical Training for Badminton Athletes" reveals that current international badminton tournaments generally reflect high demands on the physical fitness of participants. To adapt to the ever-changing nature of the game and achieve excellence, it is vital to emphasize systematic physical training for children and adolescents. (Research by (Branta et al. 1984) has shown that boys' ability averages in tests of motor qualities such as explosive strength, speed endurance, agility, and balance gradually increase with age as they grow from children to adolescents. In contrast, girls' growth in these motor qualities begins to slow at about age 13 (Jones, 1994). The study also found that boys' muscle isometric contraction strength increased linearly with age from early childhood to approximately 13 years of age. Girls, on the other hand, continued to gain muscle strength through age 15 but did not show a significant rapid increase during adolescence. Adolescent athletes typically exhibit less strength, and less endurance, and are prone to fatigue. Given the characteristics of badminton and the physiological characteristics of athletes, coaches should have clear goals and focus in strength training: badminton strength training should prioritize the development of fast strength and strength endurance; avoiding the use of large-load, high-intensity training methods to improve the quality of strength (Wang, 2013). Among badminton athletes in the 13-year-old group, regardless of male and female, there is a significant correlation between the 20-meter × 5 round trip run, standing long jump, and athletic performance (Chen, 2018).

In terms of endurance qualities, badminton is played in a two-out-of-three-game system, and a single game score of 21 points is considered a victory, but the rules allow a single game score of 30 points, so the endurance requirements for athletes are extremely high. Since adolescents are in the stage of growth and development, their cardiorespiratory function is not yet fully mature, therefore, good endurance quality becomes the key for adolescent athletes to win in the game (Wen, 2014).

In terms of competitive pressure, the psychology of adolescent badminton athletes has not yet fully matured, and they are easily affected by various internal and external factors during the

competition, leading to psychological fluctuations (Cheng and Zhao, 1999). There is a certain connection between the self-consciousness, competition trait anxiety, and psychological control sources of adolescent athletes, and the phenomenon of "Choking" of athletes under pressure conditions is closely related to the public self-consciousness and the externally controlled type of psychological control sources (Dai, 2014). There was a significant main effect of stress and attentional instructions on serve efficiency in junior badminton athletes, but the interaction between the two was not significant (Wang, 2002).

In terms of technical and tactical aspects, it was elaborated in detail from the sense of the ball (including racket sense, stroke strength, and feel) and the importance of the sense of the ball (which helps to improve the technical level and comprehensive quality and provides a guarantee for the technical and tactical aspects of junior athletes) (Xiao, 2005). When young badminton athletes are performing technical and tactical training, to accurately perceive and judge the position, speed, and power of the incoming ball, and to quickly start and quickly move to the ideal hitting position, form a reasonable preparatory posture, and form the best spatiotemporal relationship with the incoming ball and the court, etc., all of which need to be safeguarded by standardized technical movements (Zhu, 2016). The backcourt killing technique of junior male badminton athletes was studied from the perspective of myoelectricity, and the results of the study showed that the overall backcourt killing technical movements were reasonable and better grasped at the moment of killing, but the time between jumping and landing was longer, which affected the next shot, indicating that there was still room for improvement (Yang, 2013).

3. Research Review

In exploring the training and competitive performance of adolescent badminton athletes, domestic studies have mainly focused on the training process and selection criteria of the athletes, and are committed to improving their technical level and game performance through scientific training methods. The research covers the impact of adolescent growth and development on technical ability, the development and implementation of training plans, and the standardization and detailed improvement of technical movements. These research topics are closely centered on improving the training efficiency and competitive performance of adolescent badminton athletes, emphasizing the practical application value of the research results.

Comparatively speaking, foreign studies are more inclined to the technical and tactical analysis of badminton, game strategy, and psychological training. The goal of these studies is to provide more comprehensive and detailed guidance for young badminton athletes and help them deeply understand and master the core elements of badminton.

