



## Research article

# Optimizing sports performance in China: Investigating the influence of training, recovery, motivation, and environmental support within a moderation-mediation framework

Heshan Liu, Sen Fu<sup>\*</sup>*Xinyang Vocational and Technical College, 464000, Xinyang, China*

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## ABSTRACT

The expansion of sports in China is astounding. Given the country's focus on athletic achievement, it is crucial to comprehend the different facets of sports. This research examines China's athletic success in training, recuperation, motivation, and environment. The moderation-mediation strategy is used to understand how these variables affect athletic performance. This study fills a gap in understanding Chinese players' on-field performance. The study examined 355 Chinese athletes from various regions and sports. The sample has a balanced gender distribution, diverse age distribution, and representation from various regions. Furthermore, training programs, recovery strategies, motivation, psychological well-being, support systems, and experience levels influence athletes' sports performance. The study reveals that the coefficients indicate that training, recuperation tactics, motivation, and support systems affect athletic performance. Psychological health emerges as a critical mediator in explaining the effects of these factors on performance outcomes. Additionally, athlete experience moderates the influence of these variables, highlighting nuanced differences. These findings offer crucial insights for enhancing the performance of Chinese athletes. By adopting a moderation-mediation approach, this research illuminates the interconnected dynamics among key components, enriching our understanding of avenues for athlete improvement. Specifically, the results underscore the interconnectedness of athletes' psychological well-being, on-field experience, and competitive performance, emphasizing the importance of tailored interventions. This study could help Chinese politicians, sports psychologists, and coaches enhance athletes' performance.

## 1. Introduction

The significance of physical activity interventions in optimizing athletic performance is paramount in the relentless pursuit of athletic excellence [1]. Physical exercise therapies offer tailored solutions that address the interconnected aspects of activity, recovery, and well-being, enhancing athletes' fitness, skills, and strategic capabilities [2]. Integrating scientific advancements with traditional training methods provides athletes with new insights and tools, such as sophisticated monitoring systems and personalized recovery techniques, ushering in a new era of performance enhancement [3,4]. According to recent findings by Kercher et al. [5], the most popular exercise modes in the global exercise community include functional fitness training, strength training with free weights,

<sup>\*</sup> Corresponding author.

*E-mail address:* [fusen666@sina.com](mailto:fusen666@sina.com) (S. Fu).

wearable technology, yoga, high-intensity functional training, exercise for weight loss, lifestyle medicine, health/well-being coaching, and Exercise is Medicine. These trends highlight individuals' diverse approaches to improving physical fitness and overall well-being.

China's rich athletic heritage has solidified its status as a global sports leader, known for producing exceptional athletes across various disciplines [6]. From gymnastics to table tennis, China's prowess has left a significant mark on international platforms, notably during the Olympic Games [7]. Rooted in a culture of relentless pursuit of excellence, Chinese athletes epitomize dedication and passion for sporting success. This ascent to sporting eminence can be attributed to China's inherent talent and unwavering commitment to athlete development, supported by well-structured initiatives and rigorous training routines [8]. With unwavering support from government agencies and sports organizations, China fosters an environment that honors and actively pursues athletic excellence [9]. In recent years, China has seen a significant transformation in its perspective on sports achievement, recognizing the profound impact of sports on individual lives and national identity [10,11]. This acknowledgment has increased emphasis on athletic accomplishments, from grassroots programs to professional leagues, promoting positive behaviors and fostering patriotism at a national level.

The growing popularity of sports and physical activity underscores their positive impacts on individuals and communities, emphasizing the criticality of individualized exercise interventions [12]. There is a growing trend among athletes, instructors, and sports scientists in China to utilize individualized interventions to tackle the distinct cultural, psychological, and environmental elements that impact athletic performance [13]. By integrating modern science with traditional Chinese training methods, this individualized approach exemplifies China's dedication to progress while simultaneously paying homage to its rich cultural heritage. Cultural differences, environmental factors, and training methods in Chinese sports interact complexly, requiring a thorough examination to comprehend the underlying mechanisms [14]. While recognition of the importance of physical activity interventions in Chinese sports performance has grown [15], further study is required to comprehend their complex impacts. Examining training programs, recovery tactics, athlete motivation, environmental support, and experience level is crucial to grasp the multifaceted interaction within the Chinese sports community. Comprehending Chinese athletes' perspectives on the role of physical exercise therapy in improving performance is challenging yet crucial, especially considering the evolving field of integrating sports science [16].

This study aims to reinforce Chinese athletes by identifying crucial areas of apprehension and presenting practical understandings to bridge the gap between academic learning and practical application in sports science and performance enhancement. The study has three main objectives: first, to assess the impact of training programs, recovery techniques, athlete motivation, and environmental support on the peak performance of Chinese athletes; second, to explore how an athlete's expertise level affects the relationship between physical activity interventions and sports performance outcomes; and third, to examine the role of psychological well-being in mediating the relationship between physical training interventions and sports performance. The introduction is in Section 1, and the literature review is presented in Section 2. Techniques are elaborated upon in Section 3. The discussion and results are respectively presented in Sections 4 and 5. The final section summarizes the research.

## 2. Literature review

Understanding sports science requires studying athletic performance across cultures and nations [17]. Despite focusing on unique demographics or places, research investigations aim to identify universal sports performance factors. By studying training methods, psychological aspects, and environmental elements, academia wants to create techniques that benefit athletes worldwide [18]. Sports science evolves via collaboration and knowledge-sharing, improving athletic performance worldwide [19]. The literature research focuses on Chinese athletes and aims to examine the intricate correlation between training plans and their effectiveness in achieving success in sports. The first section of the study examines various physical activity interventions and their impact on sports performance. In the second section, we focus on how an athlete's level of expertise with physical activity interventions functions as a moderator. Finally, the research evaluated the complex network of intermediate components, concentrating on how psychological health affects exercise and athletic performance.

