The Construction of Evaluation Model for Analyzing Basketball Player Performance Based on Fuzzy Comprehensive Evaluation Method

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Abstract

This study aims to investigate the scientific nature and effectiveness of fitness testing evaluation standards for high-level university basketball players in China. The current practice often employs benchmarks based on professional athletes' standards, despite significant differences in the pressures, roles, and practical demands of university players.

Methods: To address this gap, we conducted a mixed-methods approach combining literature review, expert interviews, and field observations. We analyzed the current fitness testing evaluation standards used by high-level university basketball teams in China and compared them with those of professional teams. Additionally, we interviewed coaches and sports scientists to understand their perspectives on the applicability and limitations of current evaluation standards.

Results: Our findings reveal significant differences between the fitness testing evaluation standards for university and professional basketball players. While professional standards focus on peak performance and competitive readiness, university standards tend to prioritize overall fitness, injury prevention, and athlete development. Coaches and sports scientists expressed concerns about the one-size-fits-all approach of using professional standards for university players, highlighting the need for more tailored and context-specific evaluation criteria.

Conclusions: This study highlights the need for a more comprehensive and tailored fitness testing evaluation framework for high-level university basketball players in China. Future research should focus on developing evaluation standards that better reflect the unique challenges and demands of university-level competition, player development, and injury prevention.

Keywords: Evaluation Model; Basketball Player Performance; Fuzzy Comprehensive Evaluation Method; China

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Introduction

In modern competitive basketball, the evaluation of basketball players plays a crucial role. It not only has a profound impact on talent identification, training optimization, and player management but is also directly related to the overall performance and strategic decision-making of the team (Yang, 2017). Accurate athlete evaluation can help coaching staff identify potential top players, formulate personalized training plans, improve tactical arrangements, and effectively manage players' career development. Player performance evaluation is a key factor in optimizing training, developing strategies, and enhancing the overall team level. With the rapid development of basketball and advancements in data analysis technology, traditional evaluation methods have gradually become insufficient for comprehensive and precise assessments of athletes (Meng, 2021). Consequently, an increasing number of studies have begun to focus on advanced evaluation models to analyze basketball players' overall performance in depth. These models not only incorporate players' technical statistics but also take into account multiple factors such as physical fitness, tactical awareness, and psychological qualities, offering a more comprehensive evaluation perspective.

When evaluating an elite athlete, a comprehensive analysis must consider numerous factors, including anthropometric, physiological, psychological, skill-based(technical/tactical), social, and emotional aspects (Lorenz DS, 2013). Any factor that measures successful athletic performance is referred to as a "performance indicator." Testing is an essential method for evaluating athletic ability, assessing training outcomes, and obtaining feedback on the training process (Haff GG, 2021). Conducting periodic tests on athletes and tracking data over time can help establish guidelines for the training process, enhance training efficiency, and provide valuable insights. Scientific testing is also a critical tool for selecting and cultivating athletic talent and plays an important role in constructing talent identification systems for athletes of different ages.

From a systems theory perspective, basketball games are complex systems influenced by multiple factors, with athletes' on-court performance being a crucial component (Cummins,2013). Typically, qualitative methods are used to evaluate and assess player performance, but these methods are relatively coarse and subjective. At the end of the last century, the United States pioneered the use of athletes' technical statistics as a foundation for evaluating performance, applying a simple method of adding and subtracting weighted values to reflect basketball players' performance based on actual game situations (S. Michael, 2010).

The expression power and competitive level of basketball players are not only integral parts of the open and complex system of basketball games, but also constitute an independent complex system with multiple levels, intricate structures, and rich content. This paper, adhering to the core ideas of system science and following the practical approach of comprehensive integration methods, innovatively constructs a hybrid model that integrates the Analytic Hierarchy Process (AHP) and intelligent fuzzy comprehensive evaluation methods, to conduct a comprehensive and unbiased assessment of the overall performance of basketball players. College basketball programs are currently deficient in foundational research pertaining to contemporary basketball trends and methodologies. Consequently, there is a pressing demand to refine the athlete evaluation framework and selection criteria. The implementation of a standardized testing protocol would significantly streamline the athlete selection process, enhancing its efficiency and effectiveness (Lu, X,2024).

