



Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using the Delphi Method

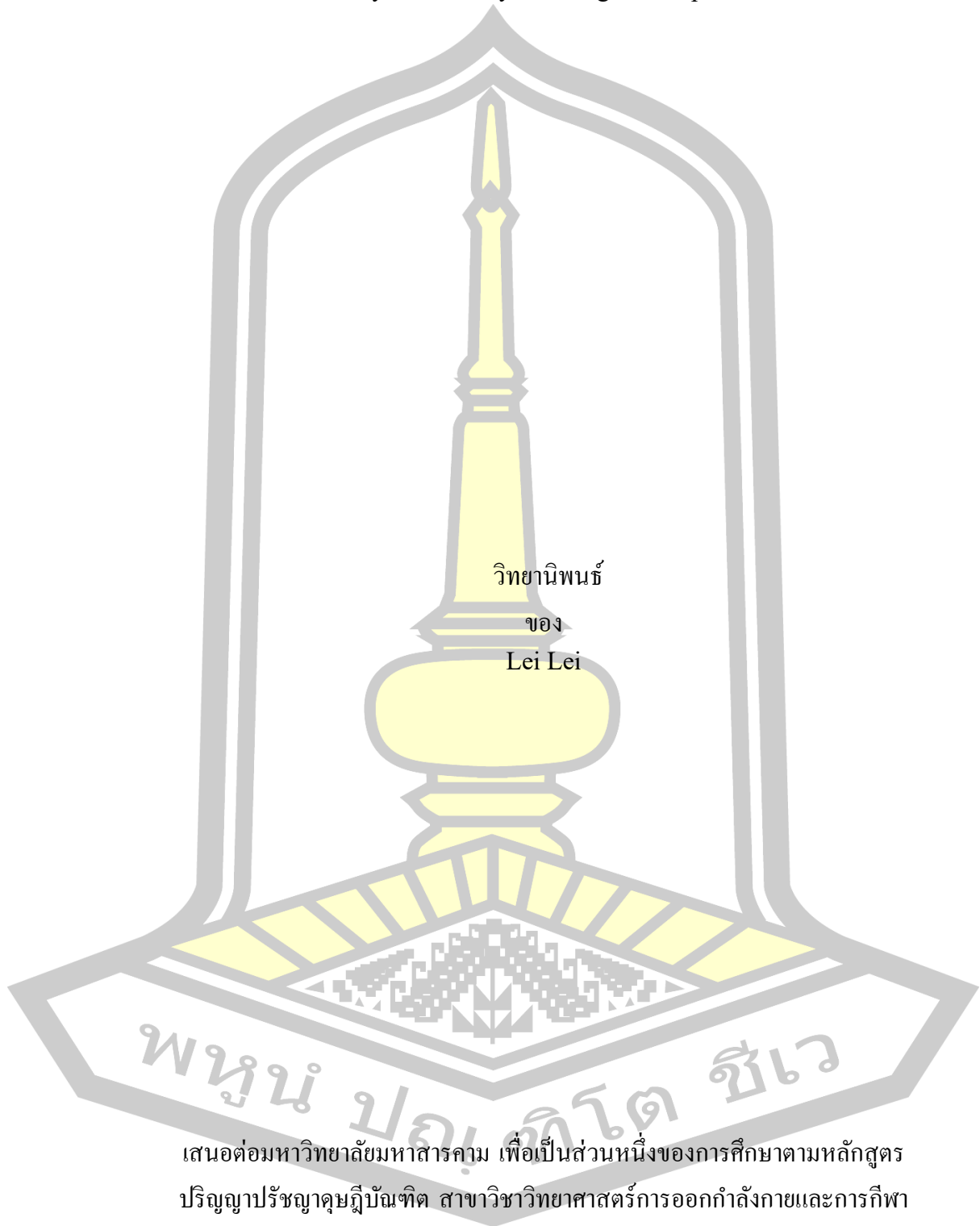
Lei Lei

A Thesis Submitted in Partial Fulfillment of Requirements for
degree of Doctor of Philosophy in Exercise and Sport Science

June 2025

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University Tennis Players Using the Delphi Method



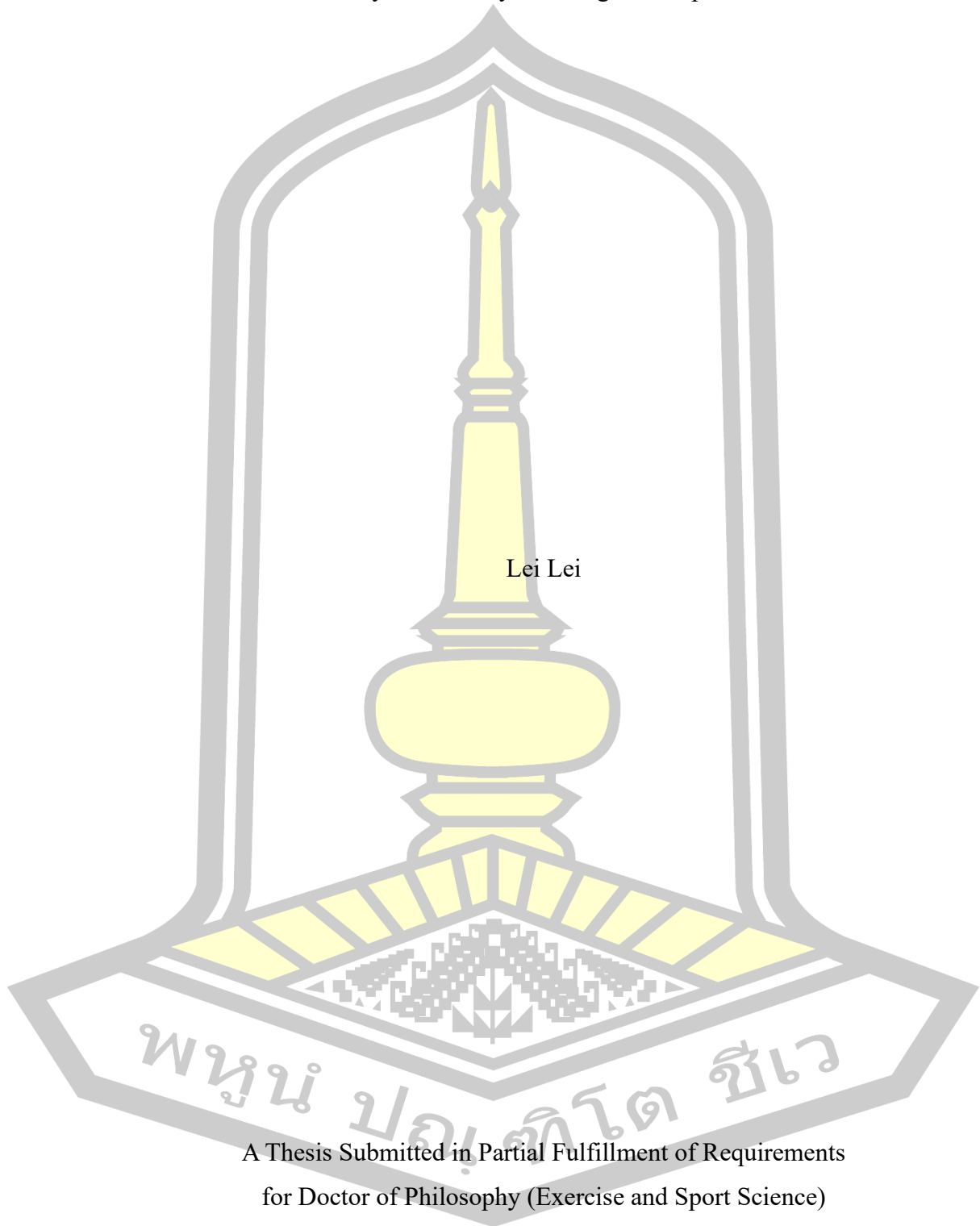
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เสนอต่อมหาวิทยาลัยมหาสารคาม เพื่อเป็นส่วนหนึ่งของการศึกษาตามหลักสูตร
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Lei Lei

A Thesis Submitted in Partial Fulfillment of Requirements
for Doctor of Philosophy (Exercise and Sport Science)

June 2025

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The examining committee has unanimously approved this Thesis, submitted by Ms. Lei Lei , as a partial fulfillment of the requirements for the Doctor of Philosophy Exercise and Sport Science at Maharakham University

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TITLE	Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using the Delphi Method		
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ABSTRACT

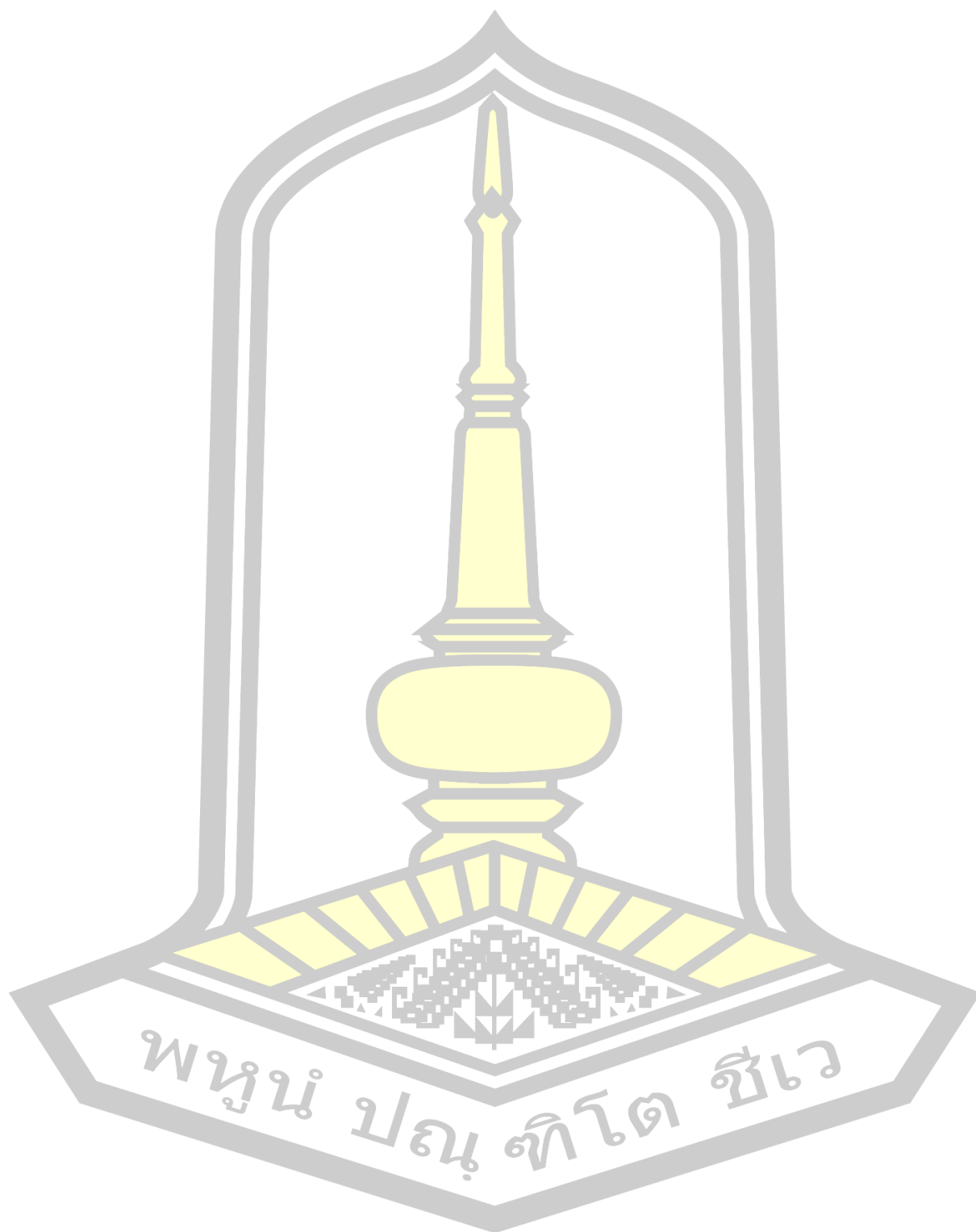
This study developed and validated a specialized physical fitness evaluation system for Chinese Elite Male University Tennis Players (CEMUTP) through a combination of qualitative and quantitative methods, integrating the Delphi method and experiments.

Anchored in sports training theory and measurement-evaluation frameworks, the research initiated with a three-round Delphi consultation (n=23) that refined 35 preliminary indicators into a consensus-based system comprising 5 primary domains (power, speed, endurance, agility, coordination) and 15 secondary indicators, supported by robust expert consensus (Cr=0.915, Kendall's W=0.684). Subsequent experimental testing with 53 athletes employed reliability analysis using Corrected Item-Total Correlation (CITC) and post-deletion Cronbach's α coefficients ($\alpha=0.876$), culminating in 14 validated secondary indicators. Exploratory Factor Analysis (KMO = 0.769) confirmed the structural validity of the five primary domains, comprising 14 secondary indicators. Weighting coefficients were determined through Principal Component Analysis (PCA) and Entropy Weight Method (EWM), while performance benchmarks were established via progressive scoring, percentile ranking, and deviation-based composite evaluation criteria. The system demonstrated exceptional reliability and validity through back-substitution (n = 30) verification and expert assessment (IOC = 0.95).

By systematically integrating qualitative expert judgment with quantitative validation, this framework addresses the critical absence of sport-specific fitness assessment tools for male collegiate tennis athletes in China, providing a scientific basis for talent identification, personalized training optimization, and performance monitoring, and advances evidence-based practice in athletic evaluation.