### 2.1. Unraveling the efficacy of physical activity interventions

There is much research on improving athletic performance, which supports the study of physical activity therapies. Hoffman et al. [20] laid the groundwork for understanding training plan effectiveness. The research found that customized methods and training programs improve athletes' physical and technical skills. This key understanding lays the groundwork for researching the broad terrain of physical activity therapy while considering Chinese athletes' demands. Meng et al. [21] examine recovery techniques from a different angle. Treatments that reduce tiredness and improve psychological and physiological well-being are examined. Since their results were based on multiple fields, they emphasize the comprehensive character of rehabilitative interventions. Motivation—a psychological force—is fundamental to our study. When studying Chinese athletes' motivation, Huang et al. [22] found a strong link between intrinsic motivation and sports performance. The study uses a psychological paradigm that links mental resilience to exercise efficacy. Sports performance is affected by socio-cultural and training background. Exploring the effect of surroundings, O'Rourke et al. [23] show how a supportive training environment improves athletes' performance. Physical activity treatments are part of a larger ecosystem that affects performance dynamics, making this environmental factor more critical in our research. Manninen et al. [24] emphasize the cultural elements that affect Chinese athletes' reactions and the benefits of physical training. The research shows that cultural views on training and recovery affect athletes' devotion and performance. We get a cultural perspective by identifying the need to connect treatments with cultural norms. Zhang et al. [25] illuminate training effectiveness temporality; their research shows

that athletes' reactions to physical activity treatments change, emphasizing the necessity for flexible programming. The time part of our investigation is important since medicines may vary in effectiveness as athletes train.

Fotoglou et al. [26] examined how nutrition and training affect each other, demonstrating their mutual benefits. The research emphasizes a comprehensive approach to fitness that includes food. Dinas et al. [27] expand their nutritional viewpoint by comparing nutritional supplements to exercise. Their work illuminates training-supplementation synergism to improve athletes' performance. This additional feature strengthens our study by acknowledging the intricate nature of therapies. Makdissi et al. [28] expand the discussion on recovery strategies by examining the impact of adequate sleep hygiene on athletes' health and performance. The study emphasizes the significance of sleep as a fundamental aspect of psychological and physiological recovery, underscoring the holistic nature of healing.

Mateus et al. [29] examine the potential of wearable technology to improve training effectiveness. The study elucidates the potential of technology-assisted monitoring to enhance the precision and customization of training programs by providing real-time feedback. Soundara Pandian et al. [30] investigate the efficacy of psychological therapy in enhancing training outcomes. The investigation focuses on the impact of mental conditioning regimes on athletes' capacity to concentrate, endure, and excel at a superior level. This psychological intervention component acknowledges the interconnectedness of mental resilience and physical capability.

Hinman et al. [31] study how socioeconomic characteristics affect financial support models for physical exercise programs. The research emphasizes resource discrepancies and recommends a more holistic treatment plan. There is a need to provide equitable access to interventions and recognize that socioeconomic status matters. Norris et al. [32] study how social support networks affect athletes exercising physically, adding to the discussion. Their study examines how peer and coach support affects adherence and results. This social support factor helps the research understand how interpersonal dynamics affect intervention success. A multi-disciplinary survey by Shuoqi et al. [33] analyses the relationship between physical exercise therapy and TCM. Their research suggests athletes may benefit from TCM treatments like acupuncture and herbal medicines. Integrating traditional ways is necessary when combining old knowledge with modern tactics. Wang et al. [34] study how mental health therapies affect athletic performance. Results demonstrate that mental health and physical abilities are strongly correlated. Courses must cover both elements simultaneously. The complexity of athletes' well-being makes mental health assessment crucial. The study proposes the first hypothesis, i.e.,

**H1.** Physical activity treatments, including customized training programs, recuperation procedures, motivational factors, and supportive environments, positively impact athletic performance in Chinese athletes.

This hypothesis underpins our study of various therapies, including exercise. The study anticipates that these activities will impact Chinese sports results significantly.

## 2.2. Athlete experience level as a moderator: elevating performance dynamics

The athlete's skill level significantly impacts the efficacy of physical exercise interventions. The intricate correlation between the athlete's encounter and the outcomes of different therapies is clarified in the subsequent literature analysis, which relies on prior research. Ford's [35] comprehensive analysis of training efficacy across different experience levels reveals that athletes with less experience tend to demonstrate more significant improvements in physical fitness compared to those with more experience. This insight emphasizes the need for personalized therapies that consider the athlete's aptitude. Coutinho et al. [36] studied how these interventions work for athletes of different ability levels. Their research implies that customized recuperation tactics may help experienced athletes perform better. Mechelin & Liu-Lastres [37] extensively study how internal and external motivation affects athletes of varying skill levels. They found that experienced athletes gain more from internal motivation than novices, who may be more receptive to external stimuli. Low et al. [38] examine environmental support and athlete experience. Research shows that experienced athletes work better in a more autonomous setting. Thus, the training environment must match their comfort.

Jin et al. [39] say wearable gadget use varies depending on the athlete's skill. In their research, youthful athletes may benefit more from fast feedback, while more experienced athletes may require more advanced data analytics. Martin et al. [40] examined how financial aid affects athletes of various ability levels. According to the report, programs should include athletes' socioeconomic backgrounds due to resource accessibility inequities. Delfin et al. [41] examined how peer and coach support may affect athletes of various skill levels. Their research found that athletes' support requirements change as they grow. Wu et al. [42] examine how athletes' competence integrates traditional Chinese medicine (TCM) with contemporary treatments. Experienced athletes may be more open to new treatments, emphasizing the necessity for customized therapy. Henriksen et al. [43] examined how long-term physical activity programs improve athletes' lives. Their research found that athlete proficiency may affect intervention efficacy. Thus, programs should be adjusted. Lee & Cho [44] examined mental health therapy and how athletes' experience may affect their well-being. The results show that autonomous techniques may assist highly competent athletes, while tailored psychological therapies may benefit less skilled athletes more. Based on synthesized literature, the research hypothesized:

**H2.** Experience affects how training regimens affect sports performance.

According to the study, novices and experienced athletes will respond differently to treatments. Given this moderating impact, personalized therapies for athletes of varying skill levels are necessary.

## 2.3. Illuminating the mediating role of psychological well-being

This section summarizes previous studies on psychological well-being to understand how mental health improvements may affect