In terms of research focus, domestic research focuses more on practical application and is committed to transforming research results into specific training methods and tools to improve the training efficiency and competitive level of young badminton athletes. Foreign studies, on the other hand, focus more on theoretical exploration and experimental verification, aiming to reveal the intrinsic connection between sports performance and various factors.

In terms of research methodology, domestic studies mostly adopt empirical research and case study analysis to verify the effects of different factors on the athletic performance of junior badminton athletes through actual investigation and data analysis. These studies are usually based on actual training and competition data, and use methods such as statistical analysis, comparative study, and trend prediction to explore the interrelationships among the factors and their effects on sports performance. In contrast, foreign studies are more inclined to experimental research and interdisciplinary research methods. These studies usually adopt experimental design methods such as randomized controlled trials, quasi-experiments, and observational methods to explore the effects of factors on athletic performance

using controlling variables and setting up control and experimental groups. In addition, foreign studies also emphasize interdisciplinary cooperation, applying multidisciplinary theories such as psychology, biomechanics, physiology, sociology, and so on to the study of adolescent badminton athletes, to comprehensively reveal the influencing factors and the mechanism of action of sports performance.

To summarize, domestic and foreign research has achieved certain results in the research of young badminton athletes, sports performance influencing factors, badminton sports performance, and other related topics. Domestic research has obvious advantages in practical application, focusing on transforming research results into specific training methods and tools; while foreign research is more in-depth in theoretical exploration and experimental verification, focusing on multidisciplinary cooperation and innovation. It is of great significance to construct a sports performance index system for Chinese junior badminton athletes, which can comprehensively assess the sports performance of junior athletes and provide a scientific basis for training and competition.

Conceptual Framework

The design idea of the project "Development of Optimal Performance Indicators for Chinese Junior Badminton Athletes" is as follows:
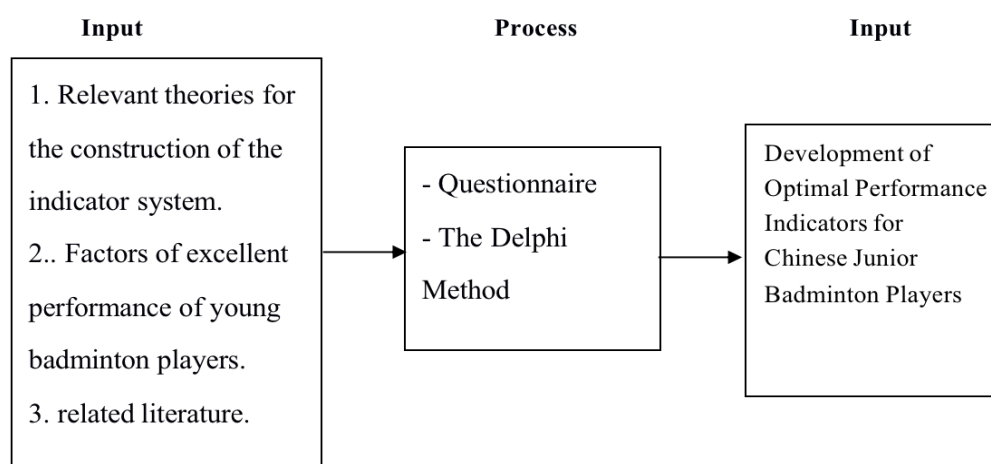

Figure 1 Conceptual framework of the study

Methodology

1. Research methodology on the influencing factors of Chinese junior badminton athletes' sports performance

Population specification and size: A questionnaire survey of selected athletes and coaches from professional sports teams, sports schools, and traditional sports schools with badminton programs in Guangdong Province, China, was conducted using a cluster sampling method. The criteria for selecting athletes were youths aged between 16 and 18 years old with a sports level of Grade 1 and above; the criteria for selecting coaches were junior coaches and above. A total of 420 questionnaires were distributed, 349 questionnaires were collected from athletes 51 questionnaires were collected from coaches, 400 questionnaires were valid, and the recovery rate was 95.2%. Among them, 265 were male and 135 were female.