Keyword : Elite Tennis Players, Specialized Physical Fitness, Evaluation System,

Delphi Method



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Lei Lei

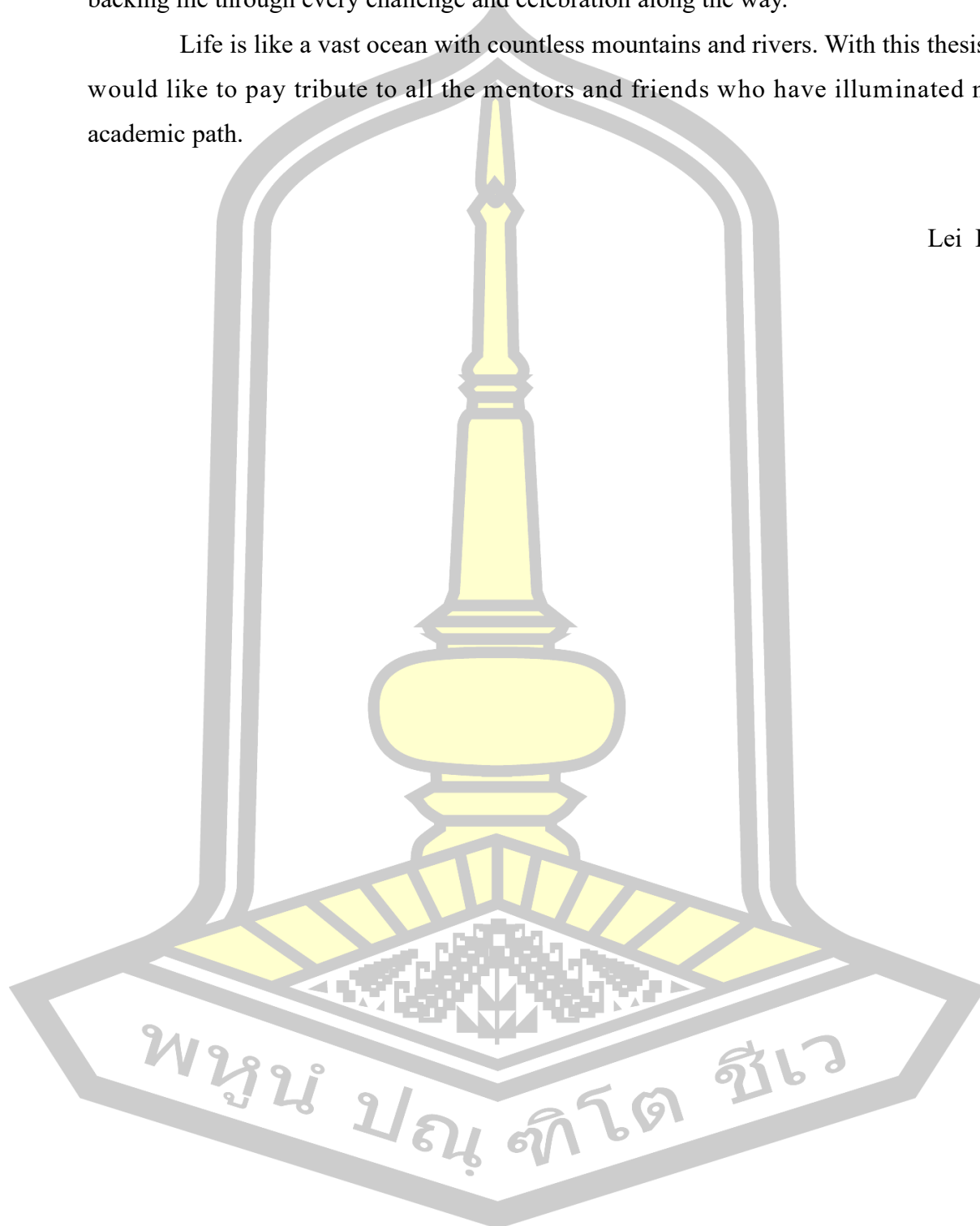


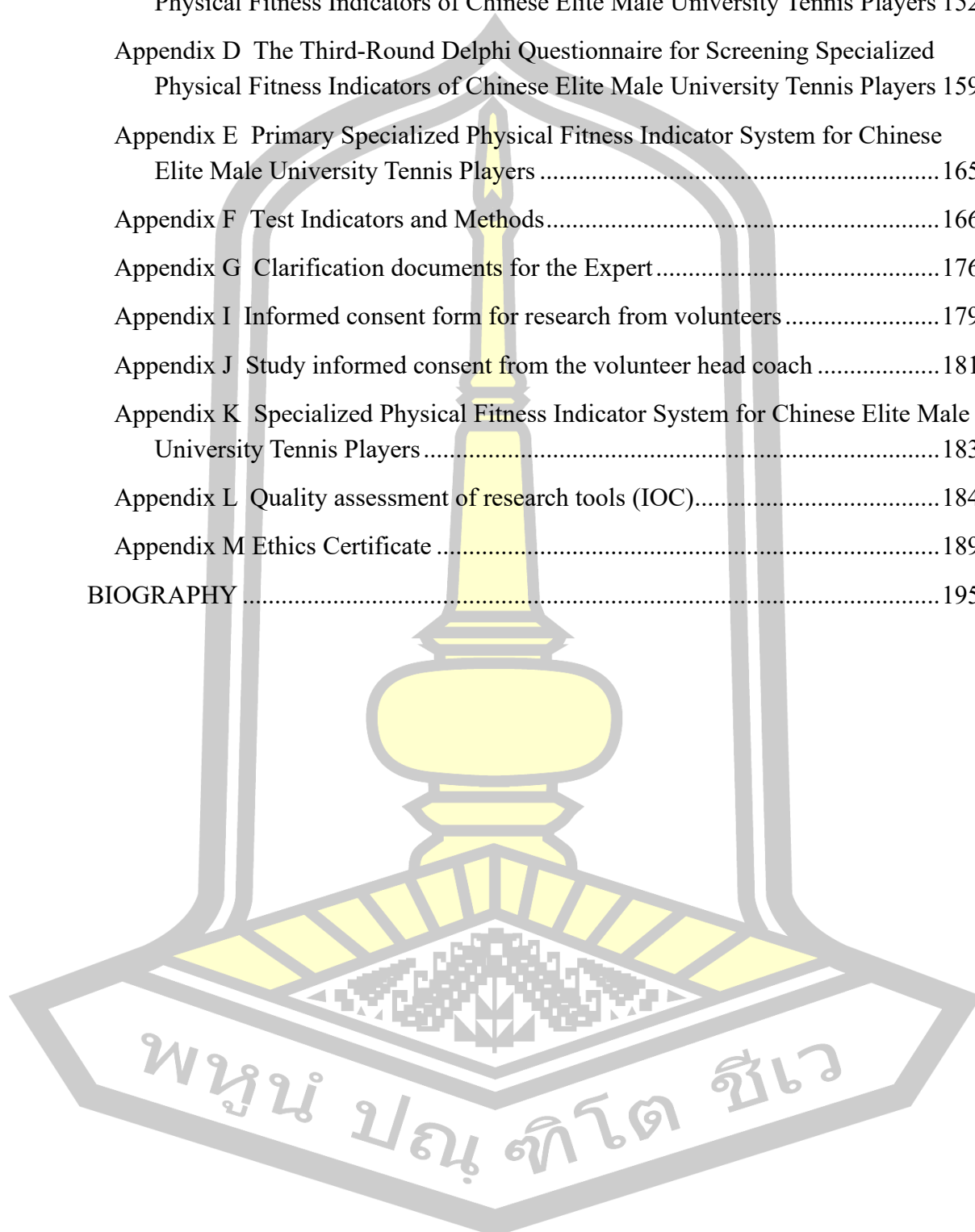
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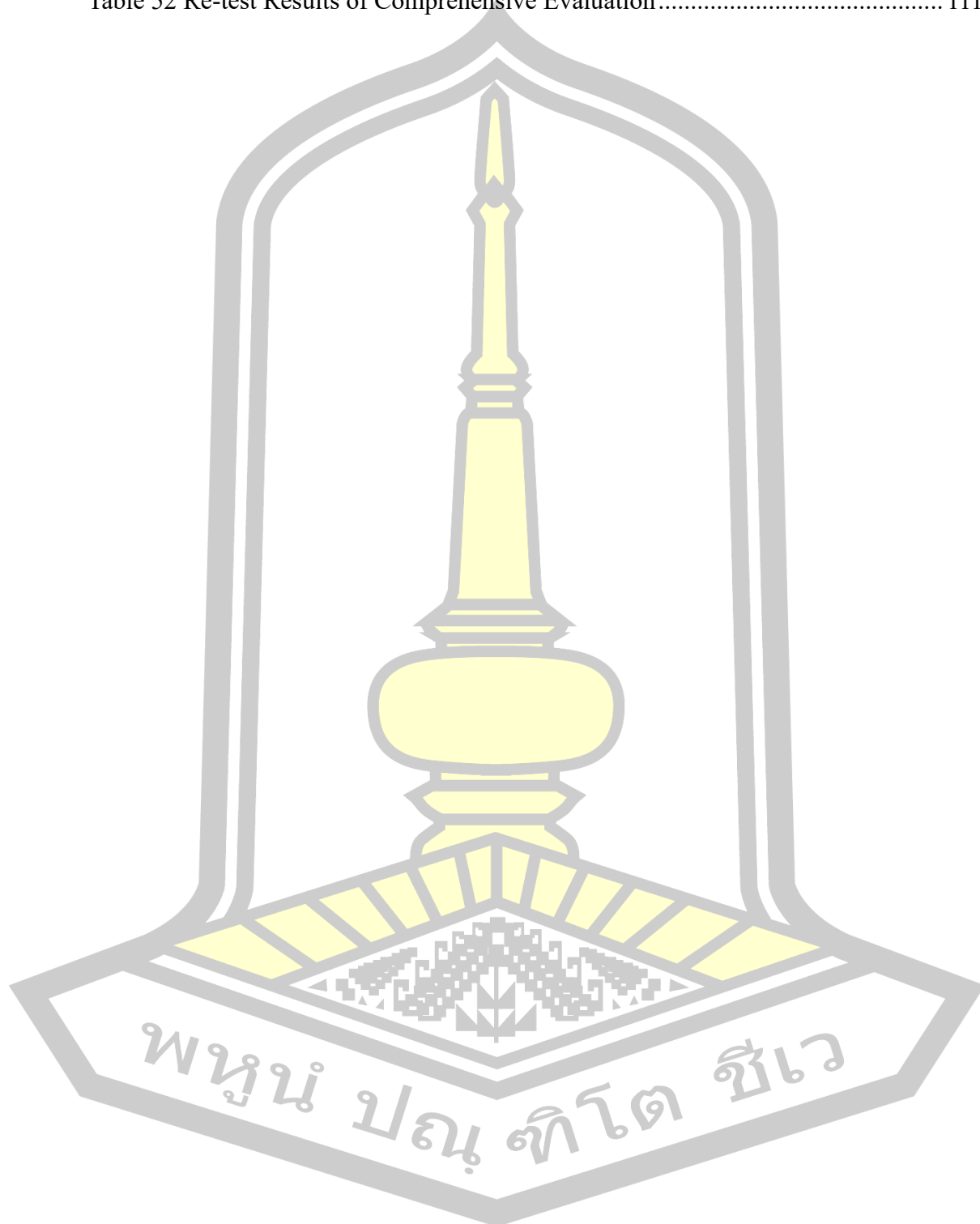
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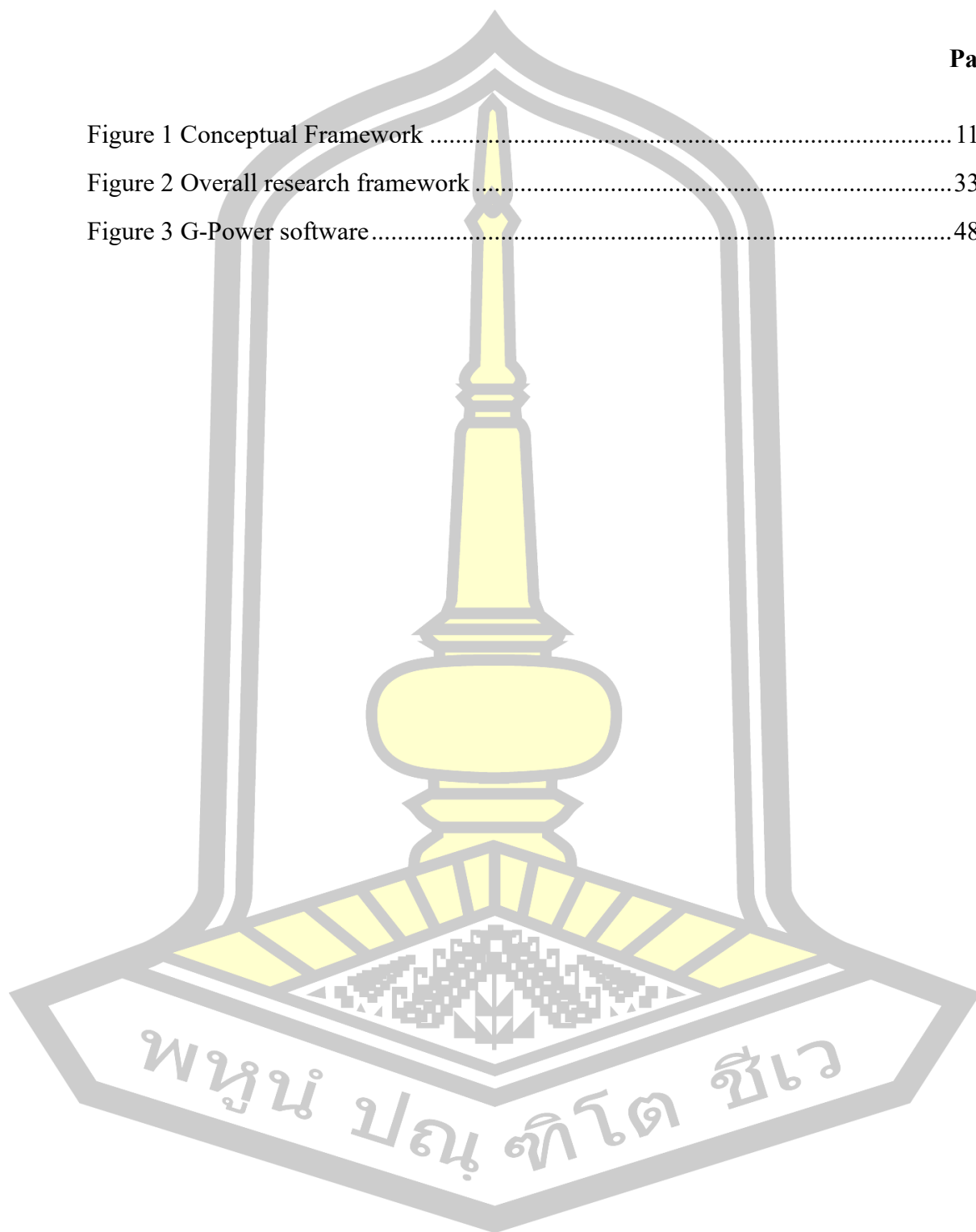
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CHAPTER I

INTRODUCTION

1.1 Background

Tennis, recognized as the world's second largest racket sport (Brouwers, 2015), boasts a profound history, rich culture, and widespread influence, making it a shining gem in the history of sports. In the world of tennis, physical fitness serves as a solid foundation for athletes to scale new heights, while technical skills are the sharp swords they wield to overcome challenges, and unwavering mental fortitude is the strong backend that supports them to the end. With the continuous development of modern competitive sports, tennis tactics have become increasingly diverse and demanding, placing ever greater emphasis on athletes' physical fitness (Tao, 2007). Enhancing physical fitness has a significant impact on improving an athlete's sport-specific performance (Sanchis et al., 2011; Fernandez et al., 2017). In competitive sports, the development of specialized physical fitness is essential for enhancing athletic performance (Gamble, 2013). To scientifically assess and improve athletes' physical fitness, establishing a specialized physical fitness evaluation system is of paramount importance (Fares et al., 2022; Ye et al., 2024).

For Tennis player the physical fitness is one of the key determinants of their competitive ability (Tian, 2017). In competitive tennis, athletes' physiological capabilities play a decisive role in match outcomes, particularly when competitors exhibit comparable skill levels (Page et al, 2017; Buszard et al., 2017). Success in the sport necessitates a multifaceted athletic profile, integrating agility, explosive power, aerobic endurance, and neuromuscular coordination to execute advanced techniques against increasingly skilled opponents (Kovacs, 2007; Fernández et al., 2009). Unlike sports reliant on isolated physical traits, tennis performance emerges from the synergistic interaction of these attributes, which collectively underpin technical proficiency and tactical execution (Buszard et al., 2017). Optimal physical conditioning further serves as the foundation for enhancing athletic performance (Yong, 2017), a principle reinforced by the International Tennis Federation's (ITF)

guidelines. The ITF explicitly identifies speed, strength, flexibility, agility, and endurance as essential metrics for assessing tennis-specific fitness (ITF, 2019), thereby justifying their inclusion in this study's framework. Systematic sports training has a significant effect on improving the physical fitness of tennis players (Xiao, et al., 2021).

The concept of physical fitness originates from sports training science. Chinese scholar Tian (2017) posits that physical fitness can be categorized into several dimensions, namely strength, speed, endurance, agility, and flexibility. However, other scholars have included coordination and power when analyzing the physical fitness of tennis players (Xiao et al., 2021; Predoiu, 2015). These elements collectively represent the comprehensive manifestation of diverse basic motor capabilities. These core components are not only an integrated representation of human physical activity but also serve as critical indicators for assessing an individual's physical capacity and athletic performance (Wang et al., 2023; Tian, 2020). Furthermore, physical fitness plays a crucial role in athletic performance, as it enables athletes to achieve their highest potential when participating in competitive sports events (Siramaneerat et al., 2020). Physical fitness has a profound impact on tennis players' athletic abilities. This has been fully confirmed in numerous studies. Rigorous sports training can significantly improve tennis players' physical fitness indicators such as speed, agility, and power, thereby enhancing their competitiveness in competitions (Xiao et al., 2021; Sanchis et al., 2011; Fernández et al., 2017). These research findings not only provide a scientific basis for coaches to develop training plans but also point out the direction for athletes to improve their physical fitness.

Specialized Physical Fitness (SPF) refers to the development of specific physical abilities tailored to a particular sport or competitive demand. Compared to General Physical Fitness (GPF), SPF places greater emphasis on specificity, requiring training and testing methods to align with the demands of the targeted sport (Bompa & Buzzichelli, 2019). SPF is typically supported by the Specific Physical Preparedness (SPP) theory, which underscores the necessity for athletes to engage in targeted training that accounts for movement patterns, energy systems, and muscular work modes (Verkhoshansky & Siff, 2009). In competitive sports, the development of SPF

is critical for enhancing athletic performance, particularly in sports that demand high levels of specialized physical capabilities, such as tennis (Gamble, 2013).

Chinese Elite Male University Tennis Players refer to male university tennis athletes who have obtained Level 2 or Level 1 Tennis Player Certification in China. In China, tennis players follow a strict ranking system, gradually advancing to higher levels by participating in formal competitions at different levels and achieving corresponding rankings. The term "graded athlete" refers to athletes who have been formally approved and awarded the title of athlete after passing assessments. They are classified into several levels: International Master Athlete, National Master Athlete, Level 1 Athlete, Level 2 Athlete, and Level 3 Athlete (Standards for Athletes' Technical Grades, 2008). In general, for tennis players to obtain an International Master Athlete certificate, they must achieve good rankings and performances in the highest-level international tennis tournaments. To meet the National Master Athlete (or simply Master Athlete) standards, they must excel in national tennis events and be qualified to participate in and obtain rankings in international-level competitions. To achieve the status of Level 1 Athlete, they need to attain top 8 or top 5 results in nationwide tennis events. To obtain the title of Level 2 Athlete, they must win among the top 3 to 8 in provincial events. Lastly, to acquire a Level 3 Athlete certificate, they need to secure individual rankings from 9th to 16th and team rankings from 5th to 8th in provincial competitions. 80% of professional athletes in China are university athletes (China Science Daily, 2022). According to statistical data released by the National Bureau of Statistics of China on July 20, 2022, the total number of elite athletes across various sports disciplines in the country reached 17,937. Among them, 5,635 athletes were classified as National Level 1, and 7,583 athletes were classified as National Level 2 (National Bureau of Statistics of China, 2022). This indicates that National Level 1 and Level 2 athletes collectively account for 74% of all athletes in China, making them the largest athlete group in the country.

This study focuses on Chinese elite male university tennis athletes, grounded in the following academic rationale: First, guided by the Principle of Specificity in sports training (Fernandez et al., 2011), significant physiological distinctions exist between male and female athletes, including testosterone levels on muscle synthesis regulation, biomechanical demands (e.g., hip-shoulder separation angles in serving kinetics), and

injury risk mechanisms (e.g., ACL injury probability) (Kovacs, 2007; ITF, 2019 ; Yanovich et al., 2008; Billaut et al., 2003; Kang et al., 2002; Knapik et al., 2001). Mixed-gender studies may lead to indicator generalization, thereby compromising the reliability and validity of the evaluation system. Second, there is a critical gap in sport-specific physical fitness research targeting this demographic in China, while the professionalization of university male tennis competitions urgently requires tailored assessment tools to scientifically inform talent selection and training protocols (Xiao et al., 2022). Future research will adopt the same framework to develop evaluation systems for female athletes and conduct gender-comparative analyses to advance sex-specific theories in tennis physical fitness.

With the rapid development of modern technology and continuous innovation in training methods, tennis players' physical fitness training is facing unprecedented challenges and opportunities. New training concepts, methods, and means are emerging, providing athletes with more diversified training options and more personalized training programs. However, how to scientifically assess training effects, promptly adjust training plans, and optimize the training process to ensure comprehensive, balanced, and sustained development of athletes' physical fitness remains a pressing issue in current tennis training practices.

The concept of the evaluation system originates from sports measurement and evaluation. It is a systematic framework based on sports science theories and empirical data, utilizing multidimensional indicators and comprehensive evaluation methods to conduct both quantitative and qualitative analyses of athletes' physical fitness (Sun et al., 2022). In the physical fitness evaluation of tennis players, establishing a comprehensive, objective, and accurate evaluation system is of paramount importance. Such a system not only helps coaches and athletes gain a better understanding of their current physical condition and identify areas for improvement but also provides a solid foundation for designing targeted training programs and enhancing competitive performance. This theory emphasizes reliability and validity (Morrow et al., 2015), which will be applied in this research to develop a tennis-specific physical fitness evaluation system, ensuring the scientific rigor of the measurement indicators.

This study adopts a mixed-methods research (MMR) design that systematically integrates qualitative and quantitative approaches across two sequential phases (Creswell & Plano Clark, 2018; Teddlie & Tashakkori, 2009). In Phase 1, the Delphi method was employed for qualitative analysis, engaging 23 domain experts across three iterative rounds to refine primary and secondary indicators through consensus building (Kendall's $W = 0.68$). Phase 2 involved quantitative validation, where data from 53 athletes were analyzed using reliability tests (Cronbach's $\alpha = 0.88$) and exploratory factor analysis ($KMO = 0.83$) to establish the evaluation system's psychometric robustness. Criteria such as progressive scoring scales and percentile-based grading were developed to operationalize the assessment framework. Through methodological triangulation (Saraswati et al., 2023), this dual-phase design not only corroborates findings across data types but also ensures the derived standards align with both expert judgments and empirical performance metrics.