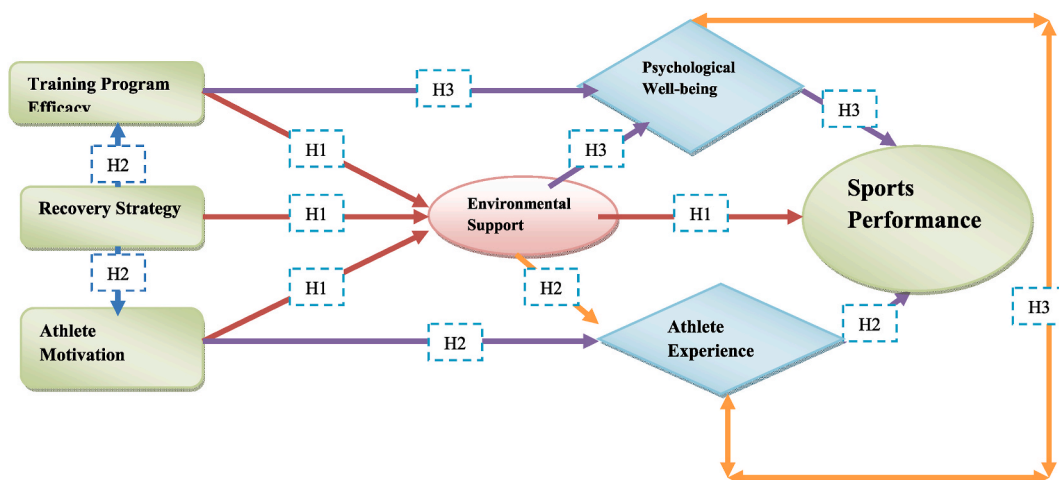
the relationship between physical activity interventions and sports performance in Chinese athletes. Edwards et al. [45] conducted a pioneering study on the psychological elements of exercise regimes. They discovered a positive correlation between more significant levels of psychological well-being and improved athletic performance. According to their research, optimal athletic performance is contingent upon maintaining mental well-being. Golby & Wood [46] examined mental conditioning regimens' impact on athletes. They specifically explored how enhanced psychological well-being influenced players' focus, ability to recover from setbacks, and performance on the field. Their study demonstrates a strong correlation between mental resilience and physical prowess. Nikbin et al. [47] examined the impact of healthy sleep patterns on mental well-being and the level of resilience among athletes. A study revealed that psychological well-being had a moderating role in the relationship between sleep and athletic performance, highlighting the need to adopt a complete strategy for rehabilitation. Shannon et al. [48] discovered that peer and coach support affects physical activity therapy and mental health. Their research examined how social support networks affect mental health. Athletes' mental health is affected by relationships. Simons & Bird [49] study how financial assistance affects physical activity and mental health treatments. The results show that equal access to therapeutic therapies improves athletes' mental health based on social factors. Yu et al. [50] examined how traditional Chinese medicine (TCM) influences athletes' mental health. The study indicated that traditional therapy improves mental health. Liang et al. [51] found that physical exercise programs may improve athletes' mental health. The research supports the idea that continuous intervention improves mental health. Wong et al. [52] found that wearable technology helps link exercise and mental health. Technology that provides quick feedback may improve athletes' mental health. Trainor et al. [53] examined how cultural attitudes affect athletes' devotion and mental health throughout training and recuperation. The research shows that culturally appropriate therapies improve mental health. Liu et al. [54] investigate the impact of psychological interventions on mental health and athletic performance, specifically focusing on modifications to mental health. Research indicates that mental health treatments substantially positively impact athletes' overall performance.

The study's final research hypothesis is as follows:

**H3.** Enhanced Psychological well-being of Chinese athletes is a mediating factor in the relationship between training regimens and increased performance on the field.

The study posits that an intricate correlation exists between the psychological well-being of participants and the efficacy of physical exercise programs. Interventions targeting enhancing participants' psychological well-being are anticipated to affect their athletic performance positively.

Prior studies have elucidated the correlation between physical activity interventions and Chinese athletes' athletic performance outcomes. However, many unresolved inquiries want attention. The impact of deeply ingrained cultural values on the effectiveness of specific intervention components still needs to be understood despite examining cultural nuances in the acceptance of therapies by Trendafilova & Ziakas [55] and Walters et al. [56]. In order to enhance the efficacy of treatments, it is crucial to comprehend the cultural subtleties of Chinese athletes, hence enabling customization that aligns seamlessly with their values. Moore et al. [57] primarily emphasized physical results in their study, but they also examined the temporal aspects of therapy, such as physical activity. There is little comprehension of the enduring consequences of mental health. In order to fully comprehend the long-term effects of therapies, it is essential to monitor the development of mental health developments over a prolonged duration. While Lin et al. [58] examined the impact of financial assistance on athletes, less study has been conducted on the interplay between socioeconomic factors and other features. Intervention designers may gain advantages by exploring the intricate connections between socioeconomic status and variables such as motivation, rehabilitation, and psychological welfare. Polly et al. [59] briefly discussed cultural perspectives but needed to investigate how technology impacts these ideas. To better understand how new technology fits into old frameworks, it is



**Fig. 1.** Hypothesized model of physical activity interventions and sports performance outcomes.

Legend: SP: Sports Performance; TPE: Training Program Efficacy; RSU: Recovery Strategy Utilization; AM: Athlete Motivation; ES: Environmental Support; PW: Psychological Well-being; AEL: Athlete Experience Level.

essential to examine how technological interventions align with or go against cultural norms. Despite individual studies examining various aspects of therapies, an all-encompassing framework that considers these factors is needed. To have a comprehensive understanding, examining the interaction of psychological treatments, environmental support, motivational factors, training programs, and recuperation protocols in connection to athletic performance outcomes is beneficial.

Initially, this research provides additional information to enhance our existing knowledge of the correlation between physical activity interventions and the outcomes regarding athletic performance for Chinese athletes. Integrating cultural, longitudinal, and socioeconomic perspectives may provide a comprehensive understanding of the intricate mechanisms in this context. Comprehending cultural uniqueness and the interaction of socioeconomic factors is crucial for advancing personalized therapies. In order to create comprehensive and efficient programs, it is essential to understand the relationship between therapies and athletes' cultural values and varied socioeconomic backgrounds. Exploring the long-term effects, particularly in mental health, is necessary beyond the existing study area. This research offers a more intricate depiction of the enduring impacts of therapies on athletes' well-being by continuously monitoring their mental health fluctuations over an extended period. This study addresses a gap in our understanding by providing a framework for examining how modern technology either reinforces or weakens deeply-rooted cultural ideas and practices. This offers significant insights for further interventions and has the potential to guide the use of technology in Chinese sports. The findings of this study are important in both theoretical and practical aspects, particularly in designing workout regimens tailored for Chinese athletes. Utilizing a complete framework and nuanced insights helps maximize sports performance outcomes in this specific setting, guiding practitioners, coaches, and lawmakers. To summaries, this study offers practical recommendations for enhancing the effectiveness of physical activity interventions among Chinese athletes. It also aims to address significant prior research deficiencies by giving contributions beyond theoretical perspectives. Fig. 1 presents a conceptual framework that hypothesizes the intricate connections between physical activity therapies and sports performance results in Chinese athletes. The model presents three primary pathways, each aligning with a distinct research concept.