Research tools: The self-developed "Best Performance Questionnaire for Chinese Junior Badminton Athletes" was used. The questionnaire covered the following parts, such as the training hours of the athletes, the training level of the coaches, the grade level of the athletes, the best performance of the athletes, and the personal situation of the athletes, etc., and the data were statistically analyzed using

SPSS.26.

2.The research method of the evaluation index system of the best sports performance of badminton athletes

Adopting the Delphi method, a panel of 19 experts, including professors, national coaches, and high-level athletes, constructs the evaluation index system of the best sports performance of badminton athletes from three main indexes, namely physical quality, athletic strength, and competition strength. This study initially formulated the three-level indicators of the best evaluation index for Chinese youth badminton athletes, in which A1-A3 is the first-level index: B1-B7 is the second-level index: C1-C115 is the third-level index. The Likert 5-point scale was used, with higher scores indicating greater importance.

The selection rate of entries is used to indicate the concentration of expert opinions, and the higher the value, the more concentrated the expert opinions are, the higher the importance of the entries, and the final "importance" classification of "very important" and "relatively important" is retained. In the end, the entries with a cumulative selection rate of more than 50% for "very important" and "relatively important" were retained.

According to the above principle of modifying entries, through the collation and analysis of the results of the first round of correspondence, a total of five entries with a selection rate of less than 50% for the factors affecting the cultivation of our country's competitive badminton reserves were deleted, which are: "C2 Sitting Height" "C7 Finger Length They are: "C2 Sitting Height", "C7 Finger Length", "C12 Lean Body Weight", "C52 Vertical Jump" and "C60 Kneeling Back Throw" and so on 29 entries, finally leaving 3 primary indicators, Finally, 3 primary indicators, 7 secondary indicators and 86 tertiary indicators were left for the second round of expert discussion. The experts of the second round of evaluation index screening are all coaches who have been engaged in badminton training for a long time. They selected the relative importance of the indicators according to their personal training experience. The second round of screening was carried out by calculating the mean value (the degree of concentration of experts' opinions on badminton) and the coefficient of variation (the degree of harmonization of experts' opinions) for each indicator.

The mean value M is the average value obtained by dividing the sum of the ratings of the 19 experts on the indicator by the number of experts. The higher the mean M of the indicator ratings, the greater the importance of the indicator (Zhou & Lv, 2012). The coefficient of variation CV is calculated from the ratio of the standard deviation of each indicator to the mean, i.e., it is equal to the standard deviation of the indicator divided by the mean (Wang & Chi, 2014). This is used to measure the degree of harmonization of the opinions of the 19 experts. The smaller the value of the coefficient of variation, the higher the degree of harmonization of expert opinions for the indicator. This study finalized the second round of deletion criteria based on relevant literature. Specifically, it is to delete the indicator when the mean value of the indicator is less than 4 or the coefficient of variation is greater than 0.1 (Liu, 2017).

Results

1. Factors influencing the athletic performance of Chinese junior badminton athletes

In this section, the results of the questionnaire surveys of coaches and athletes will be systematically analyzed, and the interviews with experts will also involved in understanding the current situation of Chinese junior badminton athletes. As a result, the key factors affecting athletes' sports performance are identified, such as the length of athletes' training, the level of coaches' training, the level of athletes' grades, the athletes' best performance, the athletes' situation, and so on.

1.1 The effect of training duration on athletic performance in athletes

As can be seen from Table 1, in the questionnaire survey of 349 youth athletes aged 16-18, 9.1% had trained for 6-8 years, mainly 16-year-olds.58.2% had trained for 9-10 years, indicating that the majority had trained badminton since elementary school. Athletes with more than ten years of training accounted for 32.7%, which indicates that badminton is a traditional sport in China and many families choose to let their children exercise and learn the sport from an early age.