Although there have been some studies on the physical fitness evaluation systems for tennis players both domestically and internationally, existing research exhibits two major limitations. First, from a methodological perspective, current studies tend to over-rely on qualitative analyses (e.g., expert interviews), leading to a lack of systematic quantitative indicators and sport-specific adaptability. Second, most research focuses on general university student populations, with empirical studies specifically targeting the segment of Chinese Elite Male University Tennis Players remaining largely absent. Based on these gaps, this study aims to develop a specialized physical fitness evaluation index system for tennis, integrating both qualitative and quantitative analyses through a mixed-methods approach. The ultimate objective is to establish an evaluation tool that balances theoretical rigor and practical applicability, providing a scientifically grounded assessment framework to enhance the training effectiveness of Chinese Elite Male University Tennis Players. The construction of this evaluation system holds dual significance: First, theoretical Contribution : by introducing sport-specific evaluation indicators, this study addresses the limitations of traditional generalized physical fitness assessment systems, which often lack precision in evaluating the demands of elite tennis players.

Second, practical application : The system will generate personalized physical fitness diagnostic reports, allowing for the precise identification of physiological weaknesses. This, in turn, will enable coaching teams to formulate targeted intervention strategies. Additionally, the evaluation framework can serve as a scientific basis for athlete selection in competitive sports teams. By bridging methodological and empirical research gaps, this study contributes to both sports science research and applied training methodologies, fostering a more evidence-based approach to physical fitness assessment and performance enhancement for Chinese Elite Male University Tennis Players.

1.2 Research Questions

This study aims to establish an evaluation system for the specialized physical fitness of Chinese Elite Male University Tennis Players. It will focus on the following core research questions:

1. How to investigate the specialized physical fitness indicators of Chinese Elite Male University Tennis Players?
2. How to construct an evaluation system for the specialized physical fitness of Chinese Elite Male University Tennis Players?
3. How to scientifically and reasonably verify the specialized physical fitness evaluation system for Chinese Elite Male University Tennis Players?

1.3 Objective of the Study

The objective of this study is to establish an evaluation indexes system specific to the physical fitness of Chinese Elite Male University Tennis Players. This endeavor specifically entails the following three aspects:

1. To investigate the specific physical fitness indicators of Chinese Elite Male University Tennis Players.
2. To construct a specific physical fitness evaluation system for Chinese Elite Male University Tennis Players.
3. To validate the scientific accuracy and rationality of the specific physical fitness evaluation system for Chinese Elite Male University Tennis Players.

1.4 Research Hypothesis

Studies have shown that improving physical fitness can enhance athletic performance (Marin., et al., 2023; Xiao, 2023). This study aims to construct a specialized physical fitness evaluation system for Chinese Elite Male University Tennis Players. The research will utilize the Mixed method, sports measurement techniques, and statistical analysis to establish the evaluation system. The process will begin with the design and development of measurement tools (Step 1), proceed with the construction of the evaluation system (Step 2), and conclude with the validation of the final evaluation (Step 3).

H₁: Identification of Specific Physical Fitness Indicators

There are distinctive physical fitness indicators that are critical for Chinese Elite Male University Tennis Players, which differ from general physical fitness metrics used in conventional evaluations. These indicators will include agility, explosive power, endurance, coordination, and tennis-specific strength, which significantly influence athletic performance.

H₂: Development of a Specialized Physical Fitness Evaluation System

A sport-specific physical fitness evaluation system tailored to Chinese Elite Male University Tennis Players can be effectively constructed by integrating quantitative and qualitative methodologies, ensuring that the evaluation framework accurately reflects the physiological and biomechanical demands of tennis performance.

H₃: Validation of the Scientific Accuracy and Practicality of the Evaluation System

The specialized physical fitness evaluation system will be validated for its scientific accuracy and effectiveness through back-substitution testing and expert assessment. The system will provide reliable data for performance diagnostics, enabling coaches and athletes to make evidence-based training decisions and optimize training interventions for improved competitive outcomes. Additionally, it will serve as a theoretical basis for athlete selection, ensuring a more scientific and systematic approach to identifying and developing high-potential players.

1.5 Scope of the Study

The scope of this study encompasses the following dimensions:

1. Geographic Scope

The target population of this study consists of male university tennis players in China. Data collection will be primarily conducted in six universities located in Xi'an and Shanghai. The selection of these two regions is based on their possession of specialized sports universities and universities with established tennis teams, ensuring the availability of research participants. Moreover, the altitude difference between these two cities is minimal, yet variations in geographical location and training environments among universities may potentially influence athletes' training methods and physical fitness outcomes.

2. Participant Scope

Target Population: This study targets Chinese elite male university tennis players who hold Chinese National Level 1 or Level 2 Tennis Player Certifications. Among them, there are 22 athletes at Level 1 and 31 athletes at Level 2.

3. Variable Scope

Independent Variables: The independent variables in this study are the secondary indicators formulated through Step 1 and Step 2 of the evaluation system development process.

Dependent Variables: The dependent variables in this study are the physical fitness test results of the athletes.

4. Research Limitations

Geographical Constraints: Due to practical feasibility, this study is limited to six universities in Xi'an and Shanghai, which may not be generalizable to universities in underdeveloped regions.

Sample Specificity: This study focuses exclusively on Level 1 and Level 2 tennis players, excluding lower-tier athletes and female players.

Temporal Scope: Since this study adopts a cross-sectional research design, it cannot provide longitudinal data on the development of tennis players' physical fitness over time.

1.6 Significant of study

The significance of this study lies in the construction of a comprehensive physical fitness evaluation system specifically designed for Chinese Elite Male University Tennis Players. This evaluation system addresses a critical gap in the existing literature by providing a systematic framework to assess the physical attributes that are essential for improving performance and overall health within this specific population in the field of tennis.

By establishing a targeted evaluation system, this study contributes to the advancement of sports science knowledge, particularly in the domain of athletic performance among Chinese Elite Male University Tennis Players. Furthermore, the developed evaluation system has practical implications for coaches, trainers, and sports management professionals involved in the training, development, and talent identification processes of university-level tennis programs.

In addition, this research serves as a foundational platform for future investigations and interventions aimed at optimizing the physical fitness, performance, and long-term athletic development trajectories of Chinese Elite Male University Tennis Players. The findings of this study may also inform the selection and evaluation processes for training teams and athletes, not only fostering the development of elite tennis talent and supporting the holistic growth of male tennis players in China but also offering valuable insights into the training and selection of athletes from other sports. By highlighting the importance of a hierarchical understanding of physical fitness and targeted training strategies, this research can serve as a methodological reference for optimizing performance and talent identification across various athletic disciplines.

1.7 Definitions of Terms

The following definitions were used in this research.

Specialized Physical Fitness

The concept of specialized physical fitness originates from sports training science. Specialized Physical Fitness (SPF) refers to the development of specific physical abilities tailored to a particular sport or competitive demand.

This research initiated with 7 preliminary primary indicators: strength, speed, endurance, agility, flexibility, coordination, and power, identified through a synthesis of general physical fitness frameworks and tennis-specific literature. Following three rounds of Delphi expert questionnaires, 5 core primary indicators were retained: power, speed, endurance, agility, and coordination. For secondary indicators, an initial pool of 35 candidate metrics (Appendix B) was refined to 15 through Delphi consensus, with further reliability testing (Cronbach's $\alpha > 0.85$; CITC > 0.3) yielding 14 validated indicators, including: 1.Overhead Medicine Ball Throw, 2.Medicine Ball Throw with Forehand Closed Stance , 3.Medicine Ball Throw with Backhand Closed Stance, 4.Hexagonal Reaction Ball Test, 5.4x10 Meter Sprint, 6.20 Meter Sprint, 7.Beep Test, 8.Plank, 9.Wall Sit, 10.Spider Test, 11.Singles Baseline Shuttle Run, 12.Two-Foot Hexagon Jump, 13.30s Double Unders Jump Rope Test, 14.Hand-Eye Coordination Test.

Chinese Elite Male University Tennis Players

In this research, Chinese Elite Male University Tennis Players refer to male university athletes who hold a Level 2 or level 1 certification as Chinese tennis players.

Delphi Method

The Delphi method is a type of questionnaire - based research method. Different from ordinary questionnaires, the Delphi method usually involves multiple rounds of questionnaires. During the process, all experts are required to complete the questionnaires independently and are not allowed to discuss with others. After each round of questionnaire collection, the researcher needs to statistically analyze the experts' opinions, develop new questionnaires, and distribute them again. The Delphi method concludes when all experts reach a consensus.

In this study, the requirements of the Delphi method will be strictly adhered to. Questionnaires will be distributed either online or in person to ensure that all experts express their opinions independently without any interaction. Since the Delphi method does not end until all experts' opinions are unified, in this study, the experts' opinions retrieved each time will be analyzed and statistically processed, and the threshold value method method will be used to screen the indicators.

Evaluation system

The concept of evaluation system originates from sports measurement and evaluation, its core function is to transform complex phenomena into quantifiable or descriptive data to support scientific decision-making (Sun et al., 2022).

In this research, primary indicators are the core dimensions of the evaluation system and typically reflect the macro-level characteristics of the evaluation subject (e.g., power, speed etc.). Secondary indicators provide a more detailed breakdown of the primary indicators, offering greater operability and measurability (e.g., Overhead Medicine Ball Throw, Spider test etc.).

1.8 Conceptual Framework

This study is based on the Conceptual frameworks of Sports Training (Tian, 2017; Yu et al., 2019), and Sports Measurement and Evaluation (Sun et al., 2022).

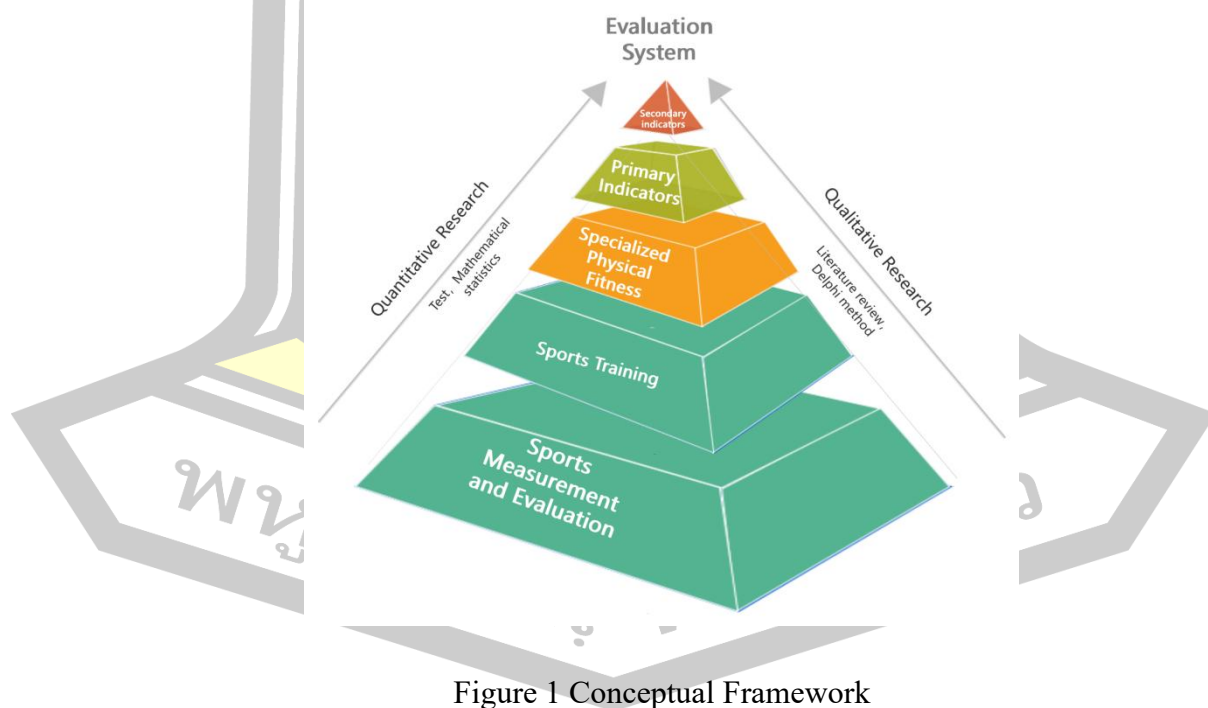
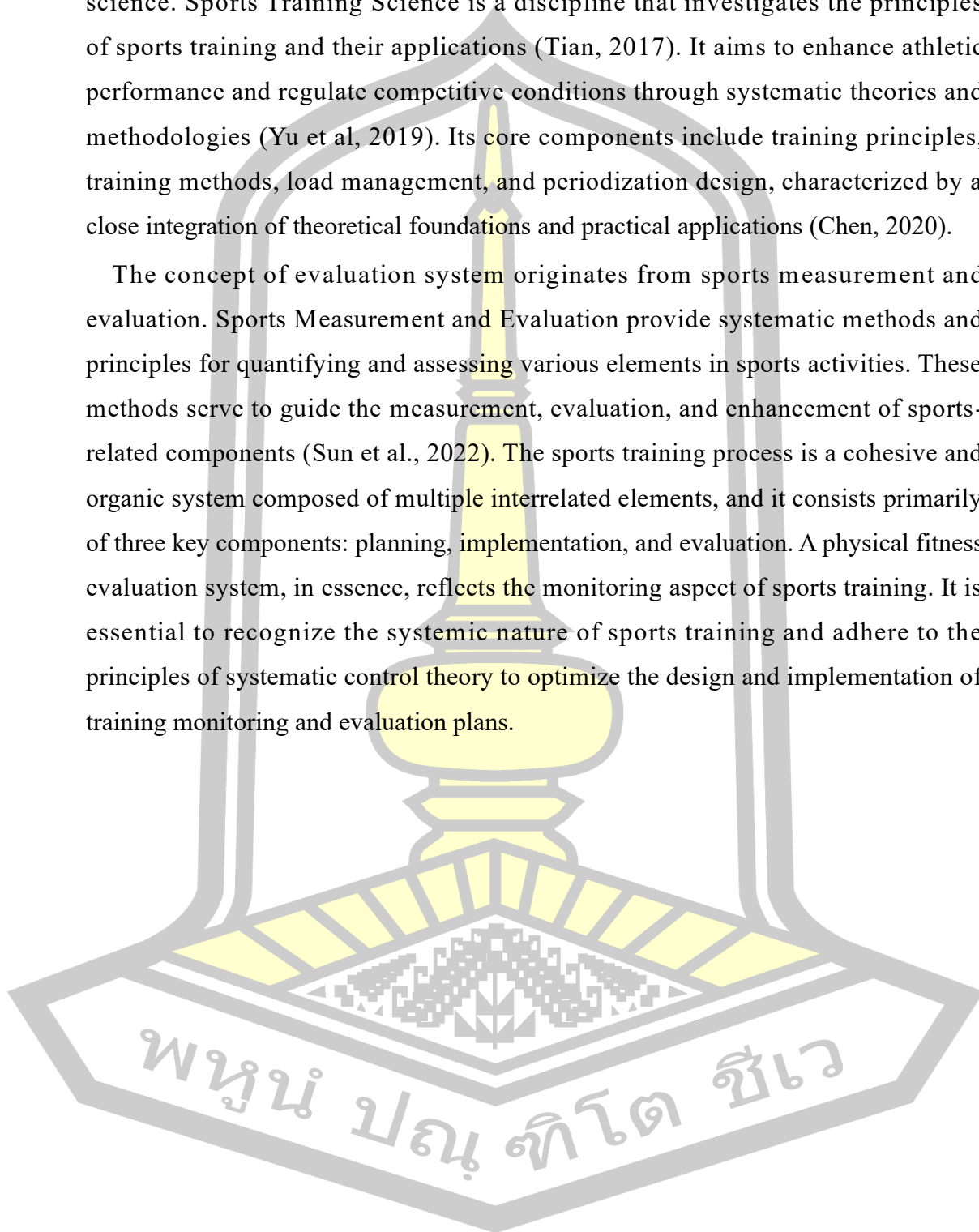


Figure 1 Conceptual Framework

The concept of specialized physical fitness originates from sports training science. Sports Training Science is a discipline that investigates the principles of sports training and their applications (Tian, 2017). It aims to enhance athletic performance and regulate competitive conditions through systematic theories and methodologies (Yu et al, 2019). Its core components include training principles, training methods, load management, and periodization design, characterized by a close integration of theoretical foundations and practical applications (Chen, 2020).

The concept of evaluation system originates from sports measurement and evaluation. Sports Measurement and Evaluation provide systematic methods and principles for quantifying and assessing various elements in sports activities. These methods serve to guide the measurement, evaluation, and enhancement of sports-related components (Sun et al., 2022). The sports training process is a cohesive and organic system composed of multiple interrelated elements, and it consists primarily of three key components: planning, implementation, and evaluation. A physical fitness evaluation system, in essence, reflects the monitoring aspect of sports training. It is essential to recognize the systemic nature of sports training and adhere to the principles of systematic control theory to optimize the design and implementation of training monitoring and evaluation plans.



CHAPTER II

LITERATURE REVIEW

This study conducted an extensive literature review through various academic databases, including PubMed, Pub Scholar, ScienceDirect, Google Scholar, CNKI, and Web of Science. A wide range of relevant literature was retrieved and reviewed by using keywords such as "tennis," "physical fitness" or "physical fitness training," "evaluation system," "speed," "strength," "power," "endurance," "agility," "flexibility," "racket-hold," or "net-separating" to search for journal articles, high-quality doctoral dissertations, and other academic resources. Additionally, various books related to sports training and tennis were consulted at Mahasarakham University Library.

Furthermore, CiteSpace software was employed to conduct bibliometric analysis on the Web of Science database, providing deeper insights into the existing research landscape. These comprehensive literature sources have laid a solid theoretical foundation for this study.

This research categorizes and describes the literature based on four parts: 1. The importance of physical fitness; 2. Studies on physical fitness evaluation systems.

By structuring the literature review around these focal points, the study aims to present a systematic and in-depth analysis of the current research on physical fitness in tennis athletes.

2.1 The Importance of Physical Fitness

2.1.1 Definition and Assessment Criteria of General Physical Fitness

In Chinese academic circles, the definition of physical fitness has been extensively explored, with slight variations in interpretation across different theoretical frameworks, all focusing on several core elements. According to the authoritative explanation provided by the Editorial Committee of the Sports Dictionary in 1983, physical fitness is defined as a comprehensive ability of human activity, primarily manifested in functional capabilities such as strength, speed, endurance, agility, and

flexibility demonstrated in sports, labor, and daily life (Sports Dictionary Editorial Committee, 1983).