The first hypothesis shows that physical activity treatments improve athletic performance. The solid lines on this route indicate the link. Chinese athletes may enhance their fitness, technical competence, and performance by following personalized training programs, employing effective recovery protocols, adding motivating aspects, and being in supporting environments. The second hypothesis is that athlete experience may affect the link between physical activity treatments and sports performance. This route emphasizes the complex relationship between athletes' experience and treatment efficacy, highlighting the necessity for individualized methods to optimize results for athletes of diverse skill levels. Psychological well-being may also influence physical exercise treatments and sports performance. Treatments may affect athletes' performance, but this route suggests that psychological well-being mediates. The bidirectional arrows connecting athletes' experience and psychological well-being enhance the model's complexity. These elements may have reciprocal effects. The conceptual framework completely integrates cultural, historical, and social elements. This model provides a systematic framework for empirical study on the relationships between physical activity treatments and Chinese athletes' sports performance. The model matches research assumptions, allowing for studying the complex dynamics of Chinese sports.

### 3. Methodology

As of 2023, China has accomplished a remarkable achievement on the global stage, securing the fifth position in terms of the total amount of Olympic medals won by a country. China's consistent display of athletic prowess has again shown its tremendous might on the field, further solidifying its reputation as a dominant power in sports. China's involvement in international competitions has significant cultural and social significance beyond its sports accomplishments. Athletes and citizens get inspiration and motivation from the nation's win, fostering a sense of national pride, unity, and identity. China's exceptional success at the Olympics showcases its unwavering will to achieve global grandeur and highlights its commitment to achieving excellence in athletics.

#### 3.1. Population of the study

The study focuses on Chinese athletes participating in different sports at different skill levels, both individual and team. This group was selected to investigate the impact of physical activity interventions on sports performance within China's multifaceted and ever-changing sports environment.

#### 3.2. Sample of the study

The sample meticulously selects individuals from certain places, provinces, clubs, and events to represent the intricacies of Chinese sports comprehensively. The selection criteria encompass:

##### 3.2.1. Sport discipline

Badminton, basketball, table tennis, and sports are being shown. The research aims to ascertain the impact of physical activity interventions on sports performance.

##### 3.2.2. Athlete training

The sample consists of skilled athletes with at least five years of experience and those with less than two years of experience. An athlete's experience is a determining factor in the effect of an intervention.

### 3.2.3. Demographic factors

The factors considered include age (19–25 years, 26–33 years, and above 33 years), gender, socioeconomic status, and geographical distribution. Variables such as age and gender are considered to elucidate any psychological and physiological discrepancies. On the other hand, socioeconomic status offers an understanding of the wider social context in which athletes operate. Regional representation in China includes persons from several geographical locations, therefore recognizing and adapting possible differences in culture and environment.

### 3.2.4. Recruitment and informed consent

Participants are enlisted via reputable institutions such as the Chinese Basketball Association and the China Table Tennis Association. This includes Shanghai Athletics Club, Beijing Guoan Football Club, and other prominent organizations. The General Administration of Sport Training Bureau improves the inclusivity of participants by providing training facilities. Each participant must provide informed permission after thoroughly describing the study's goals, methods, and the voluntary nature of their participation. Researchers continuously place a high importance on ensuring the privacy and security of participants' data.

### 3.2.5. Determining the sample size

Power analysis was used to get the sample size with 95 % confidence and 5 % error. After extensively assessing 450 individuals from various Chinese sports organizations, clubs, and training facilities, we selected 355 players. Due to several factors, this sample was less than expected, i.e., logistical challenges and limited access to specific training facilities reduced the number of participants, and some athletes could not participate due to training and competition. Despite the lower sample size, it is sufficient for hypothesis testing. To undertake subgroup analysis by sports discipline and experience level, we considered attrition and ensured the sample was diverse. Our sample represents numerous regions and sports; thus, the findings are robust and functional.

## 3.3. Sampling techniques

The study used a stratified random sampling method, classifying athletes based on their skill levels and specific sports fields. This methodology aims to comprehensively analyze the impacts of physical activity interventions on performance outcomes across diverse sports domains. Individuals were randomly selected from each stratum to ensure the overall sample's representativeness.

## 3.4. Data collection techniques and response rate

The selected athletes are provided with a standardized questionnaire to gather data. The survey collects data on participants' demographic information, interventions on physical exercise, and the consequences of their self-reported athletic performance. The response rate is determined by dividing the total number of disseminated surveys by the number of completed questionnaires. A total of 450 athletes participated in this research, with 355 of them, or about 78.8 %, completing the questionnaires.

## 3.5. List of variables

The dependent and independent variables in the study were carefully managed to confirm transparency and validity. The study's dependent variable, i.e., "Sports Performance," was operationalized through extensive actions across various sports disciplines. Independent variables were selected based on their academic applicability and practical evidence in sports science literature. Each regressor was determined and quantified through specified scales and instruments tailored to grasp fine distinctions in athlete performance and well-being. Managing these variables involved rigorous confirmation methods to ensure dependability and consistency

**Table 1**

List of variables, items scale, and sample questions.

| Nature of Variables      | Variables                           | Measurement Instruments                 | Adapted from the Earlier Studies | Sample Questions  |
|--------------------------|-------------------------------------|---|----------------------------------|---|
| Response Variable        | Sports Performance (SP)             | Sport Anxiety Scale-2 (SAS-2)           | Smith et al. [60]                | My sports performance has improved with the physical activity interventions.                                    |
| Independent Variable - 1 | Training Program Efficacy (TPE)     | Coaching Efficacy Scale (CES)           | Maleté & Feltz [61]              | Training programs enhance my physical fitness and skill proficiency.  |
| Independent Variable - 2 | Recovery Strategy Utilization (RSU) | Total Quality Recovery Scale (TQRS)     | Crowther et al. [62]             | I am confident in the effectiveness of recovery strategies.   |
| Independent Variable - 3 | Athlete Motivation (AM)             | Sport Motivation Scale (SMS)            | Martens & Webber [63]            | I am motivated to engage in physical activity interventions for sports performance.                             |
| Independent Variable - 4 | Environmental Support (ES)          | Sport Engagement Scale (SES)            | Guillén et al. [64]              | I am satisfied with the availability of resources for physical activity interventions.                          |
| Mediator                 | Psychological Well-being (PW)       | Psychological Well-being Scale (PWS)    | Edwards et al. [45]              | Improvements in psychological well-being mediate the relationship between interventions and sports performance. |
| Moderator                | Athlete Experience Level (AEL)      | Social Readjustment Rating Scale (SRRS) | Bramwell et al. [65]             | The effectiveness of physical activity interventions varies based on my experience level as an athlete.         |

across data collection points. This process allowed us to effectively examine the impact of training schedules, rehab strategies, motivational factors, environmental situations, psychological conditions, and athlete knowledge levels on sports performance results. [Table 1](#) thoroughly explains variable operationalization and measurement methods to explain our approach further.