Research Objective

To study evaluation model construction for analyzing basketball player performance based on fuzzy comprehensive evaluation method

Research Methodology

The primary goal of this research endeavor was to devise an evaluation framework tailored specifically for assessing the competitive attributes of elite male university basketball players (Marmarinos, 2019). Given its aptitude for hierarchical analysis, the Analytic Hierarchy Process (AHP) (Li, & Zhang, 2018) emerged as an ideal methodology for this purpose. Employing AHP, we systematically dissected the significance of individual metrics across various tiers within our evaluation system for basketball player competitiveness. This methodical approach entailed constructing judgment matrices and meticulously weighing the importance of each metric at every level, ensuring a scientific basis for our analysis. Recognizing the unique characteristics of basketball players as a collective, we crafted a three-tiered objective model structure to encapsulate the complexities of our evaluation. The Delphi method was employed in two successive rounds, involving a panel of 16 experts, to meticulously select test methods. The criteria ultimately chosen, boasting the highest endorsement from experts, were designated as the evaluative indicators for assessing the athletic prowess of basketball players. These refined indicators were then incorporated into a survey questionnaire. Proceeding with the Analytic Hierarchy Process (AHP), we determined the relative weights of the secondary and tertiary indicators. Given its proficiency in addressing ambiguous or uncertain scenarios, the Authentic Assessment Comprehensive Evaluation Method was adopted. This approach entailed a comprehensive analysis and assessment of the problem, factoring in the intricate relationships and varying weights of diverse elements, to arrive at a holistic evaluation outcome. Having established the evaluation index system for university-level basketball players' competitive qualities through AHP, it was imperative to verify its practicality. To this end, we selected athletes from the men's basketball team at Ningbo University as our subject pool and scientifically conducted a rigorous assessment of their evaluation model utilizing the Multi-level fuzzy comprehensive evaluation.

Multi-level Fuzzy Comprehensive Evaluation Method：The symbol U represents the overall quality of high-level university basketball players, and the specific evaluation factor set is as follows: According to U, which represents the evaluation factor set of high-level university basketball players. U= {U1, U2, U3, ..., Un}, where Ui = (Ui1, Ui2, Ui3, ..., Uin) represents the primary indicators. Single-factor evaluation of the factors in Ui, the establishment of fuzzy mapping fuzzy judgment matrix Ri, (Ui,V,Ri)as the original model, and according to the different degree of importance of each single factor accordingly determine the different weight coefficients, to find out the weight vector of the factors, Ai = (ai1, ai2, ai3, ..., ain) through the fuzzy transformation of the single-factor comprehensive evaluation vector: Bi= Ai* Ri= (bi1, bi2, bi3, ..., bin). Considering the 2-layer factor U= {U1, U2, U3, ..., Up} and using Bi as a single-factor judgment for factor Ui, a fuzzy mapping is established to obtain a 2-layer fuzzy judgment matrix R: R= [B1,B2… ,Bp]. Take (U, V, R) as the original model, and find out the weight vector A= (a1,a2, ...,ap)of all the factors by AHP method in U to get the comprehensive evaluation vector: B=A*R=(b1,b2,...,bm) (Sarlis,2020).

Questionnaire Design: This study primarily relied on expert questionnaire surveys and interviews to identify indicators for the evaluation index system of basketball players' evaluation model. Drawing upon the demands of the research, a comprehensive review of relevant literature, and inputs from experts and scholars, the first round of expert questionnaires for the preliminary indicators of basketball players' evaluation model assessment was formulated (Yang,2017). These questionnaires were distributed to experts in basketball research and sports statistics, aiming to establish the relevant components and formulation of the evaluation indicators. Upon analyzing the questionnaire data, it was observed that some indicators exhibited contradictory, overlapping, or causal relationships, potentially hindering the effectiveness of the assessment. Consequently, there was a need to categorize and integrate the initially proposed three-level indicators, accompanied by a rigorous and rational screening process, to ensure an objective and accurate assessment. To validate the evaluation system, this study selected athletes from the men's basketball team at Ningbo University as participants and conducted a scientifically sound evaluation of their evaluation model utilizing the Fuzzy Comprehensive Evaluation Method (Li.2021) And Based on the criteria of the constructed judgment matrix indicators, comparisons were made between the primary indicators in the basketball player's evaluation model index system, alongside the secondary indicators, and corresponding comparison matrices were established. These calculations were then performed using the AHP (Analytic Hierarchy Process) software.