However, there are some differences in the definition of physical fitness among various sports theory textbooks. For instance, Wang (2023) defines physical fitness in the field of exercise physiology as the basic abilities of strength, speed, endurance, agility, and flexibility exhibited during muscular activity, emphasizing the critical role of physiological mechanisms in physical fitness.

From the perspective of sports training, Tian (2020) points out that physical fitness refers to various basic athletic abilities exhibited during bodily activities, including strength, speed, endurance, flexibility, and agility. This definition focuses on the application in training practice

Mai, (2020) proposes in his book "Introduction to Sports Human Science" that physical fitness typically includes strength fitness, endurance fitness, speed fitness, flexibility fitness, and agility fitness. These qualities are essential basic abilities required for human movement and together constitute the overall performance of physical fitness .

Despite slight differences in definitions, various theoretical frameworks emphasize that physical fitness is a comprehensive manifestation of multiple basic athletic abilities, including strength, speed, endurance, agility, and flexibility. These core elements are not only the integrated manifestations of human activity but also important indicators for assessing individual physical fitness and athletic ability.

Looking globally, there are variations in the articulation of the definition of physical fitness, but the core essence remains consistent.

The American College of Sports Medicine (ACSM, 2006) defines physical fitness as "a set of attributes that people have or achieve that relates to the ability to perform physical activity." This definition encompasses not only the capacity to perform daily activities vigorously but also the characteristics and advantages that exhibit a lower risk of exercise-related diseases, such as those closely associated with a lack of physical activity. When conducting a physical fitness assessment, it is necessary to integrate an individual's health and medical records with the data from the assessment to ensure that their specific health goals and rehabilitation needs are met.

Furthermore, for ethical and legal reasons, full informed consent must be obtained from participants before any exercise testing begins.

In the book "Physical Fitness," Silverstein, (2002) elaborates on various aspects of physical fitness, including strength, endurance, flexibility, speed, and agility, and how to improve these qualities through exercise. The content involves scientific explanations of common diseases and injuries while emphasizing the importance of maintaining personal health. The broad definition of physical fitness mentioned in this book is consistent with that of Chinese scholars (Tian, 2020).

Browning, (2020), in the book "Physiology of Sport and Exercise," delves into the physiological foundations, including the mechanisms of muscle contraction, energy metabolism pathways, blood distribution, and respiratory adjustments. The book also explains how training can optimize and improve these qualities. Additionally, it provides an explanation of physical fitness, categorizing it into speed, strength, endurance, agility or coordination, and flexibility.

Table 1 International definition of physical fitness

Concept	Definition	Book	Publication date	Author
Physical fitness	Attributes related to the ability to perform physical activities (body composition measurement, cardiorespiratory endurance, muscular strength, and musculoskeletal flexibility)	ACSM	2006	American College of Sports Medicine (ACSM)
	Speed, Strength, Endurance, Flexibility, Agility	Physical Fitness	2002	Silverstein, A.,
	Speed, Strength, Endurance, Dexterity or Coordination, Flexibility	Physiology of Sport and Exercise	2020	Browning, J.

Table 2 Definition of physical fitness in China

Concept	Definition	Book	Publication date	Author
Physical fitness	Strength, Speed, Endurance, Agility, Flexibility.	Sports Dictionary	1983	Sports Dictionary Editorial Board
		Sports Training	2020	Tian Maijiu
		Introduction to Sports Human Science	2020	Mai Quan'an
		Exercise Physiology	2023	Wang Ruiyuan

2.1.2 The Importance of Physical Fitness for Athletes

Physical fitness is crucial for athletes as it directly impacts their performance and competitive level (Siramaneerat, 2020), focusing primarily on the following aspects:

1. **Enhancing Athletic Performance:** Good physical fitness improves an athlete's overall performance (Cureton, 1956). Excellent muscular strength and endurance enable athletes to sustain high-intensity performance during competitions (Harre & Hauptmann, 1983; Linser, 1994; Müller, 2000), while superior flexibility and coordination enhance their agility and skill (Teichmann et al., 2021).

2. **Preventing Sports Injuries:** Good physical fitness helps prevent sports injuries (Lauersen et al., 2013). Adequate muscular strength and flexibility reduce the risk of muscle strains and joint sprains, while good balance and coordination decrease the likelihood of falls and accidental injuries (Hrysomallis, 2007; Hrysomallis, 2011). The military research clearly indicates that individuals with lower levels of cardiopulmonary endurance or muscular endurance are more susceptible to injuries, and improving physical fitness can reduce the risk of injuries. Individuals with better physical fitness can perform tasks for longer periods of time, experience less fatigue, recover more quickly, and provide greater reserve capacity for subsequent tasks (Knapik, 2015).

3. **Accelerating Recovery Rate:** Excellent physical fitness can expedite an athlete's recovery process (Terrados et al., 2019). Athletes with high aerobic capacity

adapt better to maximal exertion and recover faster immediately after exercise testing (Ostojić et al., 2011).

4. Strengthening Psychological Resilience: Good physical fitness enhances an athlete's psychological resilience (Fossati et al., 2021). A vibrant and healthy physical state boosts athletes' confidence and morale, empowering them to cope with challenges and pressure effectively.

In summary, good physical fitness is fundamental for achieving outstanding performance and maintaining a healthy state. Therefore, athletes should strive to improve and sustain a high level of physical fitness through systematic training and a balanced lifestyle.

2.1.3 The Importance of Physical Fitness for Tennis Players

Tennis is recognized as a high-intensity interval-based sport (Fernandez-Fernandez et al., 2023; Kilit et al., 2019; Reid et al., 2008), with matchplay intensities reaching approximately 80% of $VO_2\text{max}$ (Brito et al., 2024). Beyond technical proficiency, physical fitness—encompassing strength, agility, and aerobic capacity—has been established as a critical determinant of competitive performance (Li et al., 2011; Sun, 2002; Ulbricht et al., 2016; Xiao et al., 2022). Regular fitness assessments enable coaches to monitor athletic readiness and implement targeted interventions (Fernandez-Fernandez et al., 2014), while age-specific physiological demands necessitate tailored assessment priorities (Henriques-Neto et al., 2022). Consequently, identifying sport-specific physical fitness indicators through validated evaluation frameworks is imperative for optimizing training efficacy and advancing evidence-based practice in tennis.

Numerous studies have investigated the specific physical fitness of tennis players, categorizing them into strength, speed, endurance, flexibility, and agility (Yu, 2008; Zhou, 2010; China Youth Sports Administration, 2012). Specialized measurement models for assessing the physical fitness of tennis players of different ages and genders have been developed (Ke, 2014; Chen, 2010; Li & Wang, 2023).

Competitive tennis is not solely a physical endeavor; it requires players to rapidly assess incoming balls, guide their bodies to respond accordingly, withstand

pressure in high-stakes environments, and make strategic plays over extended matches, all of which pose significant psychological challenges (Hornery, 2007). The psychological needs of tennis players primarily revolve around focus and emotional control (Lea-Cathrin et al., 2020), and psychological interventions for tennis players have been shown to effectively improve their mental states and enhance their performance (George et al., 2004).

Furthermore, research has highlighted the significant impact of balance training on tennis players. Implementing balance training for tennis players can enhance their overall performance and promote muscle balance in the limbs. Asymmetric lower limb strength may restrict the speed capabilities of tennis players, whereas balance training can effectively reduce lower limb asymmetry in young tennis players (Sannicandro et al., 2014).

(Johanna et al., 2022) A computerized systematic literature search was conducted in databases such as PubMed, Web of Science, and Sport Discus, followed by a meta-analysis to analyze the physical fitness of tennis players. The study identified a total of 24 papers related to athletic training on physical fitness and stroke velocity in healthy tennis players as of August 2022. The meta-analysis findings indicate that physical fitness training has a significantly positive impact on tennis players, highlighting its crucial role as the foundation for tennis athletes.

2.1.4 Research on the Correlation between Physical Fitness and Tennis Performance

Numerous studies have demonstrated a direct correlation between the enhancement of physical fitness and the improvement of tennis performance, indicating a positive relationship between the two (Kramer et al., 2016). Among female tennis players aged U14 to U16, lower limb strength, speed, and agility directly influence tennis performance (Girard & Millet, 2009). The upper and lower limb strength and explosive power of adolescent competitive tennis players directly impact their tennis performance (Fett et al., 2020). Specifically, upper limb strength is positively correlated with serving speed in adolescent tennis players, as enhancing upper limb strength enables tennis players to serve more aggressively.

In summary, physical fitness is crucial for tennis players. Players at different levels need to strengthen their physical fitness training according to their own needs and circumstances. Moreover, specific scientific research provides valuable evidence and guidance, helping us gain a deeper understanding of the relationship between physical fitness and tennis performance and providing more scientific and effective support for athletes' training and competition.

2.2 Relevant Research on Physical Fitness Evaluation System

The concept of evaluation system originates from sports measurement and evaluation, its core function is to transform complex phenomena into quantifiable or descriptive data to support scientific decision-making (Sun, Q., Sun, J., & Chen, P, 2022).

Based on the literature retrieved from databases including Web of Science, PubMed, Pub Scholar, ScienceDirect, CNKI (China National Knowledge Infrastructure), and Google Scholar, using keywords such as "tennis player," "indicator system," "physical fitness," "speed," "strength," "endurance," "agility," and "flexibility," it is apparent that there are relatively few studies in China focusing on the measurement and evaluation of physical fitness among university tennis players.

2.2.1 Indicator System for Strength Fitness

Fan Hongbin (2015) argues that strength fitness testing indicators are an essential component of international physical fitness testing. Each country holds different views and concepts regarding strength fitness testing indicators, resulting in varying degrees of commonality and difference among various testing indicator systems. Starting from the anatomical characteristics of human movement, the author defines strength fitness based on the distribution of different body parts and categorizes it into upper limbs, lower limbs, and trunk. Therefore, the testing indicators for strength fitness are determined as pull-ups, standard push-ups (for males) and knee push-ups (for females) for the upper limbs; 90° Dynamic Trunk Extension and plank for the trunk; and standing long jump for the lower limbs.

Ke Yong and Yu Gongwei (2014) establish primary indicators for strength fitness based on trunk, upper limb, and lower limb strength. After expert screening, 12 secondary indicators were finalized. For upper limb strength: bench press, push-ups, continuous incline bench press, and clean and jerk. For trunk strength: sit-ups, prone back vibration, hanging leg raises, and snatch. For lower limb strength: kettlebell swings, weighted squat jumps, consecutive vertical jumps in place, and half squats. The authors synthesize the insights of other scholars to establish a strength fitness evaluation indicator system.

Xiao, W et al., (2023) argue that strength training can enhance the physical fitness and performance of tennis players. The authors conducted a 12-week strength functional training program and found that functional training for more than 6 weeks could influence changes in players' physical fitness. For strength functional training testing, the authors adopted push-ups, wall squats, over medicine ball throws, and standing long jumps.

In summary, based on the content and conclusions of relevant literature on strength fitness, it is evident that scholars categorize strength fitness according to the anatomical structure of human movement, dividing it into upper limb strength, trunk strength, and lower limb strength. Therefore, to determine the evaluation indicators for strength fitness, the author draws on scholars' ideas to establish the direction for constructing the strength fitness evaluation indicator system in this study.

2.2.2 Indicator System for Speed Fitness

Li Wenlong (2015) divides primary indicators into reaction speed, movement speed, displacement speed, and combined speed based on the theory of sports training. The author's innovation lies in the addition of combined speed, specifically ball displacement speed, which combines with the characteristics of the sport. The speed fitness testing indicators are determined as 4*10-meter shuttle runs, 28-meter sprints, lateral crossover runs, disguised straight runs, and individual dribbling runs. Test indicators are screened based on sport-specific technical elements and competition characteristics.

Lin Teng (2014) believes that daily training should focus on combining sport-specific speed with training characteristics. Based on the principles of sports training, the author divides speed fitness into movement speed, reaction speed, and displacement speed. Six testing indicators are finalized: 30-second weighted forearm flexion and extension, 100-meter runs, 1-minute rope skipping, 30-second lateral movements, 20-meter shuttle runs, and high-knee lifts followed by 40-meter sprints, which are representative indicators of speed fitness for table tennis.

Liu Hongxun (2002) analyzes speed fitness from a physiological perspective based on its influencing factors. The author argues that the various factors of the physiological mechanism of speed fitness (displacement speed, movement speed, reaction speed) are also the influencing factors of speed fitness. Speed fitness is primarily determined by the nervous system activity of the cerebral cortex.

In summary, the division and screening of speed fitness indicators are primarily based on the theoretical foundation of sports training, dividing speed fitness into three secondary indicators: displacement speed, movement speed, and reaction speed. Combining with the characteristics of sports events, an appropriate speed fitness evaluation indicator system is established.

2.2.3 Indicator System for Endurance Fitness

Long Bin (2002) defines endurance fitness as the ability of the organism to maintain prolonged exercise. The author believes that endurance fitness should be divided into general endurance and sport-specific endurance. Furthermore, endurance is combined with strength and speed, resulting in strength endurance and speed endurance.

Chu Xiao (2016) conducts research on speed endurance indicators. Speed endurance indicators are determined based on gender differences. For males: 1500-meter runs, 400-meter fast walks, and 400-meter runs. For females: 100-meter runs, 1000-meter runs, and 200-meter fast walks. Speed endurance reflects different indicators based on gender.

Li Ping (2005) argues that China's physical health testing indicators are mainly 1000-meter runs and step tests. Combining foreign physical health testing indicators,

the author analyzes that endurance can be divided into general endurance, muscular strength endurance, speed endurance, and static endurance. Among them, general endurance, or cardiopulmonary endurance, is most closely related to health and an essential component of physical fitness testing.

In studies on endurance fitness indicators, endurance fitness is often divided into general endurance, speed endurance, and strength endurance. It is evident that endurance fitness is closely integrated with strength and speed. When developing strength and speed fitness, it is also necessary to enhance endurance fitness. Therefore, attention should be paid to distinguishing endurance fitness from strength and speed fitness when selecting indicators.

2.2.4 Indicator Systems for Agility and Flexibility Fitness

Chai Jiao and Li Lin (2012) point out some issues and deficiencies in the testing content and methods of agility fitness in China, prompting the authors to propose improvement suggestions. The authors believe that the original agility fitness testing indicators are mostly tested separately for the upper and lower limbs, making it difficult to reflect the overall agility fitness performance through a single test indicator. Therefore, the authors propose the hexagon reaction ball test as an agility fitness testing indicator, scientifically explaining and operationalizing the specific content of the hexagon reaction ball test indicator.

Guo Yue (2017) determines the indicators for objectively reflecting agility fitness as cross-change runs, reaction time, burpees, prone stand-ups, repeated lateral jumps, and hexagon ball reaction tests. Based on group theory knowledge, there are similarities between table tennis and tennis, thus providing a certain degree of reference.

Xue Xinxuan, Long Bin, and Li Fang (2002) argue that agility fitness is a comprehensive quality closely related to one's ability to spatially orient and perceive time, as well as the development of strength and speed, coordination, and reaction ability. The factors influencing agility fitness mainly depend on five aspects: nervous system flexibility, explosive power, movement speed, reaction speed, and judgment speed.

Marin, A et al., (2023) propose that improving agility and lateral movement can give young tennis players a competitive edge. Through plyometric-specific exercises focusing on explosive movements and plyometric exercises, junior players can enhance their speed, strength, and reaction time on the court. The authors used the step test, spider test, Egdren lateral step test, T-test, lateral, and forward movements.

Li Fang and Long Bin (2002) believe that general flexibility is the foundation for developing sport-specific flexibility, and highly developed sport-specific flexibility provides a training direction for general flexibility. During the development of flexibility, it is often combined with strength fitness to help muscles achieve suppleness without softness and flexibility without stiffness.

Regarding the selection criteria for agility and flexibility fitness indicators, scholars hold different opinions. Among them, the definition of agility fitness also varies. The selection range of agility fitness indicators is relatively broad and complex. The selection of flexibility fitness indicators is mainly divided into sport-specific and general categories.

2.2.5 A physical fitness evaluation system for tennis players

Li, Y., & Wang, J. (2023) employed research methods such as literature review, expert interviews, questionnaires, and mathematical statistics to establish evaluation indices for specific physical abilities among Chinese professional tennis players. The primary indicators selected include Overall coordination, Special coordination, Startup speed, Specialized power, Fast power, Base strength, Core power, Aerobic fitness, Anaerobic fitness, Body Function, and lower extremity functional ability. The secondary indicators encompass Left foot hexagon jump, Right foot hexagon jump, Turn left foot and run forward, Turn right foot and run forward, Right arc and run forward, 5m sprint, 10m sprint course, 20m sprint course, Throwing a medicine ball over the head, Forehand closed footwork medicine ball toss, Backhand closed footwork medicine ball toss, vertical high jump, single leg triple jump, Sit on your back, Left knee bent, Right knee bent, Lie on your back, Eight-level abdominal bridge, and Beep-Test. Additionally, indicators such as Doubles line back run, rotational stability, and Straight leg active lift were also considered.

Wensheng, X et al. (2020) utilized literature review and the Delphi method to conduct research among experts, coaches, and referees in the field of Chinese tennis. Through screening, expert validation, and statistical analysis of testing indicators, an evaluation index system for skill-related physical fitness of Chinese junior male tennis players was established. This system comprises primary indicators such as Speed, Strength, Endurance, Flexibility, and Agility. Secondary indicators include Moving speed, Upper body strength, Trunk strength, Lower body strength, Aerobic endurance, Anaerobic endurance, Flexibility, Upper body power, and Lower body power, Tennis-specific agility endurance test, Planned agility test. Tertiary indicators encompass Singles sideline round trip*4, 45s number of backhand swings, 45s number of forehand swings, Grip strength test, 1min push up, 1min sit up, Wall squat test, Beep test, Sit and reach, 30s double swing rope skipping, Over medicine ball throw test, Sidearm medicine ball throw test (right and left), Standing long jump/hop, and Vertical splits test.

Ke Yong and Peng Jianjun (2018) conducted research on the construction of an evaluation system for Chinese elite tennis players. This system comprises five primary indicators: Strength, Speed, Agility, Endurance, and Flexibility. Among them, the indicators for evaluating Strength include overhead throwing of medicine balls with closed forehand and backhand stances, 3RM bench press, 3RM seated row, 3RM squat, vertical jump in place with both feet, and standing long jump. Speed indicators primarily consist of 5m, 10m, and 20m sprints. Agility indicators mainly encompass sprint runs with turns from the left and right sidelines, sprint runs with returns from the left and right sidelines, and hexagon jump tests. Endurance is evaluated through the Beep-Test, while Flexibility is assessed through front touch tests with the dominant and non-dominant hands.