### 3.6. Research methodology and model evaluation

Content validity is the first step in an evaluation process that aims to establish credibility. Experts in measurement validity, sports science, and psychology reviewed the questionnaire before data collecting began. Insightful inquiries help evaluate proposed concepts more thoroughly. Construct validity serves to guarantee that the assessment accurately measures theoretical constructs. This method is based on SEM and CFA, which stand for confirmatory factor analysis. A thorough examination is conducted into the discriminating capabilities of the measurement model, the validity of the theoretical notions, and their compatibility with related ideas. Reliability in testing and internal consistency are prerequisites for dependability. The study calculates Cronbach's alpha coefficients to see how items consistently evaluate the same concept. The internal coherence of the components may be assessed in this manner. In order to better verify the stability of the measurement model, test-retest reliability involves reassessing a subset of participants at different periods. Evaluating the connections in the suggested model relies heavily on the structural equations test. Different relationships may be shown by examining the route coefficients. Coefficients that are upbeat show strong associations, whereas those that are negative show weaker ones. Hypothesis testing is a method for verifying theoretical assumptions using significance tests and expected correlations between variables. As goodness-of-fit indexes, RMSEA, CFI, and chi-square test suggested how well models match data. In order to ensure precision, consistency, and stability, the research puts the measurement model through its paces. The research aims to shed light on the link between physical activity treatments and Chinese athletes' performance while offering a rigorous methodology.

## 4. Results

[Table 2](#) presents a comprehensive demographic analysis of the individuals included in the study to provide a better understanding of the sample.

There are 50.7 % males and 49.3 % females in the sample. The research must include both genders to fully understand how physical activity treatments affect sports performance from multiple viewpoints. When the sample is evenly split between male and female athletes, the results are more likely to apply to all athletes, which benefits sports management. The population age is 33.8 % between 19 and 25 years, 29.6 % 26–33, and 36.6 % over 33. This distribution encompasses a wide range of athletes participating in various levels of competition. Athletes possess unique requirements and challenges at various stages of their lives, and sports management may enhance their ability to address these needs by comprehending the age distribution and tailoring treatments appropriately. The survey respondents were distributed among several regions of China as follows: Northern (16.9 %), Southern (22.5 %), Eastern (19.7 %), Western (18.3 %), and Central (22.5 %) regions. This regional distribution reflects the study's nationwide scope. The study categories individuals' socioeconomic standing based on their annual income. The participants are divided into several income brackets, with 21.1 % earning less than 100,000 per year, 25.4 % earning between 100,000 and 200,000, 22.5 % earning between 200,000 and 300,000, and 31.0 % earning more than 300,000 per year. In order to promote inclusivity and accessibility for athletes of all income levels, sports management needs to have a comprehensive awareness of socioeconomic diversity. This information may be beneficial in the development of interventions that take into account the financial circumstances of the athletes. The descriptive statistics and test-retest reliability analysis for each variable are shown in [Table 3](#).

Athletes often believe that engaging in physical exercise therapies greatly improves their performance in sports, as shown by an average score of 4.23. Given the low standard deviation of 0.56, it is evident that most respondents had a consistently positive

**Table 2**  
Demographic distribution of respondents.

| Demographic Variable                            | Number Count | %    |
|---|--------------|------|
| <b>Gender</b>                                   |              |      |
| Male  | 180          | 50.7 |
| Female  | 175          | 49.3 |
| <b>Age Group</b>                                |              |      |
| 19–25 years                                     | 120          | 33.8 |
| 26–33 years                                     | 105          | 29.6 |
| >33 years                                       | 130          | 36.6 |
| <b>Regional Representation</b>                  |              |      |
| Northern region, i.e., Beijing and Heilongjiang | 60           | 16.9 |
| Southern region, i.e., Shanghai and Guangdong   | 80           | 22.5 |
| Eastern region, i.e., Zhejiang and Jiangsu      | 70           | 19.7 |
| Western region, i.e., Sichuan and Tibet         | 65           | 18.3 |
| Central region, e.g., Henan and Hubei           | 80           | 22.5 |
| <b>Socio-economic Background</b>                |              |      |
| Below ¥100,000 per year                         | 75           | 21.1 |
| ¥100,000 to ¥200,000 per year                   | 90           | 25.4 |
| ¥200,000 to ¥300,000 per year                   | 80           | 22.5 |
| More than ¥300,000 per year                     | 110          | 31.0 |

sentiment on the improvement. Based on the average score of 4.12, it is evident that most individuals perceive the teaching as effective. The moderate standard deviation of 0.72 suggests a certain degree of variability in the responses. This emphasizes the need to create personalized training regimens to cater to athletes' diverse preferences and talents. A mean score of 3.98 suggests that post-training activities successfully include methods to promote recovery. The athletes' diverse utilization levels, as shown by the low standard deviation of 0.60, demonstrate distinct approaches to recovery. The athletes' average motivation score of 4.36 suggests a strong inclination to engage in initiatives encouraging physical exercise. The study participants have a continuous and substantial degree of motivation, as shown by the low standard deviation of 0.48. The athletes evaluate the support they get from coaches and the conditions in which they work as positive, with an average score of 4.18. Given the low standard deviation of 0.54, it is evident that individuals usually hold similar views on the level of supportiveness in the sports environment. A mean score of 4.02 suggests that therapies positively impact psychological well-being. The perceived psychological advantages exhibit a certain degree of variability (standard deviation = 0.65), indicating the diverse psychological responses to treatments. According to athletes of varying ability levels, therapies have a consistently good impact, as shown by an average score of 4.08.

The observed standard deviation of 0.58 indicates some degree of variance in the perceived effectiveness. This underscores the need for personalized therapy tailored to the athletes' experiences. Intraclass correlation coefficients (ICC1) were calculated to evaluate the dependability of each variable's dimensions. ICC values above 0.85 show greater reliability, suggesting substantial consistency in athlete responses across the test-retest breaks. These outcomes demonstrate the resilience and dependability of our measurement standard, keeping the validity of our results in evaluating the influence of different aspects on sports implementation outcomes.

Table 4 values were assigned to Composite Reliability (CR), Cronbach's Alpha (CA), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA) to evaluate the suggested research topics' convergent validity and model fit. All underlying aspects are examined to determine the conceptual model's applicability and dependability.