Table 1 Statistics on years of training experience of Chinese junior badminton athletes (N=349)

Training Period	Number of People	Percentage
6-8 years	32	9.1%
9-10 years	203	58.2%
Over 10 years	114	32.7%

1.2 Influence of coaches' training level on athletes' performance

As shown in Table 2, in the selection of factors that Chinese junior badminton athletes believe coaches have the greatest influence on their own sports performance and achievement, 39.8% of the junior athletes believe that coaches can provide the most effective help in terms of technical guidance and training. At the same time, it can be seen from Table 3 that the results of the competition were bagged by the athletes brought out by Chinese coaches. It can be seen that coaches leading young athletes to win international competition awards accounted for one-third of the total proportion. The data show that at present, China's junior badminton athletes can have better competition results and more outstanding sports performance under the leadership of coaches.

Table 2 Statistics of Factors Influencing Athletes' Attention to Coaches (N=349)

Options	Number of People	Percentage
Technical guidance and training	139	39.8%
Mental conditioning and motivation	64	18.3%
Competition experience	62	17.78%
Career planning and development	51	14.6%
Resource integration and support	33	9.5%

Table 3 Best results achieved by coaches training athletes (N=51)

Option	Subtotal	Proportion
International - Champion	4	7.4%
International - 1st Runner-up	4	7.4%
International - 3rd place	10	18.5%
National - Champion	8	14.8%
National - 1st Runner-up	7	13.0%
National level - 3rd place	5	9.3%
Provincial/Municipal - Champion	10	18.5%
Provincial/Municipal - 1st Runner-up	1	1.9%
Provincial / Municipal - 3rd place	5	9.3%

1.3. The effect of an athlete's grade level on athletic performance

From Table 4, it can be concluded that among the Chinese junior badminton athletes involved in the questionnaire data, a total of 32 of them, accounting for 9% of the total number, have obtained the qualification of the international athlete. In addition, 97 people have obtained national-level athletes, accounting for 27.8% of the total number of people who filled in the form. Compared with the international level, the evaluation conditions for national-level athletes are more comprehensive, so the

number of those who have reached the standard has increased significantly, which indicates that the grade level and sports performance of China's young badminton athletes are better.

Table 4 Athlete Ranking Level Statistics (N=349)

Athletic grade	Number of People	Percentage
International Fitness Athletes	32	9%
National level fitness athlete	97	27.8%
International Grade 1 Athletes	220	36.2%

1.4. Impact of athletes' best times on athletes' performance

As can be seen from Table 5, youth athletes who participated in international events and achieved first, second, and third place accounted for 12.9% of the total number of people surveyed. It can also be seen that most of the best results of Chinese youth athletes are concentrated in national events, and fewer youth athletes are confined to provincial or even municipal competitions.

Table 5 Athletes' best performance statistics (N=349)

Option	Subtotal	Proportion
International – Champion	9	2.6%
International – 1st Runner–up	15	4.3%
International – 3rd place	21	6%
National – Champion	45	12.9%
National – 1st Runner–up	58	16.6%
National level – 3rd place	90	25.8%
Provincial/Municipal – Champion	69	19.8%
Provincial/Municipal – 1st Runner-up	32	9.2%
Provincial / Municipal – 3rd place	10	2.9%

1.5. Influence of the athlete's situation on athletic performance

As shown in Table 6, in the scale of key influence of personal circumstances on sports performance, the mean value of the athlete's choice of injury problems being very important is much higher than the mean value of the other options in the questionnaire, indicating that the athlete's circumstances have an important influence on sports performance.

Table 6 Influence of Athletes' Personal Situation Factors on Sports Performance (N=349)

Dimension	M	SD	Arrange in order
Injury Prevention	3.92	1.071	1
Rest and Recovery	3.82	0.874	2
Sports Thinking	3.70	1.06	3
Athletic Observation	3.68	1.185	4
Individual Talent	3.63	0.925	5
Professional Theoretical Knowledge	3.60	0.955	6
Diet and Nutrition	3.60	1.057	6
Cultural level	3.50	0.847	8

2. The construction of an evaluation index system for the best sports performance of badminton athletes

Through the second round of expert discussion, the indicators were screened twice, and the indicators that did not meet the requirements were deleted according to the mean value and coefficient of variation of the experts. In the end, we got 3 first-level indicators, 7 second-level indicators, and 71 third-level indicators. The experts who participated in the first round of correspondence were invited to continue to participate in the second round of expert discussion, and the analysis of the statistical results showed that the experts' opinions were the same and the trend was stable, so it was decided not to carry out the third round of expert discussion. The results of the study are shown in Table 7.