Li Heng (2015) designed a physical fitness evaluation model for junior tennis players. In this model, the primary indicator refers to physical fitness, which is further divided into secondary indicators of Speed, Strength, Flexibility, and Coordination. Tertiary indicators are classified as 30m sprint, fan-shaped run, bench press, tennis throwing, standing long jump, forward flexion touch, lateral splits, and double-swing rope skipping.

In summary, researchers primarily focus on assessing the specific physical fitness of junior or college tennis players in sports departments, employing various research methods such as literature review, expert interviews, the Delphi method, measurement techniques, and mathematical statistics. These studies have established evaluation models and standards for the specific physical fitness of college tennis players, providing them with scientific diagnosis and assessment. However, there are still some deficiencies in these studies, such as incomplete measurement and evaluation indicator systems, insufficient rigor in indicator screening, and the need to verify the scientificity and accuracy of evaluation standards. Particularly in terms of agility, only rapid change-of-direction ability tests are used, while reaction time tests are neglected. Moreover, no relevant research has been conducted on Chinese national level-2 male tennis players.

Table 3 Comprehensive table of literature indicators

Quality type	Secondary indicators	Tertiary indicators	Author
Power	Upper limbs, Torso, Lower limbs,	Upper limbs: Pull-ups, Push-ups; Torso: 90° Dynamic Trunk Extension and Plank; Lower limbs: Standing Long Jump	Fan Hongbin (2015)
	Upper limbs, Torso, Lower limbs,	Upper limbs: Bench press, Push-ups, Continuous incline barbell press, Clean and jerk; Torso: Sit-ups, Prone back vibration, Leg raises while hanging, and Snatch; Lower limbs: Kettlebell exercises, Weighted squat jumps, Continuous vertical jumps in place, and Half squats.	Ke,Y(2014)
speed	Push-ups, Wall squat test,	Overhead medicine ball throw, and Standing long jump.	Xiao, W.,(2023)
	Reaction speed, Movement speed, Locomotion speed, Combination speed.	4x10-meter shuttle run, 28-meter sprint, lateral crossover run, straight-line run with direction change, and individual dribbling run.	Li Wenlong(2015)
	Movement speed, reaction speed, displacement speed.	30-second weighted forearm flexion and extension, 100-meter sprint, 1-minute rope skipping, 30-second lateral shuffle, 20-meter shuttle run, high knees followed by a 40-meter	Lin Teng(2014)

		sprint.	
Endurance	Displacement speed, Movement speed, Reaction speed. General endurance, Specific endurance, Strength endurance, Speed endurance.		Liu Xunhong(2002)) Long Bin(2002)
	Speed endurance	1500-meter run, 400-meter brisk walk, 400-meter run.	Chu Xiao (2016)
	General endurance, muscular strength endurance, speed endurance, static endurance.		Li Ping(2005)
Agility	Overall agility fitness,	Hexagonal Reaction Ball Test.	ChaiJiao, Li Ping(2012)
	Reflective agility	T-test (agility test with changes in direction forming a 'T' shape), reaction time, burpees, prone jackknife sit-ups, repeated lateral jumps, and the hexagonal ball reaction test. These tests assess an individual's ability to quickly and accurately respond to stimuli, change directions, and perform coordinated movements, all of which are indicative of agility and reactivity.	GuoYue(2017)
	Flexibility of the nervous system, explosive power, movement speed, reaction speed, and decision-making speed.		Xue Xinxuan, Long Bin, Li Fang(2002)
Flexibility	Step test, spider test, Edgren lateral step test, T-test, as well as lateral and forward movements. general flexibility , specific flexibility.		Marin, A et al.,(2023) Li Fang, Long Bin(2002)
Power	Moving speed	Singles sideline round trip	Wensheng, X et al.,(2020)
Speed	Movement speed	45s number of backhand swings	
Strength	Upper body strength	45s number of forehand swings	
Endurance	Trunk strength	Grip strength test	
Flexibility	Lower body strength	1min push up	
Agility	Aerobic endurance	1min sit up	
	Anaerobic endurance	Wall squat test	
	Flexibility	Beep test	
	Agility	Sit and reach	
	Upper body power	30s double swing rope skipping	
	Lower body power	Over medicine ball throw test	
	Tennis-specific agility endurance test ,	Sidearm medicine ball throw test(right and left)	
	Planned agility test	Standing long jump/hop	

Vertical splits test

Power	Forehand closed-stance throwing of medicine ball, backhand	Ke Yong and Peng Jianjun(2018)
Speed	closed-stance throwing of medicine ball, overhead throwing	
Strength	of medicine ball, 3RM bench press, 3RM seated row, 3RM	
Endurance	squat, vertical jump in place with both feet, and standing long	
Flexibility	jump.	
Agility	5-meter sprint, 10-meter sprint, 20-meter sprint, sprint forward after turning from the left sideline, sprint forward after turning from the right sideline, sprint back and forth from the left sideline, sprint back and forth from the right sideline, and hexagon test, beep-test	
Overall coordination	Left foot hexagon jump, Right foot hexagon jump	Li, Y., & Wang, J. (2023).
Special coordination	Turn left foot and run forward, Turn right foot and run forward, Right arc and run forward	
Startup speed	5m sprint, 10m sprint course, 20m sprint course	
Specialized power	Throwing a medicine ball over the head, Forehand closed footwork medicine ball toss, Backhand closed footwork medicine ball toss	
Fast power		
Base strength	vertical high jump, single leg triple jump, Sit on your back	
Core power	Left knee bent, Right knee bent, Lie on your back, Eight-level abdominal bridge	
Aerobic fitness	Beep-Test	
Anaerobic fitness	Doubles line back run, rotational stability, Straight leg active lift	
Body Function		
lower extremity functional ability		
Physical Fitness	Speed, strength, flexibility, coordination	Li Heng(2015)
	30m sprint, fan-shaped running, bench press, tennis throwing, standing long jump, forward flexion to touch the depth, left and right leg splits, double-swing rope skipping	
Coordination	Simple reaction, complex reaction, Spalding test, spider test, hexagon jumping, Starosta's test, hand-eye test, balance, plate tapping, jump rope	Waldziński, T et al.,(2024)

2.3 Relevant Research on Delphi Method

The Delphi method is a multi-round anonymous questionnaire research method, which emphasizes the independence of experts and the convergence of results by independently soliciting expert opinions, statistical feedback, and iterating the

questionnaire until a consensus is reached, and is often used to construct an indicator system or predict trends (Nasa et al., 2021; Del Grande & Kaczorowski, 2023).

The core of the Delphi method lies in its iterative process, wherein panel members participate in multiple rounds of anonymous feedback collection (Häder, 2014; Niederberger & Köberich, 2021). During each round, participants provide individual feedback, which is then aggregated and analyzed to identify areas of consensus and divergence. This iterative process continues until consensus is reached or it becomes evident that consensus cannot be achieved (Niederberger et al., 2025; Jandhyala, 2020). The anonymity of feedback is a critical feature, as it prevents direct communication among panel members and encourages honest and unbiased responses (McPherson et al., 2018). Upon completing the iterative rounds, the final phase involves summarizing the research findings. This summary reflects the collective insights and consensus achieved by the panel members, providing a robust foundation for decision-making and policy formulation. The systematic nature of the Delphi method ensures that the resulting consensus is well-founded and representative of the diverse perspectives of the participants (von der Gracht, 2012; Jorm, 2015).

The Delphi method has found widespread applications across diverse fields. In healthcare research, it has been extensively used to develop clinical guidelines, assess the quality of healthcare services, and prioritize research questions (Nasa et al., 2021; Campbell, 2004). For instance, Campbell (2004) utilized the Delphi method to explore variations among stakeholder groups in primary mental health care and the factors influencing their ratings, providing valuable insights into the decision-making process in this area.

In technological forecasting, the Delphi method helps in predicting future technological trends, evaluating the potential impact of new technologies, and formulating technology-related policies (Bolger et al., 2011; von der Gracht, 2012). Bolger et al. (2011) investigated whether the Delphi process enhanced the accuracy of group-based judgmental forecasts or merely induced consensus among forecasters, which is crucial for technology-driven industries to make informed strategic decisions.

Regarding policy - making, the Delphi method enables policymakers to gather expert opinions on complex policy issues, facilitating evidence - based policy development. It has been applied to areas such as environmental policy, education policy, and economic policy (de Loë et al., 2016). de Loë et al. (2016) conducted a systematic review to evaluate the methodological evolution, innovation, and opportunities in policy Delphi practice, highlighting its significance in policy - related decision - making.

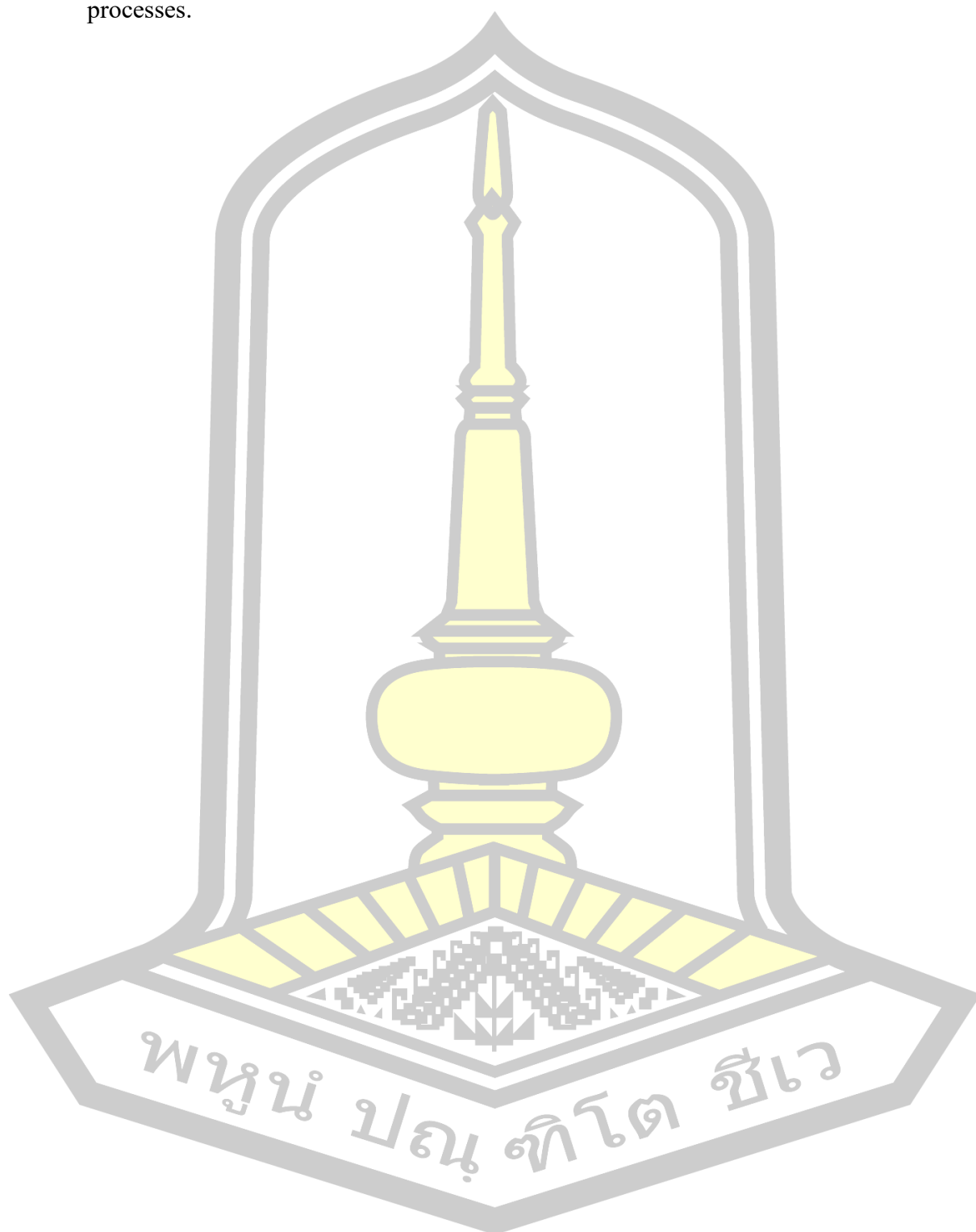
However, like any research method, the Delphi method has its limitations. One of the main challenges lies in the selection of experts. The quality and representativeness of the expert panel can significantly impact the results. If the experts are not diverse enough or lack relevant knowledge, the consensus reached may not be comprehensive or accurate (Jünger et al., 2017). Jünger et al. (2017) emphasized the importance of carefully selecting experts in their guidance on conducting and reporting Delphi studies in palliative care.

Another potential drawback is the time - consuming nature of the iterative process. Conducting multiple rounds of surveys, aggregating data, and providing feedback to experts requires substantial time and resources, which may limit its application in time - sensitive situations (Rowe et al., 2005). Additionally, the reliance on expert judgment means that the results may be subject to subjective biases, despite the anonymity of the process.

In recent years, efforts have been made to improve the Delphi method. For example, integrating it with other research methods such as qualitative interviews or quantitative data analysis can enhance the comprehensiveness of the results. Some studies have also explored the use of online platforms to conduct Delphi surveys, which can increase the efficiency of data collection and reduce costs (Aengenheyster et al., 2017). Aengenheyster et al. (2017) carried out a comparative analysis of existing software - based tools for real - time Delphi, demonstrating the potential of technology to optimize the method.

In conclusion, the Delphi method remains a valuable tool for obtaining expert consensus in various research and decision - making scenarios. Despite its limitations, ongoing methodological advancements and adaptations are enhancing its effectiveness and applicability. As research continues, the Delphi method is likely to

further evolve and contribute to more informed and reliable decision - making processes.



CHAPTER III

RESEARCH METHODS

3.1 Research Design

This study adopted a developmental research design incorporating a mixed-methods approach, systematically integrating quantitative data (e.g., experimental results, statistical analyses) and qualitative data (e.g., Delphi technique findings, literature survey insights) within a cohesive framework. The core principle of mixed method lies in data triangulation, which employs multiple data sources, types, and methodologies to validate and corroborate research findings. Qualitative Research:

The Delphi Method will be used to screen and refine the evaluation indicators. Quantitative Research: Physical fitness tests will be conducted based on the secondary indicators from the preliminary indicator system developed through the Delphi Method, followed by statistical validation (e.g., Cronbach's α coefficient and Exploratory Factor Analysis).

The primary purpose of this study is to construct a specialized physical fitness evaluation system for Chinese Elite Male University Tennis Players, enabling a comprehensive and systematic assessment of their physical fitness levels. Grounded in sports physiology, sports training theory (Yu & Hu, 2019), and sports measurement and evaluation (Sun et al., 2022), this study integrates qualitative and quantitative research methods to ensure the scientific rigor of the evaluation system.

This study is conducted in three steps (Figure 2):

Step 1: Qualitative Delphi Method for Indicator Selection

Delphi method is employed to collect expert opinions from tennis coaches, sports scientists, and tennis specialists, aiming to establish a preliminary indicator system for the specialized physical fitness of Chinese Elite Male University Tennis Players. A structured expert questionnaire is used to identify and refine the most relevant assessment indicators.

Step 2: Quantitative Validation and System Development

A random sampling method is applied to conduct field testing and data collection on Chinese Elite Male University Tennis Players from six universities with

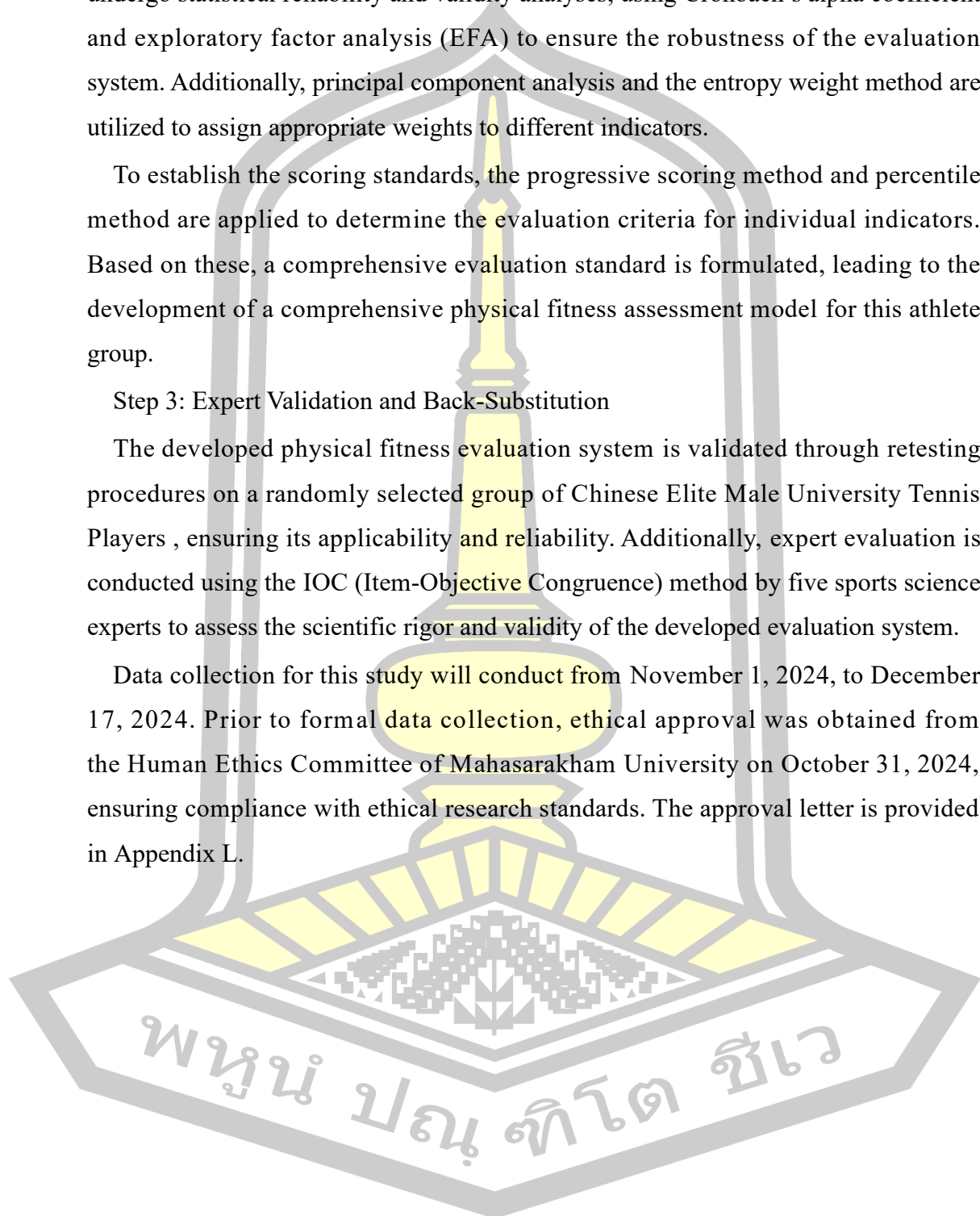
high-level tennis teams in Xi'an and Shanghai. The collected test results undergo statistical reliability and validity analyses, using Cronbach's alpha coefficient and exploratory factor analysis (EFA) to ensure the robustness of the evaluation system. Additionally, principal component analysis and the entropy weight method are utilized to assign appropriate weights to different indicators.