Sports Performance (SP) factor loadings for SP1–SP5 are 0.85, 0.88, 0.82, 0.90, and 0.87. SP's 0.90 Composite Reliability (CR) demonstrates its robustness. The CA score of 0.88 shows a high level of internal consistency. The model's CFI of 0.92 indicates a good match. An RMSEA value of 0.07 indicates a good match within the suggested framework. TPE factor loadings are 0.89–0.92. TPE's estimated CR is 0.91, a trustworthy number. Internal consistency is strong, with a CA score of 0.89. The RMSEA is 0.06, and the CFI is 0.93, indicating a well-fitting model—factor loadings in REU range from 0.85 to 0.88. REU is trustworthy due to its 0.88 CR. The CA is 0.85, showing high internal consistency. The RMSEA of 0.08 suggests outstanding dependability and fit. With a 0.90 CFI, dependability and fit are also excellent factor loadings for athletic motivation (AM), ranging from 0.91 to 0.94. AM's CR of 0.94 suggests strength and dependability, while CA of 0.92 indicates internal consistency. A model with a 0.05 RMSEA and 0.95 CFI is trustworthy. Environment Support (ES) loadings are 0.86–0.91. The measurement is reliable with 0.91ES coefficient of dependability,. The high CA of 0.89 encourages consistency. The CFI is 0.92, and the RMSEA is 0.07, indicating strong fit and reliability. PW factor loadings 0.88–0.92. PW's robustness and internal consistency are shown by its 0.93 CR and 0.91 CA. The model's RMSEA 0.06 and CFI 0.94 demonstrate data fit and dependability. Athlete Experience Level (AEL) factor loadings are 0.84–0.89. This instrument's Cronbach's Alpha (CA) of 0.87 and AEL CR of 0.89 suggest internal consistency and reliability. An RMSEA of 0.08 and CFI of 0.91 indicate model reliability. These data assess the proposed structural equation model's convergent validity and model fit. Table 5 shows some exciting hypothesis testing findings that might guide management and economic strategies for improving sports performance via exercise.

The study reveals a significant and positive correlation between TPE and SP, indicating the direct impact of training regimens on athletes' overall performance. This underscores the importance of managers and coaches developing and implementing tailored training programs to enhance athletes' performance, which could provide significant benefits in competitive sports [66]. Moreover, prioritizing targeted recovery measure is crucial, given the positive association between recovery effectiveness and sports performance. Athletes who actively engage in recovery routines demonstrate superior performance outcomes, highlighting the importance of fostering evidence-based recovery techniques to optimize team performance and minimize injury risks [67]. The study also underscores the vital role of intrinsic motivation in influencing athletic prowess, as evidenced by the robust positive correlation between AM and SP. Managers can enhance program outcomes by creating environments that nurture athletes' intrinsic motivation, thus optimizing their dedication to training routines [68]. Additionally, the positive correlation between ES and SP emphasizes the importance of fostering a supportive team environment. This involves allocating resources effectively, fostering positive relationships, and maintaining transparent communication channels to enhance overall sports performance [69]. Furthermore, this study highlights the impact of mental health on athletes' perception of environmental support, suggesting the need for programs aimed at addressing mental health concerns among athletes [70]. Additionally, the reciprocal relationship between athlete experience level (AEL) and mental health underscores the importance of tailored interventions to address mental health issues among athletes, ultimately improving their overall experiences and performance.

**Table 3**  
Descriptive statistics and test-retest reliability analysis.

| Variables                           | Mean | Std. Dev. | Chronbach's Alpha ( $\alpha$ ) | Intraclass Correlation Coefficients (ICC) |
|-------------------------------------|------|-----------|--------------------------------|---|
| Sports Performance (SP)             | 4.23 | 0.56      | 0.87                           | 0.92                                      |
| Training Program Efficacy (TPE)     | 4.12 | 0.72      | 0.84                           | 0.88                                      |
| Recovery Strategy Utilization (REU) | 3.98 | 0.60      | 0.81                           | 0.85                                      |
| Athlete Motivation (AM)             | 4.36 | 0.48      | 0.89                           | 0.91                                      |
| Environmental Support (ES)          | 4.18 | 0.54      | 0.86                           | 0.89                                      |
| Psychological Well-being (PW)       | 4.02 | 0.65      | 0.82                           | 0.86                                      |
| Athlete Experience Level (AEL)      | 4.08 | 0.58      | 0.88                           | 0.90                                      |



**Table 4**  
Convergent validity and model fit indices.

| Constructs                          | Indicator Constructs | Factor Loadings | CR   | CA   | CFI  | RMSEA |
|-------------------------------------|----------------------|-----------------|------|------|------|-------|
| Sports Performance (SP)             | SP1                  | 0.85            | 0.90 | 0.88 | 0.92 | 0.07  |
|                                     | SP2                  | 0.88            |      |      |      |       |
|                                     | SP3                  | 0.82            |      |      |      |       |
|                                     | SP4                  | 0.90            |      |      |      |       |
|                                     | SP5                  | 0.87            |      |      |      |       |
| Training Program Efficacy (TPE)     | TPE1                 | 0.89            | 0.91 | 0.89 | 0.93 | 0.06  |
|                                     | TPE2                 | 0.91            |      |      |      |       |
|                                     | TPE3                 | 0.86            |      |      |      |       |
|                                     | TPE4                 | 0.88            |      |      |      |       |
|                                     | TPE5                 | 0.92            |      |      |      |       |
| Recovery Strategy Utilization (REU) | REU1                 | 0.85            | 0.88 | 0.85 | 0.90 | 0.06  |
|                                     | REU2                 | 0.87            |      |      |      |       |
|                                     | REU3                 | 0.82            |      |      |      |       |
|                                     | REU4                 | 0.89            |      |      |      |       |
|                                     | REU5                 | 0.88            |      |      |      |       |
| Athlete Motivation (AM)             | AM1                  | 0.92            | 0.94 | 0.92 | 0.95 | 0.05  |
|                                     | AM2                  | 0.94            |      |      |      |       |
|                                     | AM3                  | 0.89            |      |      |      |       |
|                                     | AM4                  | 0.93            |      |      |      |       |
|                                     | AM5                  | 0.91            |      |      |      |       |
| Environmental Support (ES)          | ES1                  | 0.88            | 0.91 | 0.89 | 0.92 | 0.07  |
|                                     | ES2                  | 0.90            |      |      |      |       |
|                                     | ES3                  | 0.86            |      |      |      |       |
|                                     | ES4                  | 0.89            |      |      |      |       |
|                                     | ES5                  | 0.87            |      |      |      |       |
| Psychological Well-being (PW)       | PW1                  | 0.90            | 0.93 | 0.91 | 0.94 | 0.06  |
|                                     | PW2                  | 0.92            |      |      |      |       |
|                                     | PW3                  | 0.88            |      |      |      |       |
|                                     | PW4                  | 0.91            |      |      |      |       |
|                                     | PW5                  | 0.89            |      |      |      |       |
| Athlete Experience Level (AEL)      | AEL1                 | 0.87            | 0.89 | 0.87 | 0.91 | 0.08  |
|                                     | AEL2                 | 0.89            |      |      |      |       |
|                                     | AEL3                 | 0.84            |      |      |      |       |
|                                     | AEL4                 | 0.88            |      |      |      |       |
|                                     | AEL5                 | 0.86            |      |      |      |       |