Table 7 Statistics on the results of the expert survey on indicators at all levels

Level 1 indicators	Secondary indicators	Tertiary indicators	M	SD	CV
	B1　Body form　(C1-C4)	C1 Height	4.75	0.444	0.093
		C2 Ketolet Index	4.7	0.47	0.1
		C3 Weight	4.15	0.366	0.088
		C4 Leg Length	4	0.649	0.162
	B2　Physical function (C5-C15)	C5 Injuries	4.95	0.224	0.0453
		C6 Reaction time	4.9	0.308	0.0629
		C7 Spirometry	4.9	0.308	0.0629
		C8　Cardiac　Performance Index	4.9	0.308	0.0629
		C9　Maximum　heart　rate after exercise	4.8	0.41	0.0854
		C10 Blood Lactate	4.2	0.41	0.0976
		C11　Maximum　Oxygen Uptake	4.1	0.308	0.0751
		C12　Maximum　Oxygen Consumption	4.1	0.308	0.0751
		C13 Blood pressure	4.1	0.308	0.0751
		C14 Morning pulse	4.1	0.308	0.0751
		C15 Anaerobic function	4.05	0.224	0.0553
A1 Physical fitness	B3　Physical fitness (C16-C32)	C16 Grip strength	4.9	0.308	0.063
		C17 1-minute pull-ups	4.85	0.366	0.075
		C18　1-minute　double pendulum jump rope	4.8	0.41	0.085
		C19　20-second　barbell snaps	4.8	0.41	0.085
		C20　10　low　center　of gravity quad track	4.75	0.444	0.093
		C21 1500 meter run	4.2	0.41	0.098
		C22 400 meter run	4.2	0.41	0.098
		C23 Vertical jump in place	4.2	0.41	0.098
		C24 1-minute push-ups	4.2	0.41	0.098
		C25 1-minute quick sit-ups	4.15	0.366	0.088
		C26　Left　and　right　lateral run 5 times	4.15	0.366	0.088
		C27 100 meter run	4.1	0.308	0.075
		C28 1x meter speed change	4.1	0.308	0.075
		C29 5x straight-line run	4.1	0.308	0.075
		C30　Wrist　Flexion　and Extension Test	4.05	0.224	0.055

Level 1 indicators	Secondary indicators	Tertiary indicators	M	SD	CV
A2 Competitive strength	B4 Technical ability (C33-C47)	C31 Seated forward bending	4.05	0.224	0.055
		C32 1x Crossover Change of Direction Run	4.05	0.224	0.055
		C33 Active Error Rate	5	0	0
		C34 Draw (badminton)	4.95	0.224	0.045
		C35 Push (badminton)	4.95	0.224	0.045
		C36 Net Release (Badminton)	4.95	0.224	0.045
		C37 Shots per round	4.9	0.308	0.063
		C38 Percentage of Active Points	4.9	0.308	0.063
		C39 Backhand	4.9	0.308	0.063
		C40 Slope Heel	4.9	0.308	0.063
		C41 Killing (Badminton)	4.9	0.447	0.091
		C42 Hanging Ball	4.9	0.447	0.091
		C43 Lifting Ball	4.9	0.447	0.091
		C44 Pick-off (Badminton)	4.9	0.308	0.063
		C45 Backhand sling (badminton)	4.85	0.366	0.075
		C46 Net Kill (Badminton)	4.85	0.366	0.075
		C47 Hook shot (badminton)	4.85	0.366	0.075
	B5 Tactical ability (C48-C54)	C48 Quality of completion of tactical actions	4.9	0.308	0.063
		C49 Tactical Concepts	4.9	0.308	0.063
		C50 Tactical instruction	4.85	0.366	0.075
		C51 Level of understanding of tactical knowledge	4.85	0.366	0.075
		C52 Level of tactical awareness	4.75	0.444	0.093
		C53 Ability of self-control	4.25	0.444	0.1
		C54 Number of tactical forms mastered	4.2	0.41	0.098
A3 Competitive Strength	B6 Mental ability (C55-C64)	C55 Willingness to move	4.85	0.366	0.075
		C56 Personality and psychological characteristics	4.85	0.366	0.075
		C57 Competition experience	4.85	0.366	0.075
		C58 Motivation	4.85	0.366	0.075