To establish the scoring standards, the progressive scoring method and percentile method are applied to determine the evaluation criteria for individual indicators. Based on these, a comprehensive evaluation standard is formulated, leading to the development of a comprehensive physical fitness assessment model for this athlete group.

Step 3: Expert Validation and Back-Substitution

The developed physical fitness evaluation system is validated through retesting procedures on a randomly selected group of Chinese Elite Male University Tennis Players, ensuring its applicability and reliability. Additionally, expert evaluation is conducted using the IOC (Item-Objective Congruence) method by five sports science experts to assess the scientific rigor and validity of the developed evaluation system.

Data collection for this study will conduct from November 1, 2024, to December 17, 2024. Prior to formal data collection, ethical approval was obtained from the Human Ethics Committee of Mahasarakham University on October 31, 2024, ensuring compliance with ethical research standards. The approval letter is provided in Appendix L.



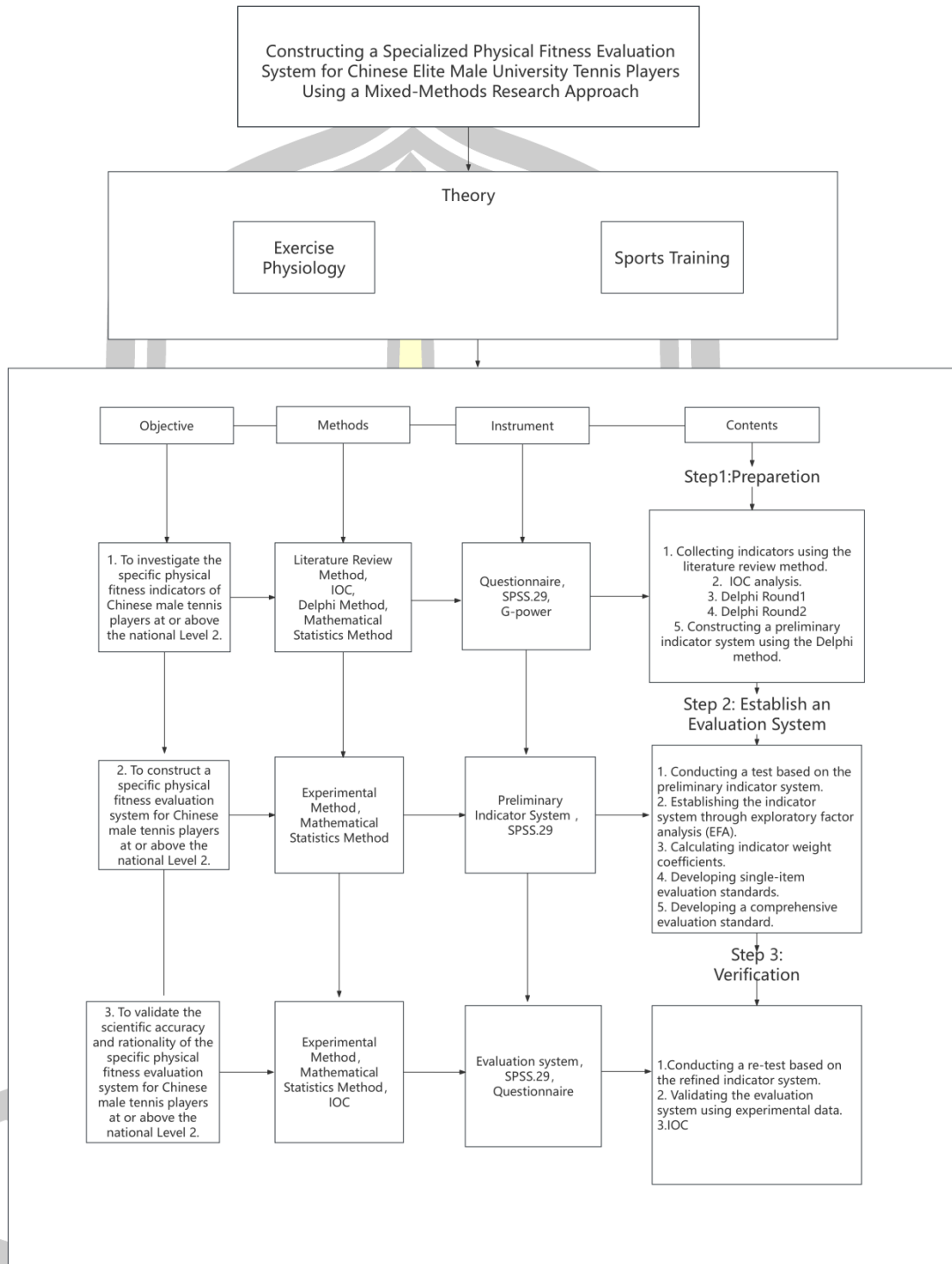


Figure 2 Overall research framework

3.2 Population

The population was divided into two groups: 1. the expert group with 29 individuals, 2. the athlete group with 83 individuals, totaling 112 individuals.

The expert group: comprised 29 members, including 5 sports science experts(IOC), 17 tennis experts, and 6 senior tennis coaches(Delphi).

The athlete group: comprised 83 members, the test group consisted of 53 Chinese Elite Male University Tennis Players , while the re-test group included 30 participants.

Phase 1.

3.3 Participants

3.3.1 Sports Science Experts (IOC)

These were university professors or associate professors in the field of sports science with extensive research experience.

In Phase 1 will involve 5 sports science experts to ensure the alignment of the "Expert Questionnaire on the Physical Fitness Evaluation Indicators for Chinese Elite Male University Tennis Players" with the research objectives. These experts conducted an Index of Objective Congruence (IOC) test (Thomas & Balkin, 2002; Turner & Carlson, 2003).

The selection of "expert" samples was purposeful, applying their knowledge to specific issues based on criteria formulated from the nature of the research question (Hasson, 2000). Purposeful sampling is based on "the researcher's knowledge of the population to select cases" (Berg et al., 2011), rather than being determined by the number of participants (Berg, 2001). Scholars suggest that a sample size of 5-25 experts is effective at this stage (J.W. Creswell, 2012). Snowball sampling is suitable for specific populations, selected based on the researcher's judgment, convenience, or specific characteristics of the target population (Vehovar, 2016).

3.3.3.1 Inclusion and Exclusion Criteria for the Expert Group

1. Inclusion Criteria for Sports Science and Tennis Experts:

- (1) Research focus: closely related to sports, covering fields such as sports science, sports training, sports pedagogy, and sports human science.
- (2) Age range: between 30 and 65 years.

- (3) Occupation: university teachers.
- (4) Professional title: professors or associate professors.
- (5) Ability to sign the informed consent form.

2. Exclusion Criteria for Sports Science and Tennis Experts:

- (1) Research focus unrelated to sports.
- (2) Lack of scientific research or coaching experience.
- (3) Experts who have a direct or indirect interest in the subject matter of the study.
- (4) Inability to comply with research requirements.

3.3.3.2 Expert Information

The basic information of IOC experts involved in this study is presented in Table 4.

Table 4 Basic Information of IOC Expert

Name	Institution	Title	Expert Type	Research Field
Expert 1	Chengdu Normal College	Professor	Sports Science Expert	Physical Education
Expert 2	Chengdu Normal College	Professor	Sports Science Expert	Physical Education
Expert 3	Xi'an Physical Education University	Professor	Sports Science Expert	Sports Training
Expert 4	Xi'an Physical Education University	Professor	Sports Science Expert	Sports Training
Expert 5	Ankang College	Professor	Sports Science Expert	Physical Education

3.3.2 Delphi Expert Group

Tennis Experts (17 individuals): These were university tennis instructors with associate professor or professor titles, extensive coaching experience, or robust research backgrounds.

Senior Tennis Coaches (6 individuals): Refers to university tennis team coaches with a lecturer-level academic title and extensive team coaching experience. A total of six individuals were included.

3.3.2.1 Inclusion and Exclusion Criteria for the Delphi Expert Group:

(1) Inclusion Criteria for Tennis Experts:

- 1) Research focus: closely related to sports, covering fields such as sports science, sports training, sports pedagogy, and sports human science.
- 2) Age range: between 30 and 65 years.
- 3) Occupation: university teachers.
- 4) Professional title: professors or associate professors.
- 5) Ability to sign the informed consent form.

(2) Exclusion Criteria for Tennis Experts:

- 1) Research focus unrelated to sports.
- 2) Lack of scientific research or coaching experience.
- 3) Experts who have a direct or indirect interest in the subject matter of the study.
- 4) Inability to comply with research requirements.

(3) Inclusion Criteria for Senior Tennis Coaches:

- 1) Age range: between 30 and 60 years.
- 2) Hold a lecturer-level academic title.
- 3) Serve as a tennis coach at a university.
- 4) Able to provide informed consent by signing the consent form.

(4) Exclusion Criteria for Senior Tennis Coaches:

- 1) Ceased coaching for over 12 months.
- 2) Who have a direct or indirect interest in the subject matter of the study.
- 3) Inability to comply with research requirements.

3.3.2.2 Expert Information

Scholars suggest that the number of experts in Delphi studies most commonly ranges between 11-20, 21-30, or 31-40 participants (Zartha Sossa, J. W., et al., 2019; de Loë, R. C., et al., 2016).

Therefore, during Phase 1 of the Delphi method in this study, 23 tennis-related experts were selected to participate in the research. These experts come from five cities: Xi'an (15 experts), Shanghai (4 experts), Shaanxi (2 experts), Hunan (1 expert), and Shandong (1 expert). The experts are distributed across four universities in Shanghai, fifteen universities in Xi'an, and universities in three other cities. There are 6 Lecturers, 10 Associate Professors, and 7 Professors. Their research fields include Sports Training (11 experts), Physical Education (11 experts), and Sports Human Science (1 expert).

The detailed information of these Delphi experts is presented in Table 5.

Table 5 Basic Information of Delphi experts

Name	Institution	Title	R 1	R 2	R 3	Expert Type	Research Field
Expert 1	Shanghai University	Lecturer	√	√	√	Tennis Coach	Sports Training
	Northwest Agriculture and Forestry University	Associate Professor	√	√	√	Tennis Expert	Physical Education
Expert 2	Xi'an University of Technology	Professor	√	√	√	Tennis Coach	Physical Education
	Shanghai Jiao Tong University	Lecturer	√	√	√	Tennis Expert	Sports Training
Expert 3	Xi'an Physical Education University	Associate Professor	√	√	√	Tennis Expert	Sports Training
	Shanghai University	Associate Professor	√	√	√	Tennis Expert	Sports Training
Expert 4	Xi'an University of Technology	Associate Professor	√	√	√	Tennis Expert	Physical Education
	Hengyang Normal University	Lecturer	√	√	√	Tennis Coach	Physical Education
Expert 5	Liaocheng University	Associate Professor	√	√	√	Tennis Expert	Sports Human

Name	Institution	Title	R 1	R 2	R 3	Expert Type	Research Field
	University	Professor				Expert	Science
	Xi'an University of Finance and Economics	Lecturer	√	√	√		Tennis Coach Sports Training
Expert 10	Xi'an Physical Education University	Lecturer	√	√	√		Tennis Expert Sports Training
Expert 11	Shanghai Normal University	Associate Professor	√	√	√		Tennis Expert Physical Education
Expert 12	Xi'an Medical University	Associate Professor	√	√	√		Tennis Expert Physical Education
Expert 13	Shaanxi Preschool Normal University	Associate Professor	√	√	√		Tennis Coach Sports Training
Expert 14	Xi'an Physical Education University	Professor	√	√	√		Tennis Expert Physical Education
Expert 15	Xi'an Jiao Tong University	Associate Professor	√	√	√		Tennis Expert Sports Training
Expert 16	Xi'an Physical Education University	Associate Professor	√	√	√		Tennis Expert Sports Training
Expert 17	Xi'an International Studies University	Professor	√	√	√		Tennis Expert Physical Education
Expert 18	Xi'an International Studies University	Associate Professor	√	√	√		Tennis Expert Physical Education
Expert 19	Xi'an Jiao Tong University	Professor	√	√	√		Tennis Expert Physical Education
Expert 20	Xi'an University of Electronic Science	Associate Professor	√	√	√		Tennis Expert Physical Education
Expert 21							

Name	Institution	Title	R 1	R 2	R 3	Expert Type	Research Field
	and Technology Xi'an Physical Education University	Lecturer	√	√	√	Tennis Coach	Sports Training
Expert 22	Xi'an University of Architecture and Technology	Professor	√	√	√	Tennis Expert	Sports Training

3.4 Instrument

1. Based on an extensive literature review, 42 relevant indicators related to the specialized physical fitness of tennis players were collected and compiled into the Expert Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players (Appendix A) to do the Item-Objective Congruence (IOC).
2. Through an Item-Objective Congruence (IOC) expert evaluation result, the First-Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players (Appendix B) was formally distributed.
3. After analyzing and statistically processing the results from the First round and Second Delphi expert questionnaire, the Third Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players was formulated (Appendix D).
4. Upon further analysis of the third round Delphi expert questionnaire results, the Preliminary Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players was established (Appendix E).

3.5 Data Collection Procedure

1. Preliminary Construction of the Indicator System

(1) Development of the Initial Expert Questionnaire

This study began with an extensive literature review, which informed the design of a preliminary questionnaire. The review and organization of existing measurement and evaluation indicators for tennis-specific physical fitness revealed primary and secondary indicators. These were compiled into the "Expert Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players ." The development process adhered to four key principles for indicator systems: scientific validity, applicability, independence, comprehensiveness, and feasibility (Sun, Q., Sun, J., & Chen, P, 2022).

(2) Item-Objective Congruence (IOC)

To ensure the consistency between the "Expert Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players " and the study's objectives, five experts were selected to conduct the Item-Objective Congruence (IOC) index test. The IOC measures the degree to which the test items align with the intended objectives (Turner & Carlson, 2003).

The evaluation criteria for IOC are as follows:

If the item aligns with the objective, a score of +1 is assigned.

If it is uncertain whether the item aligns with the objective, a score of 0 is assigned.

If the item does not align with the objective, a score of -1 is assigned.

The scores provided by the experts were used to calculate the IOC using the following formula:

$$IOC = \frac{\sum R}{N}$$

IOC: Item-Objective Congruence, $\sum R$: the sum of the scores assigned by experts, N: the total number of experts .

Based on the feedback from IOC experts, the Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players was developed.

2. Initial Selection of Indicators Using the Delphi Method

At this stage of the study, the Delphi method was employed as a structured research technique to synthesize expert opinions by integrating academic expertise with practitioners' experiences (Trevelyan et al., 2015). Recognized as an effective and systematic approach, the Delphi method has been widely utilized to reach consensus in research areas where empirical evidence may be limited (Humphrey-Murto et al., 2017; von der Gracht, 2012).

The Delphi method operates through an iterative process, where a panel of selected experts participates in multiple rounds of anonymous feedback collection. During each round, panelists provide individual responses, which are then aggregated and analyzed to identify areas of agreement and disagreement (Sinha et al., 2011). This iterative process continues until a consensus is reached or it becomes evident that consensus cannot be achieved. A key feature of this method is the anonymity of responses, which eliminates potential biases arising from dominant opinions and encourages honest and independent feedback. Upon completing the iterative rounds, the final stage involves summarizing and interpreting the collective insights of the panel members, forming a robust foundation for decision-making and policy development (Lilja et al., 2011; Landeta, 2006).

In this study, experts were carefully selected based on their professional theoretical knowledge and practical experience in tennis training and evaluation. Their role was to identify and refine key physical fitness indicators specifically relevant to Chinese Elite Male University Tennis Players. In the initial phase, experts evaluated and selected indicators by considering the skill level, physical abilities, and training characteristics of the target population. Additionally, they provided supplementary insights to enhance the applicability and precision of the selected indicators, ensuring that they accurately reflect the specific demands of Chinese elite university tennis players.

Researchers following the Delphi methodology adhere to a series of well-defined stages. The process begins with the identification of a relevant research problem, followed by the selection of expert panel members based on their expertise and relevance to the study. Subsequently, a detailed questionnaire is developed, containing items and statements that address key aspects of the research

focus (Boulkedid et al., 2011; Sinha et al., 2011). This systematic and progressive refinement of expert opinions ensures that the final evaluation framework is scientifically sound, practically relevant, and methodologically rigorous.

By leveraging the Delphi method, this study establishes a comprehensive and validated specialized physical fitness evaluation system tailored for Chinese Elite Male University Tennis Players. This methodological approach not only ensures scientific rigor and reliability but also enhances the practical application of the developed evaluation framework in real-world tennis training and performance assessment.

(1) Distribution and Collection of Questionnaires

To ensure the comprehensiveness of the collected information and the smooth progression of the study, multiple channels were used to distribute the Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players, including direct on-site distribution and distribution via WeChat. Experts were promptly reminded to return the questionnaires to maximize the response rate and ensure the timeliness of the study.

The anonymity principle was strictly adhered to throughout the survey process to ensure that experts did not know each other's identities or opinions. This approach minimized potential interactions and communications between panel members, enabling each expert to independently express their insights without being influenced by others. This ensured the independence and objectivity of the responses, ultimately enhancing the quality and reliability of the questionnaires and research results.

During the inquiry process, if any doubts or misunderstandings arose, the research team communicated with the experts in a timely manner to verify and confirm the information, ensuring the authenticity and reliability of the data.

(2) Organization and Analysis of Questionnaires

The collected data were meticulously verified by the researchers. Once confirmed to be accurate, the data were entered into a database established using Microsoft Excel 2019.