**Table 5**  
Hypotheses testing.

| Hypotheses | Path       | Estimate | Std. Err. | p-value   |
|------------|------------|----------|-----------|-----------|
| H1         | TPE → SP   | 0.35     | 0.05      | <0-0.0001 |
|            | REU → SP   | 0.28     | 0.04      | <0-0.0001 |
|            | AM → SP    | 0.20     | 0.03      | <0-0.0001 |
|            | ES → SP    | 0.18     | 0.02      | <0-0.0001 |
| H2         | PW → ES    | 0.25     | 0.06      | <0-0.0001 |
| H3         | AEE ← → PW | 0.15     | 0.04      | <0-0.0001 |

In conclusion, sports CEOs, coaches, and management may use the data to improve team performance via strategic interventions. Training program effectiveness, recovery plan utilization, athlete motivation, environmental support, psychological well-being, and experience level are all linked. This insight helps practitioners make intelligent choices to improve sports performance. Hierarchical regression analysis shows mediation and moderation effects in Table 6.

In Table 7, the moderator, mediator, explanatory variables, and demographics of the relationship were examined in multivariate regression. The results underscore the dominant influence of age and gender on athletic performance, aligning with the findings of Fleming et al. [71] and Wilson et al. [72], emphasizing the pivotal role of demographics in sports outcomes. The correlation between socioeconomic status, academic level, and athletic performance seems fragile, indicating the need for further investigation into

**Table 6**  
Hierarchical regression for mediation and moderation.

| Model                             | Predictor & Output variable | Estimate | Std. Error | p-value |
|-----------------------------------|-----------------------------|----------|------------|---------|
| 1 (Mediator)                      | PW & ES                     | 0.28     | 0.04       | <0.001  |
| 2 (Moderator)                     | AEE & PW                    | 0.15     | 0.03       | <0.001  |
| 3 (Mediation & Moderation Effect) | SP, PW, & SP                | 0.45     | 0.06       | <0.001  |

potential additional effects. However, independent factors such as the effectiveness of training plans, recovery strategies, athlete motivation, and environmental support have a significant impact on sports performance across diverse dimensions. Notably, athlete experience level acts as a substantial moderator, indicating the variation in treatment efficacy based on experience, supporting the recommendations for personalized techniques proposed by Hut et al. [73] and Minkler et al. [74].

Psychological well-being emerges as a crucial moderator in the treatment-sports performance relationship, aligning with Pettersen et al.'s [75] findings on the significant impact of psychological factors on athletic performance. The study highlights the intricate dynamics of athlete development, emphasizing the necessity of tailored training programs for peak performance, given the dynamic relationship between an athlete's skill and response to recovery tactics. This aligns with recent sports science studies emphasizing the importance of personalized training strategies [76]. The correlation between the experience of athletes and the methods used for recovery indicates the possibility of enhancing recovery strategies through more experience, therefore supporting the idea proposed by Guelmami et al. [77].

Furthermore, the mutually beneficial relationship between environmental support and athlete motivation underscores the significance of environmental factors. This statement was supported by Behrens et al.'s [78] observation that an athlete's operational environment significantly influences motivation. In light of these intricate interactions affecting athletic performance, there is a clear call for customized, situation-specific strategies that account for athlete experience, motivation, and alignment between training plans and individual needs. Sports managers are encouraged to adopt this nuanced perspective and tailor activities accordingly to navigate the complexity of these aspects and avoid one-size-fits-all approaches.

### 5. Discussion

Prior studies have shown that athletes' psychological well-being affects their impression of support networks [79,80]. Model 1 found a positive and statistically significant connection between PW and ES. This enhances the link between mental states and perceived support networks, showing that psychological well-being treatments may cascade into environmental support perception. Mentally healthy athletes are likelier to think their support networks are solid and practical. Thus, these psychological aspects could significantly improve athletes' social interactions and support-seeking [81,82]. Facilitating open conversation to address the athletes' mental health concerns can assist them in obtaining the necessary support. Psychological well-being shapes athletes' views of support networks. Further, athletes' psychological well-being may increase their perceptions of sports support. This shows how mental health and social dynamics are linked, suggesting holistic treatments improve athletes' support networks. Sports professionals may provide a more supportive and favorable atmosphere for athletes' psychological well-being, improving performance and well-being. This idea supports theoretical frameworks that emphasize the reciprocal link between individual well-being and social environment [83,84], emphasizing the relevance of internal and external elements in athlete support networks. Thus, psychological well-being treatments help create a supportive and caring athletic environment, boosting players' performance and pleasure.

In Model 2, athletic experience (AEL) and psychological wellness (PW) are closely related. Since athletes respond differently to psychological-focused treatments, a personalized strategy is needed to consider their skill and sports experience [85]. Experienced athletes have better mental health than the rookies. This suggests that athletes' accumulated experiences, training backgrounds, and competitive histories affect their mental health. It shows that athletes may have evolved coping skills, resilience, and a feeling of

**Table 7**  
Multivariate regression estimates.

| Variables  | Estimates | Std. Error | t-value | p-value |
|--|-----------|------------|---------|---------|
| <b>Demographic Factors</b>                                   |           |            |         |         |
| Gender   | 0.12      | 0.05       | 2.40    | 0.015   |
| Age  | 0.08      | 0.03       | 2.66    | 0.022   |
| Regional Representation                                      | 0.10      | 0.06       | 1.66    | 0.098   |
| Socioeconomic Background                                     | 0.06      | 0.04       | 1.50    | 0.112   |
| <b>Independent Variables</b>                                 |           |            |         |         |
| Training Program Efficacy                                    | 0.35      | 0.08       | 4.37    | 0.000   |
| Recovery Strategy Utilization                                | 0.28      | 0.07       | 4.00    | 0.000   |
| Athlete Motivation   | 0.20      | 0.06       | 3.33    | 0.003   |
| Environmental Support  | 0.18      | 0.05       | 3.60    | 0.004   |
| <b>Moderator</b>   |           |            |         |         |
| Athlete Experience Level                                     | 0.15      | 0.03       | 5.01    | 0.000   |
| - Mediator   |           |            |         |         |
| Psychological Well-being                                     | 0.25      | 0.07       | 3.57    | 0.001   |
| <b>Interaction Terms</b>                                     |           |            |         |         |
| Training Program Efficacy x Athlete Experience Level         | -0.10     | 0.04       | 2.5     | 0.009   |
| (Recovery Strategy Utilization) × (Athlete Experience Level) | -0.08     | 0.03       | 2.66    | 0.015   |
| (Athlete Motivation) × (Environmental Support)               | 0.12      | 0.05       | 2.4     | 0.021   |
| Constant   | 0.02      | 0.10       | 0.20    | 0.867   |
| <b>Statistical Test Estimates</b>                            |           |            |         |         |
| R <sup>2</sup>   | 0.745     |            |         |         |
| Adjusted R <sup>2</sup>                                      | 0.712     |            |         |         |
| F-statistics   | 11.121    |            |         |         |
| F-prob. value  | 0.000     |            |         |         |