Level 1 indicators	Secondary indicators	Tertiary indicators	M	SD	CV
		C59 Self-confidence	4.75	0.444	0.093
		C60 Refereeing Factors	4.2	0.41	0.098
		C61 Sport Emotions	4.2	0.41	0.098
		C62 Perception of Sport	4.1	0.308	0.075
		C63 Judging Factors	4.05	0.224	0.055
		C64 Neurotypes	4	0	0
		C65 Activity Thinking	4.8	0.41	0.085
		C66 Motor Observation	4.8	0.41	0.085
	B7 Movement Intelligence (C65-C71)	C67 Motor Attention	4.8	0.41	0.085
		C68 Motor Imagery	4.75	0.444	0.093
		C69 Individual Talents	4.2	0.41	0.098
		C70 Theoretical knowledge	4.2	0.41	0.098
		C71 Cultural Dimensions	4.1	0.308	0.075

Conclusion

1. Influencing factors of Chinese junior badminton athletes' best performance

In this study, through a questionnaire survey of China's current junior badminton athletes and coaches who have been engaged in badminton training for a long time, we have gained a preliminary understanding of the factors influencing the best performance of China's junior badminton athletes. Most of China's youth badminton athletes begin their badminton training in elementary school. The number of young badminton athletes with more than ten years of training accounted for 32.7% of the total number of the survey. In addition to training, they also have to take care of study tasks, which makes them feel very pressured. Athletes receive comprehensive training from a young age, which may lead to over-training of young athletes in the adult stage, resulting in physical injuries, leading to the inability to get good competition results, and to get good results, in addition to excellent physical quality, the coaches in the training of young badminton athletes and the development of performance is also particularly important, the coach's training system, the experience of the competition, and the psychological guidance, etc., can help athletes to Improve sports performance.

2. Indicator system for evaluating the best performance of Chinese junior badminton athletes

In this study, two rounds of indicator screening were conducted using the Delphi method. In the first round of screening, experts in the field of badminton initially eliminated irrelevant indicators. In the second round of screening, by quantifying the experts' ratings of the remaining indicators and calculating the mean and coefficient of variation (CV), the best sports performance evaluation index system for Chinese youth badminton athletes aged 16 to 18 was finally established.

The system covers three primary indicators: physical fitness, athletic strength, and playing ability. The first-level indicators are subdivided into seven second-level indicators, including physical form, physical function, physical fitness, technical ability, tactical ability, psychological ability, and motor intelligence. The total number of secondary indicators is 71, which include: height, Ketolet's index, body weight, leg length, cardiac performance index, injuries, lung capacity, maximal oxygen uptake, reaction time, blood lactate level, maximal oxygen consumption, maximal post-exercise heart rate, lateral mobility, rapid linear mobility, low center of gravity quadrangular mobility, grip strength, pull-ups (1

minute), and rapid sit-ups (1 minute), push-ups (1 minute), barbell quick jerk (20 seconds), vertical jump in place, 400-meter run, 100-meter run, 1500-meter run, double-swing rope skipping (1 minute), seated forward bending, wrist flexion test, various badminton technical movements (e.g., placing the net, picking the ball, pushing the ball, hooking the ball, pumping the ball, slinging the ball, killing the ball, etc.), understanding of tactical knowledge, level of tactical awareness, tactical concepts, tactical guidance, self-control, achievement motivation, psychological characteristics, ability to control oneself, ability to achieve, ability to make a good performance, ability to make a good performance, and the ability to make good decisions. Ability, achievement motivation, psychological characteristics, game experience, sports emotions, sports will, sports perception, self-confidence ability, refereeing factors, sports thinking, sports observation, sports imagination, personal talent, and professional theoretical knowledge. Together, these indicators constitute a complete system for evaluating the best sports performance of Chinese junior badminton athletes aged 16 to 18.