(3) Calculation of Expert Consensus

① Expert Participation Coefficient

The expert participation coefficient refers to the response rate of the questionnaire (Response Rate = Number of Responding Experts / Total Number of Experts).

This coefficient reflects the level of importance that experts attribute to the research.

② Expert Authority Coefficient (Cr)

The authority coefficient (Cr) of the experts is determined by two factors:

The basis of judgment (Ca): This reflects the rationale behind the expert's judgments.

The level of familiarity (Cs): This reflects the expert's familiarity with the research field.

Both Ca and Cs are self-assessed by the experts.

The formula for calculating the authority coefficient is:

$$Cr = \frac{Ca + Cs}{2}$$

$Cr \geq 0.70$ is generally considered an indicator of a high level of expert authority.

The judgment basis (Ca) is evaluated across four criteria, each assigned a weight based on its influence (large, medium, or small), and the total score is summed. The familiarity level (Cs) is assessed on a 5-point scale, with each level assigned a specific quantitative value.

③ Degree of Consensus Among Expert Opinions

After collecting the questionnaires, the degree of consensus among expert opinions was calculated using Kendall's coefficient of concordance, full-score rate, coefficient of variation, and mean values.

Kendall's Coefficient of Concordance

Kendall's coefficient is used to calculate the level of agreement among multiple ordinal variables (Field, 2005). It provides an objective method for selecting the most appropriate indicators. The formula for Kendall's coefficient is as follows:

$$W = \frac{S}{\frac{1}{12} K^2 (N^3 - N)}$$

In this study, K represents the number of raters, N denotes the number of evaluated objects, and S refers to the sum of the ranks assigned to each object by the raters. Kendall's coefficient of concordance is used to evaluate the consistency of ratings provided by multiple raters. A Kendall's coefficient closer to 0 indicates lower consistency, while a coefficient closer to 1 indicates higher consistency. If the coefficient fluctuates around 0.5, it suggests moderate coordination among experts. Typically, a p-value less than 0.05 indicates significant consistency among experts' ratings.

a. Full-Score Rate

The full-score rate is a statistical measure used to assess the importance of an indicator. It is defined as the proportion of evaluations that assign the maximum score to a given indicator. This measure reflects the level of agreement and importance attributed to an indicator by experts.

The formula for calculating the full-score rate is: $K = \frac{m'}{m}$

K: Full-score rate, m': Number of experts who assign the maximum score, m: Total number of participating experts.

The full-score rate ranges from 0 to 1, with higher values indicating a greater proportion of experts assigning the maximum score, signifying the higher importance of the indicator.

b. Coefficient of Variation (CV)

The coefficient of variation (CV), also known as the relative standard deviation, is a normalized measure of the dispersion of a probability distribution. It is defined as the ratio of the standard deviation to the mean. CV is particularly useful when comparing the degree of dispersion between two datasets with different scales or units.

The formula for CV is:

$$CV = \frac{SD}{Mean} \times 100\%$$

SD: Standard deviation, Mean: Average value, CV is dimensionless, making it an objective tool for comparing datasets with different units or scales. Generally, a higher CV indicates greater data dispersion, while a lower CV suggests less variability. If the CV exceeds 15%, the data may be considered abnormal and should be excluded from analysis.

c. Mean Value

The mean is used as a measure of central tendency and is determined based on the position of values within the distribution. Although this calculated mean may not always precisely reflect the true average, it is statistically regarded as a valid indicator of central tendency.

The rationale for using the mean as a measure of central tendency includes:

Its proximity to the mode, the most frequently occurring value in the distribution.

Its location near the midpoint when values are arranged in ascending or descending order.

(4) Item Screening Criteria

This study employed the threshold method to screen indicators.

High-priority indicators were identified using the formula:

Threshold=Mean-SD, Indicators with scores below the threshold were excluded.

Low-priority indicators were identified using the formula:

Threshold=Mean+SD, Indicators with scores above the threshold were excluded.

The screening process considered the concentration and dispersion of the indicators, with specific criteria based on: 1. Mean value, 2. Full-score rate, 3. Coefficient of variation. Only indicators failing to meet two or more criteria were excluded. Modifications to the indicators were made by incorporating expert feedback to ensure comprehensive and accurate evaluation.

3. Secondary Selection of Indicators Using the Delphi Method

The number of Delphi rounds depended on whether consensus among experts was achieved. The process continued until further consensus could not be reached (Hasson, F., et al., 2000).

The steps for this stage mirrored those of the initial round:

① **Distribution and Collection of Questionnaires:** In the second round, experts were provided with an analysis of the results from the first round. This included statistical summaries to highlight items that had achieved collective agreement (Hasson, 2000).

② **Organization and Analysis of Questionnaires:** The procedures for organizing and analyzing questionnaires were identical to those of the first round.

③ **Calculation of Expert Consensus:** Similar to the first round, Kendall's coefficient of concordance, full-score rate, coefficient of variation, and mean value were calculated for each questionnaire.

④ **Item Screening Criteria:** The same criteria from the first round were applied.

After two rounds of Delphi questionnaires, the Preliminary Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players was finalized.

3.6 Data Analysis

The data collection process in this study was accompanied by continuous data analysis to ensure the accuracy and validity of the results (Couper, M. P., 2005).

1. Item-Objective Congruence (IOC)

If the index of the IOC is between 0.5 and 1.00, it suggests that the item is acceptable, but if IOC falls below 0.5, it means that the item is not fitting and must be removed or reviewed (Brown, J. D. 2005; Supparerkchaisakul, N et al., 2017; Takwin, M et al., 2018; Pengruck, L et al., 2019).

2. Expert Participation Coefficient

The expert participation coefficient refers to the response rate of the questionnaire ($\text{Response Rate} = \frac{\text{Number of Responding Experts}}{\text{Total Number of Experts}}$).

American sociologist Earl Babbie (1990) proposed a general standard: a response rate of 50% is considered "adequate," 60% is considered "good," and 70% or higher is considered "very good." This implies that a minimum response rate of 50% is

necessary for analysis and reporting, while a response rate of 70% or higher provides greater reliability and validity.

3. Expert Authority Coefficient (Cr)

In this study will use Windows Excel 2019. The authority coefficient (Cr) of the experts is determined by two factors: 1. the basis of judgment (Ca), 2. the level of familiarity (Cs).

$Cr \geq 0.70$ is generally considered an indicator of a high level of expert authority (Chen, Y et al., 2018; Zhou, H et al., 2023).

4. Kendall's Coefficient of Concordance

In this study will use SPSS 29. Kendall's coefficient is used to calculate the level of agreement among multiple ordinal variables (Field, 2005).

Kendall coefficient < 0.2 : Indicates a low level of consistency.

Kendall coefficient between 0.2 and 0.4: Indicates a moderate level of consistency.

Kendall coefficient between 0.4 and 0.6: Indicates a medium level of consistency.

Kendall coefficient between 0.6 and 0.8: Indicates a high level of consistency.

Kendall coefficient between 0.8 and 1.0: Indicates a very high level of consistency (Spssau, 2024).

Phase 2.

3.7 Participants

In this phase the athlete group was comprised of 53 Chinese male national level 2 and level 1 tennis players. These athletes held Chinese national level 2 and level 1 tennis athlete certifications.

3.7.1 Athlete Group Sample Size

Athletes were selected from six sports universities located in two provinces in China where tennis development is relatively advanced. These universities included Shanghai University of Sport, Shanghai University, Xi'an Physical Education University, Xi'an University of Electronic Science and Technology, Xi'an University of Architecture and Technology, and Northwest Agriculture and Forestry University.

According to the definitions provided by the United Nations, UNICEF, the World Health Organization, and the Population Fund, adolescents are individuals aged between 15 and 24 years (United Nations, 1981). Considering the physiological differences between male and female athletes (Lundsgaard, A. et al., 2017), this study specifically focused on male athletes.

Due to male tennis players in China and the difficulty of organizing them, this study used G-Power software to calculate the required sample size to ensure sufficient statistical power for the research design.

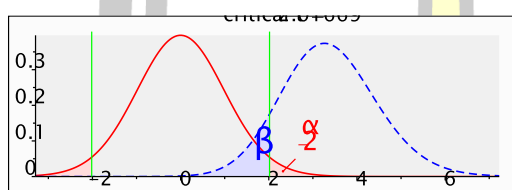


Figure 3 G-Power software

When conducting the a priori power analysis, the parameters were set as follows: a two-tailed test, an effect size (d) of 0.5, a significance level (α) of 0.05, and a statistical power ($1-\beta_1-\beta$) of 0.90.

The calculation using G Power software yielded the following results:

Noncentrality parameter (δ): 3.3166248

Critical t-value: 2.0166922

Degrees of freedom (df): 43

Total sample size: 44

Actual statistical power: 0.9000306

To ensure the smooth progression of the experiment and to account for potential interferences or data loss during the process, the sample size was increased by 20% based on the calculated result. Therefore, the final sample size for this study was determined to be 53 participants. This sample size not only satisfies the statistical requirements but also enhances the stability and reliability of the experimental results.

3.7.2 Inclusion and Exclusion Criteria for the Athlete Group

(1) Inclusion Criteria for Athletes:

- 1) Age range: between 18 and 24 years, falling within the category of adolescent athletes.
- 2) Male tennis players.
- 3) Tennis performance meets the standards of the Chinese National Level 2 or level 1 Tennis Player Certifications.
- 4) No injury records in the last 3 months.
- 5) Ability to understand and sign the informed consent form.

(2) Exclusion Criteria for Athletes:

- 1) Ceased training for over 1 month.
- 2) Long-term medication use or alcoholism.
- 3) Presence of underlying medical conditions or injuries in the last 3 months.
- 4) Inability to comply with research requirements.

3.8 Instrument

1. Based on the Preliminary Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players (Appendix F), athlete sampling and testing were conducted to collect empirical data. This study used G-Power to calculate the sample size of the athletes.

2. Statistical analyses were performed on the test results, including reliability testing and validity testing (exploratory factor analysis, EFA). Based on these results, the final Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players was developed (Appendix K).

3. Further data analyses were conducted to determine indicator weights, individual scoring standards, and comprehensive scoring standards to ensure the accuracy and applicability of the evaluation system.

3.9 Data Collection Procedure

1. Data Collection for Indicator Evaluation

To validate the Preliminary Indicator System, purposeful sampling was employed to test the physical fitness of 53 Chinese Elite Male University Tennis Players with a National Level 2 Athlete Qualification. Descriptive statistics of the collected data were subsequently analyzed.

The study distributed measurement handbooks and score recording forms to the coaches of the sampled tennis players using on-site and email methods. Coaches recorded the athletes' scores and returned the completed forms via the same methods. The testing process strictly adhered to the sequence outlined in the measurement handbook.

To ensure the athletes' well-being, all tests were conducted under conditions of full physical health. Athletes were required to refrain from eating and engaging in strenuous activities for at least one hour prior to testing. Coaches supervised the entire testing process to ensure standardization and validity.

The collected data were analyzed using statistical methods to assess the reliability, validity, indicator weights, single-item evaluation standards, and comprehensive evaluation standards.

2. Descriptive Statistics

Descriptive statistical analysis was employed to summarize the fundamental characteristics of the data, providing intuitive support for subsequent analysis. By measuring central tendency, dispersion, and distribution shape, this method offered a comprehensive view of the data's underlying patterns.

Central Tendency: Includes mean, median, and mode, which describe the central location of the data.

Dispersion: Includes standard deviation, variance, range, and interquartile range, which reflect the variability of the data.

Distribution Shape: Skewness and kurtosis were used to characterize the distribution of the data.

Before conducting data and model analysis, it was essential to assess whether the data followed a normal distribution. According to Kline (1998), data with absolute

skewness values below 3 and kurtosis values below 8 can be considered approximately normal. This criterion provided a basis for applying statistical methods and improved the accuracy and scientific validity of the analysis.

3. Reliability and Validity Testing

① Reliability Analysis

Reliability analysis is a crucial metric for evaluating the stability and consistency of measurement tools. Higher reliability indicates smaller measurement error, thus enhancing the credibility of the results. In social sciences, particularly with Likert-scale studies, Cronbach's alpha (α) is commonly used to assess reliability (Cronbach, 1951). The formula for calculating Cronbach's alpha is as follows:

$$\alpha = \frac{K}{K-1} \left(1 - \frac{\sum S_i^2}{S^2} \right)$$

K: Represents the total number of items in the scale.

$\sum s_i^2$: Denotes the sum of the variances of individual items.

s^2 : Indicates the variance of the total scores of the scale.

The value of Cronbach's α ranges between 0 and 1. Although extreme values (0 or 1) are theoretically possible, they are nearly impossible in practical applications. There has been extensive discussion regarding the minimum acceptable threshold for α . (Henson, 2001) suggested that for pilot questionnaires or exploratory measurement structures, an α value between 0.50 and 0.60 is acceptable. However, for foundational research, higher reliability is typically required, and an ideal α value should be 0.80 or above. (Nunnally, 1967) further recommended that for general exploratory research, the minimum acceptable α value ranges between 0.50 and 0.60. For applied or confirmatory research, an ideal α value should exceed 0.80, with a preferred threshold of 0.90 or higher.

During the reliability analysis process, examining changes in the overall α coefficient of a scale after removing individual items is critical. If removing a particular item significantly increases the α value, it may indicate low homogeneity between that item and the other items, suggesting that it measures a different attribute or psychological construct. In such cases, removing the item should be considered.

Additionally, if the scale encompasses two or more distinct constructs, it is advisable to calculate separate α coefficients for the subscales representing each construct to more accurately assess the reliability of each structure.

By conducting reliability analysis using the above methods, researchers can effectively enhance the quality of measurement tools, ensuring the credibility and robustness of research outcomes.

② Validity Analysis (Exploratory Factor Analysis)

Exploratory Factor Analysis (EFA) is a multivariate statistical method widely used in social sciences to reveal the structure of data and explore the existence and relationships of latent variables (latent factors). The primary objective of EFA is to analyze the correlations among a set of variables, identify latent factors with common characteristics, simplify the data structure, and uncover the underlying structure of the observed variables. Principal component analysis is a versatile statistical method for reducing a cases-by-variables data table to its essential features, called principal components. Principal components are a few linear combinations of the original variables that maximally explain the variance of all the variables (Greenacre et al., 2022). Maximum Likelihood Estimate (MLE) is defined as the parameter value that maximizes the likelihood function, representing the probability of observing a given set of data. It is a fundamental method in statistics for estimating unknown parameters in models (Aghamohammadi et al., 2022).

EFA assumes that the observed variables are driven by a smaller number of latent factors. By analyzing the covariance or correlation matrix of the variables, EFA groups variables under specific factors. The main steps in EFA include factor extraction and factor rotation:

Factor Extraction: Commonly performed using Principal Component Analysis (PCA) or the Maximum Likelihood Method, this step identifies factors that explain the majority of the variance in the data.

Factor Rotation: After extraction, orthogonal rotation (e.g., Varimax) or oblique rotation (e.g., Promax) is applied to optimize the interpretability of factor loadings, ensuring that each variable is more clearly associated with a specific factor.

The stability of EFA results is critically dependent on the suitability of the data for factor analysis can be evaluated using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. A KMO value greater than 0.6 and a significant Bartlett's test result ($p < 0.05$) indicate that the data is appropriate for factor analysis. The KMO values between 0.8 to 1.0 indicate the sampling is adequate. KMO values between 0.7 to 0.79 are middling and values between 0.6 to 0.69 are mediocre. KMO values less than 0.6 indicate the sampling is not adequate and the remedial action should be taken. If the value is less than 0.5, the results of the factor analysis undoubtedly won't be very suitable for the analysis of the data. If the sample size is < 300 the average communality of the retained items has to be tested. An average value > 0.6 is acceptable for sample size < 100 , an average value between 0.5 and 0.6 is acceptable for sample sizes between 100 and 200 (Shrestha, N. 2021, Tabachnick, B. G., & Fidell, L. S. 2013, Guttman, L. 1954, Kaiser, H. F. 1970).

The results of EFA typically include a factor loading matrix and the total explained variance:

Factor Loadings: Reflect the strength of the relationship between observed variables and latent factors. Higher loadings (typically ≥ 0.4) indicate that a variable strongly contributes to explaining the corresponding factor.

Total Explained Variance: Indicates the proportion of total variance in the observed variables that is accounted for by the extracted factors.

EFA plays a critical role in theory development and scale construction, providing researchers with insights into the latent structure of data while serving as a foundation for subsequent Confirmatory Factor Analysis (CFA).

Based on the results of the exploratory factor analysis, the Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players was developed. This system serves as the foundation for subsequent analyses and evaluations.

4. Determination of Indicator Weights

Once the indicator system for the specialized physical fitness of Chinese Elite Male University Tennis Players was established, the importance of each indicator was determined. Indicator weight is defined as a measure of the importance of a specific

indicator within its respective group of indicators. The weight is directly proportional to the importance of the indicator; a higher weight signifies greater importance, and vice versa.

There are various methods to calculate indicator weights. In this study, a combined weighting method was employed to assign weights to the developed indicator system:

For primary indicators, principal component analysis (PCA) or factor analysis was used to determine the weights.

For secondary indicators, the entropy method was applied to calculate the weights.

Based on these calculations, the Evaluation Model for Specialized Physical Fitness of Chinese Elite Male University Tennis Players was constructed. This model provides a comprehensive structure for evaluating the specialized physical fitness of athletes, ensuring a scientifically valid weighting system.

5. Establishment of Evaluation Standards for Single Indicators

Sports evaluation is a process of judging the results of sports measurement based on certain evaluation standards and assigning value and significance to them. During the physical fitness training of male university tennis players, the evaluation standards for single indicators play a crucial role in monitoring the physical fitness levels of the athletes. These standards allow for real-time reflection on the status of various fitness indicators, helping both coaches and athletes make targeted adjustments and improvements during training.

(1) Development of Single-Item Scoring Standards Using the Progressive Scoring Method

The progressive scoring method is based on the principles of normal distribution theory and uses a parabolic equation to establish scoring standards (Zhang, L. M., & Qi, H., 2003). To apply this method, the K-S test for the indicator must yield a value greater than 0.05.

One of the key advantages of the progressive scoring method is that it ensures the progressive value is aligned with performance improvements during the quantification of scores. This method provides a coherent and adaptive approach to scoring.

The formula for the progressive scoring method is as follows:

$$Y = KD2 - Z$$

Y: Progressive score, K: Coefficient, D: Position of the specific indicator on the horizontal axis of the normal distribution curve, Z: Base score on the left of the baseline point.