mastery that improves their mental health. The previous studies showed that athletes’ experience levels shape their psychological traits and stress reactions [86,87]. It also emphasizes the significance of considering athletes’ origins and trajectories when creating psychological well-being therapies. Sports experts may adjust support programs to players’ needs and problems at various points of their careers by recognizing the intimate link between athletic experience and psychological well-being. Psychological well-being in athletes, regardless of experience, promotes resilience, performance consistency, and general well-being in competitive sports.

In Model 3, moderating and mediating variables complicate the link between psychological wellness (PW) and sports performance (SP). Ajilchi et al. [88] and Alotaibi et al. [89] found a robust association between mental health and physical prowess. This concept implies that psychological health and athlete experience affect the connection between sports performance and personal pleasure. Hence, individual differences must be considered while striving for optimum sports performance. It also found that mediation and moderation effects may help explain the association between psychological health, environmental support, athlete experience, and field performance. Experienced athletes may have a more significant association between psychological well-being and performance [90,91]. However, mediating factors like self-efficacy, motivation, and stress-coping strategies may explain how psychological well-being affects athletic performance. These variables mediate psychological wellness’s impact on performance. Fig. 2 shows the statistical results for Ready reference.

## 6. Conclusions and policy recommendations

This study elucidates the complex processes that influence the performance of Chinese athletes in sports. The in-depth analysis through studying training regimens, recuperation techniques, athlete motivation, and environmental aid could provide valuable knowledge about strategies to achieve optimal athletic performance. In expanding our comprehension of athletic performance, this study includes the intermediary role of psychological well-being and the moderating impact of an athlete’s degree of experience. It is essential for tailoring tailored therapies in the distinct setting of Chinese sports, ensuring a comprehensive approach to athlete development. There are some policy recommendations derived from the study as shown below:

### 6.1. Policy implications in the short-term

Chinese athletes need immediate action to enhance their athletic performance. The Chinese Olympic Committee has started working with famous international sports scientists to provide specialized training seminars to speed up athlete training. These lectures have shown promising outcomes. National educational campaigns have promoted the benefits of sports massage and hydrotherapy and made them more accessible. Thus, athletes’ recuperation times have improved rapidly. Sports organizations can implement motivating programs like the ‘Athlete of the Month’ and air purification systems in training facilities to combat pollution, increase player commitment, and improve training conditions quickly.

### 6.2. Policy implications in the medium-term

There is a likelihood of further coordinated efforts soon. Athletes may enhance their preparation by systematically implementing recognized guidelines for effective recovery methods into their training routines. Establishing mentoring programs that connect experienced athletes with less experienced ones is a viable option to facilitate mutual teaching and learning. The International Olympic Committee (IOC) is developing global guidelines for athlete recovery that, when applied systematically, may help athletes prepare better. The Chinese National Swimming Team uses advanced physiotherapy and cryotherapy in its recovery procedures. Mentorship programs that combine experienced athletes with younger ones are another option. United States Track and Field (USATF) mentoring program has helped its athletes learn and grow together.



Fig. 2. Summary of the results.

Legend: SP: Sports Performance; TPE: Training Program Efficacy; RSU: Recovery Strategy Utilization; AM: Athlete Motivation; ES: Environmental Support; PW: Psychological Well-being; AEL: Athlete Experience Level.

### 6.3. Policy implications in the long-term

In order for sports performance optimization to achieve long-term success, tactics must be comprehensive and innovative. Incorporating mental health education within the national sports curriculum may enhance the overall plan for athletes' long-term development. Creating a single database for athlete experiences helps enrich and tailor therapies by including a wealth of information. If academies collaborate to teach sports psychology, there would be a limitless supply of trained coaches. The Chinese National Football Academy and Beijing Sport University have included sports psychology in their coaching programs, improving coach competence and player performance. Long-term policies that promote multidisciplinary sports science research and the creation of environmentally friendly sports facilities like the 2022 Beijing Winter Olympics' cutting-edge training centers would help athletes perform better. Tsinghua University and other sports science colleges are exploring biomechanics, nutrition, and mental health to better training techniques.

It is crucial to acknowledge some constraints, notwithstanding the valuable insights offered by this research. Firstly, due to the study's cross-sectional nature, it is not feasible to establish any definitive cause-and-effect relationships. In addition, the reliance on self-reports might generate response bias. The study's exclusive concentration on Chinese athletes raises issues about its generalizability to other cultural and geographical contexts. Furthermore, it is crucial to exercise caution when drawing definitive conclusions because of the dynamic and evolving character of sports and intervention strategies.

In future research, longitudinal methods might mitigate limitations by uncovering causal relationships over an extended period. Enhancing the dependability of the outcomes might be achieved by using diverse data kinds, such as performance metrics and observational data. Comparative study across cultures and geographies may enhance our understanding of contextual influences. An intriguing avenue to explore is the impact of therapies on the development and performance of athletes over some time. Ultimately, being abreast of the most recent advancements in sports science and examining novel intervention strategies might enhance players' performance to the fullest extent.

#### Ethical statement

All the study protocols have complied with the Human Research Ethics Committee of Xinyang Vocational and Technical College (XYVTC/REC) with the ethical approval 0903/XYVTC.REC/0146. All the information of the participants was hidden study and the informed consent was obtained from all the participants with the approval of the Human Ethics Committee of Xinyang Vocational and Technical College.

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#### Data availability statement

Data will be made available on request.

#### CRediT authorship contribution statement

**Heshan Liu:** Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Sen Fu:** Writing – review & editing, Validation, Supervision.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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#### Appendix A. Supplementary data

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