Research Scope

This study focused on the following aspects population of this article consists of top eight coaches and assistant coaches in the Southeast Division of the Chinese University Basketball Association (n=16)，at least Second Grade Coach. Through interviews with high-level coaches at universities and reviewing relevant materials, research the eligibility of high-level basketball players to join the university basketball team. The interviews aim to explore the comprehensive qualities and selection criteria required for identifying high-level athletes.The study will be conducted at Nanchang University, East China Normal University, Huaqiao University, Ningbo University, China University of Mining and Technology, Guangdong University of Technology, Zhejiang University and Xiamen University.

Research Conceptual Frameworks

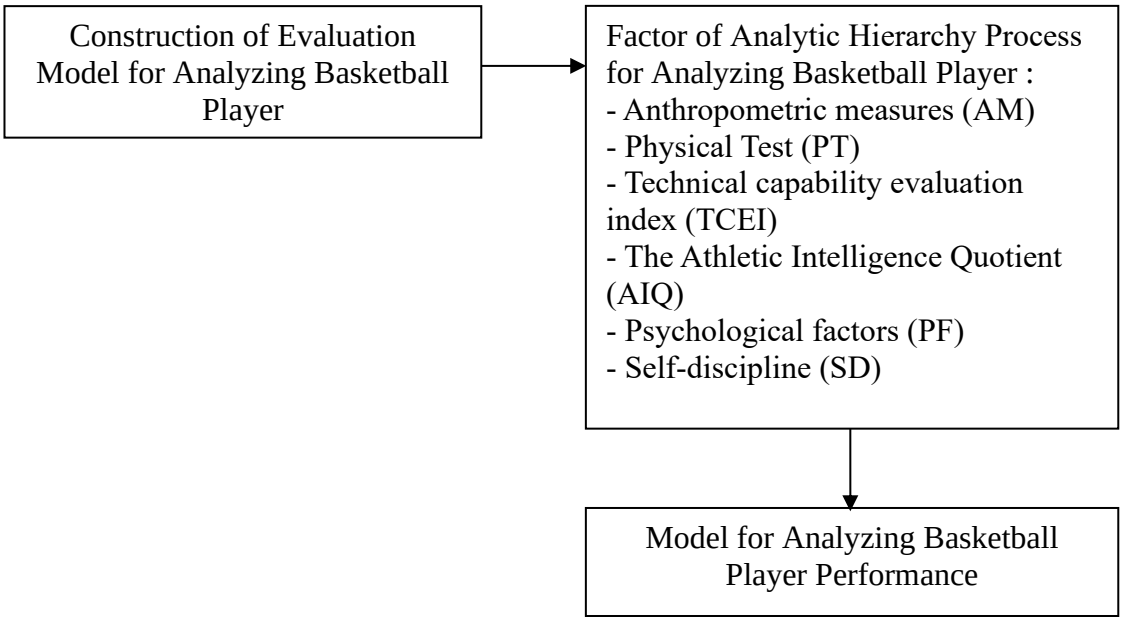

Figure 1 Research Conceptual Frameworks

Research Results

Determination of Comprehensive Quality Assessment Indicators

The comparison data of the secondary indicators of basketball players in Table 1 are obtained through the geometric mean method and calculated by AHP (Analytic Hierarchy Process) software.As can be seen from the data in Table 2, they are combined with expert interviews. Based on the study of relevant literature, after decomposing the primary indicators, six secondary indicators are preliminarily drawn up, respectively Anthropometric measures (AM), Physical Test (PT), Technical capability evaluation index (TCEI), The Athletic Intelligence Quotient (AIQ), Psychological factors (PF), Self-discipline (SD), (Russell,2021) which add up to six structures. The weight coefficients corresponding to these six secondary indicators are respectively 17.423%, 21.752%, 20.842%, 20.699%, 11.916%, and 7.368%

Table1 Comparison matrix table

Name of scale	AM	PT	TCEI	AIQ	PF	SD
AM	1	0.6857	0.7439	0.8657	1.2868	2.1523
PT	1.5268	1	0.9335	2.1526	0.8696	0.6524
TCEI	2.1525	1.2458	1	0.9563	1.5365	2.1745
AIQ	0.8563	0.6854	1.5684	1	2.8554	2.1452
PF	0.4152	0.3695	0.5698	0.5789	1	1.1253
SD	0.3896	0.5684	0.5263	0.2574	1.2888	1

Table2 Metric weights for Evaluation Model

Name of scale	Eigenvector	Weight Value	λmax	CI
AM	1.045	17.423%	6.410	0.082
PT	1.305	21.752%		
TCEI	1.251	20.842%		
AIQ	1.242	20.699%		
PF	0.715	11.916%		
SD	0.442	7.368%		

The evaluation index of sports improvement of high-level basketball players in colleges

basketball, as a competitive sport played on the same court, requires athletes to possess a certain level of enhancing athletic performance in both training and competition. Through meticulous analysis of previous research, this study has collected a significant amount of literature on indicators for assessing athletic performance. Simultaneously, the literature has been studied and analyzed, leading to the selection of relevant indicators. As a result, preliminary criteria for evaluating the improvement of athletic performance in high-level collegiate basketball players have been formulated (Shi, 2022).