Discussion

This study provides a comprehensive assessment of optimal performance indicators in Chinese junior badminton athletes aged 16 to 18 years old, confirming the central role of physical fitness, technical skills, tactical awareness, and psychological tolerance in the development of athletes. Numerous studies have confirmed the criticality of these metrics in sports performance. For example, a quantitative analysis by Zhang, M. et al. revealed a direct link between physical training and technical movement accuracy, while pointing out the importance of endurance and agility for performance in high-intensity games (Zhang, 2022). Liu Yanhong's study further revealed a strong link between psychological stress tolerance and game stability and showed that psychological training can significantly improve athletes' stress tolerance and concentration (Liu, 2023).

In addition, this study used the Delphi method to validate the expert consensus on these indicators and to demonstrate their applicability to the training of junior badminton athletes. Chen et al.'s study showed that an expert consensus-based training program was effective in enhancing the overall performance of athletes, especially in the optimization of technical details and the development of tactical awareness (Chen et al., 2023). Similarly, a study by Li Na et al. found that a personalized training plan tailored to individual differences improved training effectiveness (Li, 2023). This further confirms the practical value of the results of this study.

Recommendation
1. Utilizing big data and artificial intelligence technology to assist in improving the level of youth badminton sports

The evaluation index system for the best performance of Chinese youth badminton athletes constructed in this study aims to provide theoretical support for the cultivation of Chinese youth badminton athletes. Coaches can develop personalized evaluation and training programs based on the unique characteristics and needs of each athlete. Looking ahead, we expect to include multi-dimensional factors such as physical fitness, technical ability, tactical understanding, and psychological quality, and to utilize big data and artificial intelligence technology to conduct in-depth analysis of athletes' training and game data. This will help build a more comprehensive evaluation system. Through scientific methods and tools, we are committed to improving the accuracy and practicality of the evaluation, to more effectively guide training and competition, and thus enhance the athletes' competitive level. In addition, we plan to conduct long-term tracking studies on athletes to verify the effectiveness of the evaluation indexes and make corresponding adjustments and optimizations according to the actual results.

2. Combined evaluation system of badminton reserve talent cultivation

When discussing the complex and vital topic of badminton reserve talent cultivation and selection, we must deeply understand that it is a highly dynamic and continuously evolving process, which is closely connected with the rhythm of social development, the wave of scientific and technological progress, and the inherent laws of competitive sports itself. With the deepening of globalization and the rapid development of sports science and technology, the competitive level of badminton is constantly improving, and the requirements for the comprehensive quality of athletes are becoming more and more stringent. Therefore, the selection standard of reserve talents must keep abreast of the times and combine with the evaluation system of athletes' best sports performance for selection and cultivation, to improve its reliability, feasibility, and scientificity. It is suggested to build the badminton reserve talents training system by constructing the evaluation system of the best sports performance of badminton athletes of different age groups, establishing personal files, and formulating personalized training plans.

3. Shortcomings of this study and suggestions for further research

Although the results of this study show the effectiveness of KPIs, its limitations should be noted. Since the sample was mainly from Guangdong Province, the findings of this study may have limitations when generalizing to other regions or cultural contexts. Future research should consider expanding the sample size and adopting a longitudinal research design to further validate and refine the indicator system developed in this study. Future research should shift the focus to practical application by selecting representative junior badminton athletes as samples, applying the evaluation index system to their daily training and competition, collecting real-time data, and conducting dynamic monitoring and assessment. At the same time, a feedback mechanism should be established to continuously adjust and optimize the evaluation index system according to the feedback of practice, to ensure that it can reflect the immediate status of the athletes as well as predict the potential development trend of the athletes.

In summary, this study not only provides a scientific basis for the training of young badminton athletes but also provides an important reference for coaches to apply these indicators in practice.

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