Primary Indicator: Considering the "Performance Evaluation Suitable for Elite Basketball Players" as a primary indicator aligns perfectly with the objectives of this study. It provides a comprehensive overview of the entire set of evaluation criteria, both directly and indirectly, making it well-suited to meet the practical requirements of this research.

Secondary Indicators: After decomposing the primary indicators, six secondary indicators have been preliminarily formulated. Please refer to Table for details.

Third Indicators: Based on the foundation of secondary indicators, and through the review of previous research literature and expert interviews, in conjunction with the purpose and significance of this study, corresponding tertiary indicators have been developed. This includes a total of 28 items across the tertiary indicators, as outlined in Table 3.

Through the study analyzing anthropometric characteristics within the NBA Draft Combine and considering the local context, the selected anthropometric variables (AV) include: height without shoes, wingspan (Height multiple), hand length, and body fat percentage (Yan, 2017). Physical fitness of basketball players which consist of three stages as follows: the lane agility test (lat), the running anaerobic sprint test (rast), bench press test, maximum jump reach (mjr), shuttle run test (Terner, 2021). Technical capability evaluation index(TCEI) include 2-minute Inside-Outside Three-Point Shooting Percentage for Self-Shots and Offensive Rebounds (TSPSOR);Field Goal Percentage for Inside-the-Paint Two-Point Shots with Self-Shooting and Self-Rebounding Within 2 Minutes (FGPSOR);Full-court Dribble and Layup (FDI);Perimeter Catch and Dribble Drive (PCDD);Interior Catch and Dribble Drive (ICDD);Hexagonal Movement (HM). The Athletic Intelligence Quotient (AIQ) include Tactical Execution (TE);Spatial Awareness (SA);Game Judgment Ability (GJ);Emotional Control (EC);Game Leadership Ability (GL);Team Collaboration (TC) (Fox, 2017). Self-discipline are the number of class absences per semester(CA), the instances of violating team rules per semester (VT), and the coach's assessment of training attitude (CATA) (Li,2021). Psychological factors (PF) include Level of Confidence(LC), Intrinsic

Motivation(IM), Psychological Resilience(PR), Post-Game Diligence Level(PDL) (Yan, 2023).

Table3 Overview of Indicators for Evaluating the Athletic Performance

Secondary Indicators	Weight Value	Third Indicators	Weight Value
Anthropometric measures(AM)	17.423%	X1 Height	17.028%
		X2 W	42.902%
		X3 HL (cm)	30.315%
		X4 BF %	9.755%
Physical Test	21.752%	X5 RAST	5.207%
		X6 LAT	8.373%
		X7 BP	18.429%
		X8 MJR (m)	50.330%
		X9 SR	17.661%
Technical capability evaluation index(TCEI)	20.842%	X10 TSPSOR	39.13%
		X11 FGPSOR	22.85%
		X12 FDI	19.01%
		X13 PCDD	10.31%
		X14 ICDD	5.38%
		X15 HM	3%
The Athletic Intelligence Quotient (AIQ)	20.699%	X16 GL	28.95%
		X17 TE	21.45%
		X18 GJ	16.85%
		X19 EC	13.24%
		X20 TC	10.99%
		X21 SA	8.52%
Psychological factors(PF)	11.916%	X22 PR	50.227%
		X23 IM	24.52%
		X24 LC	14.736%
		X25 PDL	10.516%
Self-discipline	7.368%	X26 CA	58.899%
		X27 VT	25.185%
		X28 CATA	15.926%

Determine the membership function

To objectively analyze and evaluate the comprehensive performance level of a particular college high-level basketball player, it is necessary to use a real case to validate the accuracy of the evaluation criteria. Ask the coach to first score based on different evaluation criteria, and then convert them into statistical values. The formula is as follows:

Grade	Formula	Range
ExcellentU(x)	0	0≤x＜80
	（x-80）/(95-80)	80≤x＜95
	1	95≤x＜100
GoodU(x)	（x-70）/(80-70)	70≤x＜80
	（95-x）/(95-80)	80≤x＜95
	0	others
AverageU(x)	（x-60）/(70-60)	60≤x＜70
	（95-x）/(95-80)	70≤x＜80
	0	others
PoorU(x)	（x-45）/(60-45)	60≤x＜70
	(70-x)/70-60	60≤x＜70
	0	others
BadU(x)	1	0≤x＜45
	(60-x)/(60-45)	45≤x＜60
	0	60≤x＜100

Based on the above function, the coach's scores for different indicators in the comprehensive evaluation of college high-level basketball players can be transformed into evaluation grades. This facilitates a clearer understanding of the evaluation results.`

Discussion

The findings reveal important discrepancies between fitness testing and qualification standards for collegiate basketball players. Although performance standards focus on maximum efficiency and competitive readiness, But the standards and performance of basketball players at the university level focus on overall fitness injury prevention and athlete development sports trainer and scientist expressed concern about the guidelines for implementing professional standards for university players. It emphasizes the need to use more tailored and context-specific assessment criteria.

Conclusions: This study highlights the need for a more comprehensive and appropriate physical fitness testing evaluation framework for high-level university basketball players in China. Future research should focus on developing assessment standards that reflect the challenges and demands of university competition. player development and prevention of sports injuries

The performance test suitable for elite college basketball players refers to the evaluation system where high-level college basketball players are assessed during their university years in basketball training or competitions. It involves coaches observing and scoring players based on their individual characteristics, analyzing and judging the comprehensive performance of players.

The evaluation index system for the performance test of high-level college basketball players is constructed with one primary indicator, namely the performance test suitable for elite college basketball players. It comprises six secondary indicators: Anthropometric measures (AM), Physical Test (PT), Technical capability evaluation index (TCEI), The Athletic Intelligence Quotient (AIQ), Psychological factors (PF), and Self-discipline (SD), along with corresponding 28 tertiary indicators which corresponds to Russell, 2021 et al to study on Measuring Physical Demands in Basketball: An Explorative Systematic Review of Practices. The results of the study found that This review comprehensively evaluated the current body of literature related to training load monitoring in basketball. Within this literature, there is a clear lack of alignment in applied practices and methodological framework, and with only small data sets and short study periods available at this time, it is not possible to draw definitive conclusions about the true physical demands of basketball. A detailed understanding of modern technologies in basketball is also lacking, and we provide specific guidelines for defining and applying duration measurement methodologies, vetting the validity and reliability of measurement tools, and classifying competition level in basketball to address some of the identified knowledge gaps. Creating alignment in best-practice basketball research methodology, terminology and reporting may lead to a more robust understanding of the physical demands associated with the sport, thereby allowing for exploration of other research areas (e.g. injury, performance), and improved understanding and decision making in applying these methods directly with basketball athletes.

The weight coefficients of the secondary indicators in the evaluation index system for the performance test of high-level college basketball players are as follows: Anthropometric measures (AM) 17.424%, Physical Test (PT) 21.752%, Technical capability evaluation index (TCEI) 20.842%, The Athletic Intelligence Quotient (AIQ) 20.699%, Psychological factors (PF) 11.916%, Self-discipline (SD) 7.368%. Additionally, the weight coefficients of the tertiary indicators for the evaluation of the athletic intelligence of high-level college basketball players are also calculated. Finally The constructed evaluation index system for the athletic intelligence of high-level college basketball players, along with expert interviews, demonstrates the good operability of this indicator system.

Recommendations

1. Theoretical Recommendation

Recommend future research to further validate the effectiveness of the basketball player evaluation system we constructed. Through on-field testing and broader sample inclusion, ensuring the applicability of the system across different cultures, backgrounds, and competition levels can be enhanced.

2. Policy Recommendations

Encourage international collaboration and exchange. Sharing our research findings with the international basketball community can stimulate joint efforts among researchers from different countries and regions, promoting global development in the field of basketball player evaluation and training. These recommendations aim to provide guidance for future research, training initiatives, and decision-makers in the basketball domain, fostering the comprehensive development and performance enhancement of basketball players.

3. Practical Recommendations

Given the crucial role of psychological factors in basketball player performance, suggest delving deeper into the complex relationships between psychological factors and athletic performance. Specifically, explore how individual differences may influence the impact of psychological factors on player performance.

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