This scoring method ensures that the evaluation is sensitive to performance improvements, providing both athletes and coaches with an objective and scientifically grounded tool for monitoring and guiding training progress.

$$D = 5 \pm \frac{X - \bar{X}}{S}$$

X represent the mean value and S represent the standard deviation. To avoid the occurrence of zero scores, the maximum and minimum scores are controlled within the range of $X \pm 3S$

Based on the calculation process of the progressive scoring method, a scoring interval of 5 points is applied to calculate the indicator scores corresponding to 100, 95, 90, ..., 0. This process forms the single-item scoring scale for evaluating specific indicators.

(2) Percentile Method for Single-Item Evaluation Standards

The percentile scoring scale divides evaluation levels or score intervals using percentiles as units. This scale imposes no specific requirements on the distribution of raw data, directly reflecting an individual's performance relative to their position within a group. Evaluation levels or scores are determined based on the percentage of individuals scoring below a particular percentile, making it a measure of relative position.

The primary advantage of the percentile method lies in its ability to intuitively demonstrate an individual's relative performance within a group, providing a fair and transparent basis for comparing scores within the group. In this study, the percentile method was applied to construct evaluation scales for raw data, approximately normally distributed data, and count data. This approach ensures the scientific validity and applicability of the evaluation results, while effectively reflecting the relative position relationships of different data types in group evaluations.

By using the percentile method, tailored evaluation scales were developed for various data types, ensuring consistency with the study's objectives and the relative positioning of scores in group assessments.

6. Development of Comprehensive Evaluation Standards

Reliance on single-item grading alone is insufficient and often one-sided. A comprehensive evaluation of athletes' physical fitness is essential to accurately and objectively diagnose the overall fitness levels of athletes. To achieve this, this study utilized athletes' overall scores to develop a comprehensive evaluation standard for Chinese male national-level 2 tennis players' physical fitness using the deviation method.

This comprehensive standard provides university tennis coaches with a diagnostic tool to evaluate the overall fitness levels of athletes. Furthermore, it aligns with the evolving trend in sports measurement and evaluation from static to dynamic evaluation standards, encouraging both coaches and athletes to aspire to higher performance levels.

(1) Deviation Method for Developing Comprehensive Scoring Standards

Based on the collected and statistically processed data, some indicators could not be evaluated using the progressive scoring method. Therefore, the deviation method was adopted as an alternative scoring approach for these specific indicators.

The deviation method uses statistical deviations of individual scores from the group mean to assign scores, ensuring that the evaluation is tailored to the characteristics of the data. By addressing the limitations of other scoring methods, the deviation method provides a flexible and scientifically sound approach for constructing comprehensive evaluation standards.

This comprehensive evaluation standard serves as a robust tool for assessing the physical fitness of athletes, offering valuable guidance for both training practices and future research in the field of sports science.

The formula for the deviation method is as follows:
$$T = 10Z + 50$$

$$Z = \frac{X - \bar{X}}{S}$$

Z: The Basic Form of Standard Scores

where the T-score is derived from the transformation of the Z-value. Scores of 0 and 100 correspond to Z-scores of -5 and +5, respectively, thereby preventing the occurrence of negative Z-values.

Once the score range for 100 and 0 points is determined, a single-item scoring scale is developed based on the derived T-scores.

(2) Establishment of Comprehensive Grading Standards

To comprehensively evaluate the specialized physical fitness level of Chinese male national-level 2 tennis players, it is necessary to incorporate not only the comprehensive scores derived in the previous stages but also the categorization of these scores into performance levels. The five-level grading system is employed to classify results into five levels: "Excellent," "Good," "Average," "Below Average," and "Poor." This classification is based on the deviation method.

The deviation method requires that the data conform to the assumption of normal distribution. The mean value of the sample serves as the base value, while the standard deviation reflects the degree of data dispersion. Using the deviation method, the boundary points for each performance level are calculated, forming the comprehensive grading standard.

3.10 Data Analysis

1. Reliability Analysis

In this study will use SPSS 29. The value of Cronbach's α ranges between 0 and 1. Although extreme values (0 or 1) are theoretically possible, they are nearly impossible in practical applications. There has been extensive discussion regarding the minimum acceptable threshold for α . (Henson, 2001) suggested that for pilot questionnaires or exploratory measurement structures, an α value between 0.50 and 0.60 is acceptable. However, for foundational research, higher reliability is typically required, and an ideal α value should be 0.80 or above. (Nunnally, 1967) further recommended that for general exploratory research, the minimum acceptable α value ranges between 0.50 and 0.60.

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The results of EFA typically include a factor loading matrix and the total explained variance:

Factor Loadings: Reflect the strength of the relationship between observed variables and latent factors. Higher loadings (typically ≥ 0.4) indicate that a variable strongly contributes to explaining the corresponding factor.

Total Explained Variance: Indicates the proportion of total variance in the observed variables that is accounted for by the extracted factors.

The opinions from experts and the test data were meticulously entered into a database using Microsoft Excel 2019. This ensured systematic and organized data management throughout the research process.

For data analysis, a combination of statistical tools was employed: SPSS.29, Microsoft Excel 2019.

Phase 3.

3.11 Participants

In this phase , the athlete group(re-test) compare 30 Chinese male national level 2 and level1 tennis players. These athletes held Chinese national level 2 and level 1 tennis athlete certifications. The expert group compare 5 Sport Science experts, same as phase 1.

3.11.1 Sample size

The athlete group(re-test group) accounted for 30% of the test group(phase 2 athlete sample size), calculated as $53 \div 0.7 = 75.7$. To ensure the feasibility of the sample, the final retest group consisted of 30 participants.

The expert same with phase 1.

3.11.2 Inclusion and Exclusion Criteria

In this phase the athlete group Inclusion and Exclusion Criteria same with phase2.

In this phase the expert group Inclusion and Exclusion Criteria same with phase1.

3.12 Instrument

1. Using the Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players (Appendix K), athlete sampling and testing were conducted. The test results were applied to the individual scoring standards and comprehensive scoring standards to validate the developed evaluation system through back-testing procedures to ensure its scientific rigor, reliability, and practical applicability.

2. Five sports science experts were invited again to conduct an Item-Objective Congruence (IOC) (Appendix L)test on the established evaluation system to verify its validity.

3.13 Data Collection Procedure

1. Verification of the Comprehensive Evaluation Standard Through re-substitution validation (Re-test)

To evaluate the validity and reliability of the established evaluation system, a random sampling was conducted at two professional sports universities with specialized tennis programs: Xi'an Physical Education University and Shanghai University of Sport. A total of 30 athletes from different competitive levels were

selected to test the content of the developed "Indicator System" and to perform back-substitution verification of the comprehensive evaluation standards.

The data obtained from the tests were statistically analyzed and quantified to generate a final composite score, which was used to validate the authenticity and reliability of the comprehensive evaluation standards.

The testing requirements were consistent with those outlined for the initial test.

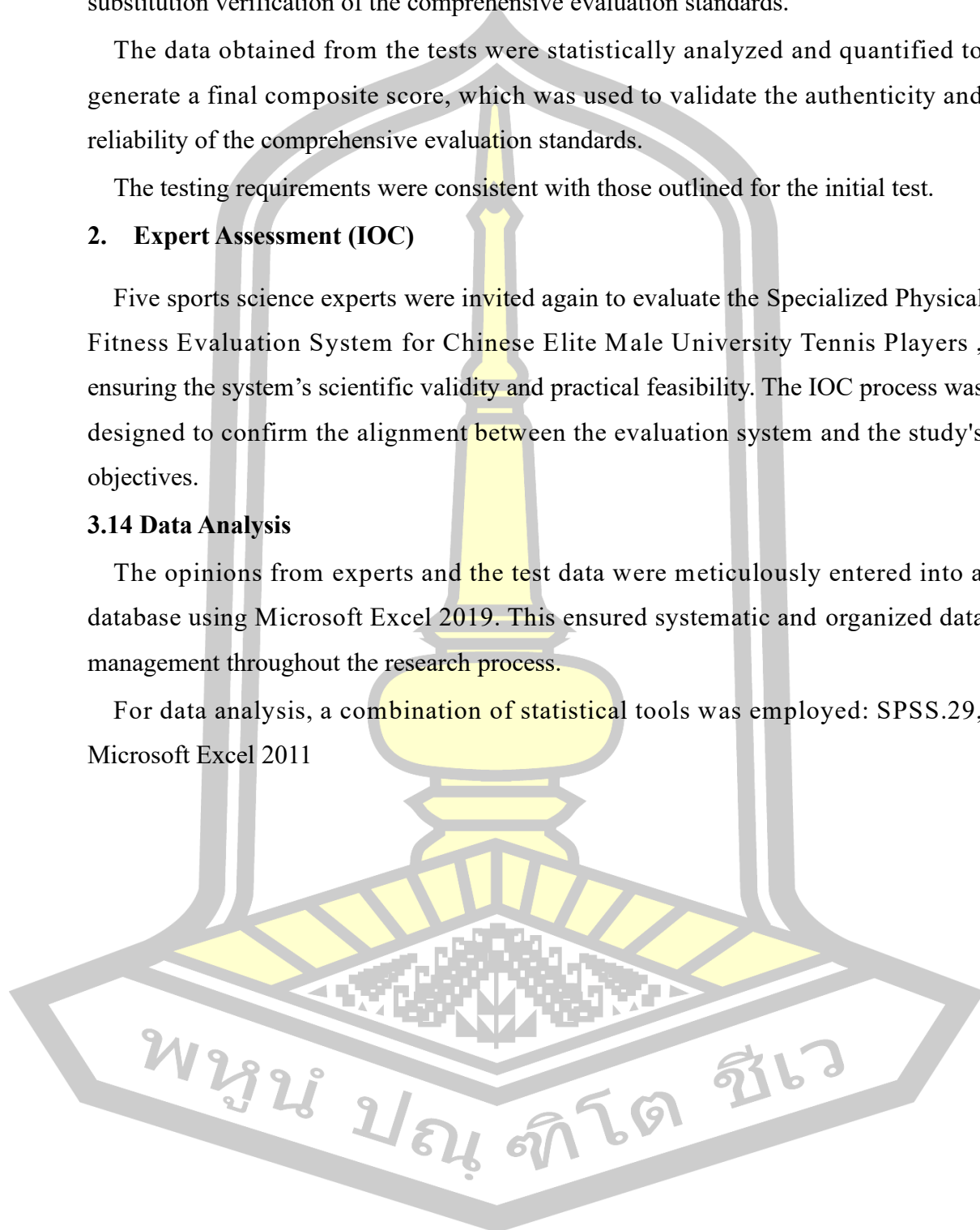
2. Expert Assessment (IOC)

Five sports science experts were invited again to evaluate the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players , ensuring the system's scientific validity and practical feasibility. The IOC process was designed to confirm the alignment between the evaluation system and the study's objectives.

3.14 Data Analysis

The opinions from experts and the test data were meticulously entered into a database using Microsoft Excel 2019. This ensured systematic and organized data management throughout the research process.

For data analysis, a combination of statistical tools was employed: SPSS.29, Microsoft Excel 2011



CHAPTER IV

RESULTS

PHASE 1.

4.1 Preliminary Screening of Indicators

4.1.1 Development of the Expert Questionnaire

This study utilized extensive database searches to establish the foundation for the first-round expert consultation questionnaire. Databases such as China National Knowledge Infrastructure (CNKI), Wanfang Database, Google Scholar, and Web of Science were systematically searched for literature related to the influencing factors of physical fitness.

The collected literature and information were analyzed to identify key indicators relevant to physical fitness. These indicators served as the basis for formulating the first-round Delphi expert consultation questionnaire. The detailed list of collected indicators is presented in Table 6.

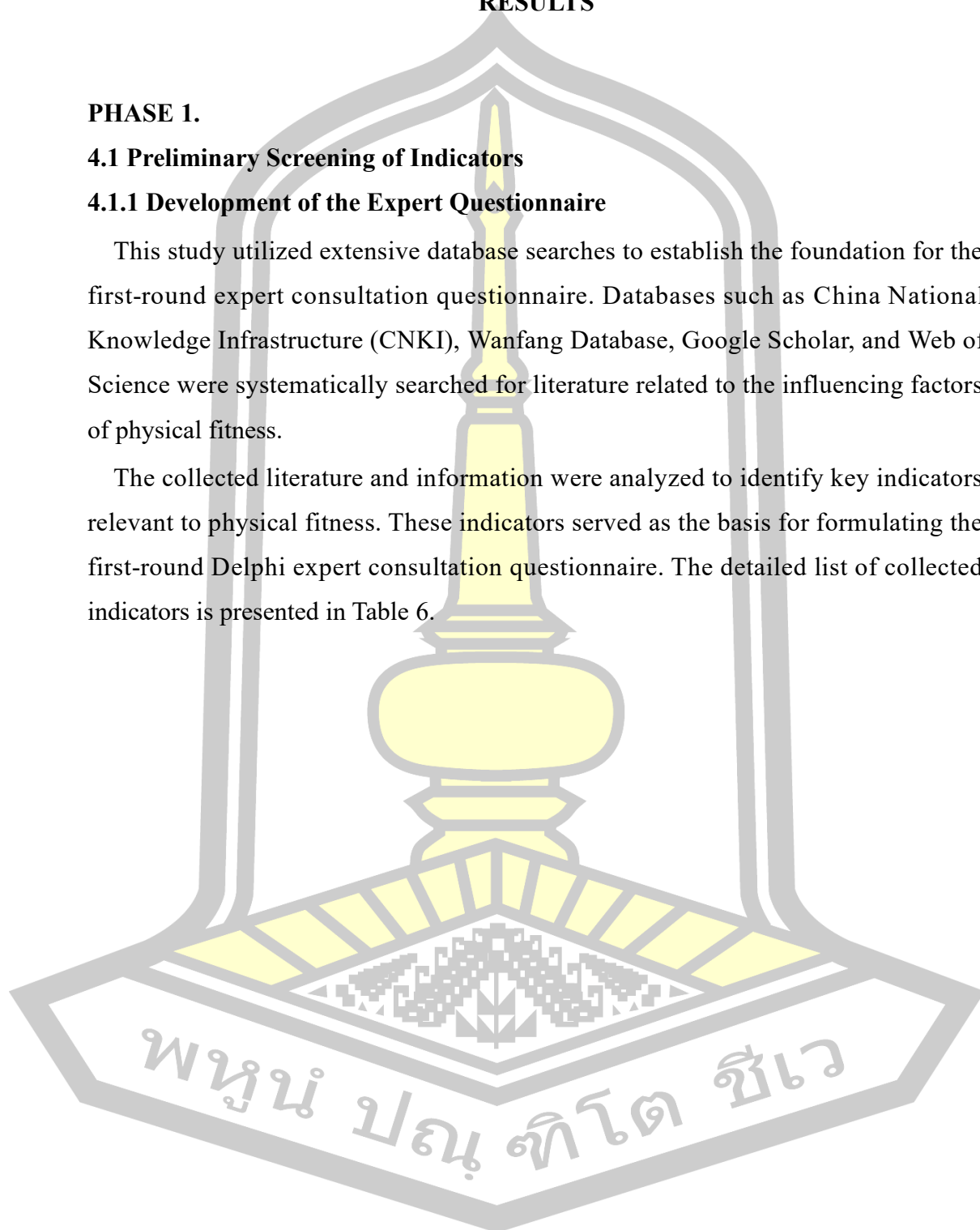


Table 6 Preliminary Screening Indicators

Primary Indicators	Secondary Indicators	
Strength	1. Pull-ups	4. Bench Press
	2. Push-ups	5. Barbell Clean and Jerk
	3. Standing Long Jump	6. Two-Footed Vertical Jump
Power	1. Continuous Incline Barbell Press	3. Medicine Ball Throw with Forehand Closed Stance
	2. Overhead Medicine Ball Throw	4. Medicine Ball Throw with Backhand Closed Stance
Speed	1. Crossover Change-of-Direction Run	4. 10 Meter Sprint
	2. 4x10 Meter Sprint	5. 20 Meter Sprint
	3. 28 Meter Sprint	6. 30 Meter Sprint
Endurance	1. 400-Meter Sprint	4. Beep Test
	2. 1500-Meter Run	5. Plank Exercise
	3. Wall-Sit Test	
Agility	1. Hexagonal Reaction Ball	4. Spider Test
	2. Singles Baseline Shuttle Run	5. Two-Foot Hexagonal Jump
	3. Burpee Test	
Flexibility	1. Sit and Reach	3. Standing Forward Bend to Touch the Ground
	2. Vertical Split	
Coordination	1. 30s Double-Under Jump Rope Test	4. Tennis Ball Throw
	2. Single-Leg Stand with Eyes Closed	5. Backward Turn with Left Foot, Forward Sprint
	3. Hand-Eye Coordination Test	6. Backward Turn with Right Foot, Forward Sprint

Through the preliminary selection and collection of indicators, the first-round IOC expert questionnaire (Appendix A), titled “The First-Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players”, was developed. Based on the experts' rating of the validity of the questionnaire structure, the first-round Delphi expert questionnaire was distributed.

4.1.2 IOC

From November 1 to November 5, 2024, this study invited five experts from the fields of sports training science and physical education science to evaluate the questionnaire.

If the index of the IOC is between 0.5 and 1.00, it suggests that the item is acceptable, but if IOC falls below 0.5, it means that the item is not fitting and must be

removed or reviewed(Brown, J. D. 2005; Supparerkchaisakul, N et al., 2017; Takwin, M et al., 2018; Pengruck, L et al., 2019).

During the IOC evaluation process, all remaining items achieved IOC values above the specified threshold, demonstrating acceptable validity of the questionnaire structure. Based on the IOC results, “The First-Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players” was distributed. (Appendix B).

4.2 Delphi Method

4.2.1 Analysis of the Results from the First-Round of the Delphi Questionnaire

From November 6 to November 12, 2024, the “First-Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players ” (Appendix B) was distributed.

The collected questionnaire results were input into a database established with Excel and statistically analyzed using SPSS 29 software. In the first round, experts were provided with a brief introduction to the research background, methodology, and their familiarity with the study. They were asked to rate the importance of each indicator and provide their feedback. Upon receiving the completed questionnaires, responses were organized and analyzed. Based on the threshold method (insert citation) and expert feedback, indicators were adjusted or modified to determine the second-round questionnaire.

(1) Expert Enthusiasm Coefficient

25 questionnaires were distributed, and 23 were returned, resulting in a 92% response rate. Among them, 23 were valid, reflecting an effective return rate of 100% and demonstrating high expert engagement.

(2) Expert Authority Coefficient

The self-assessed judgment basis of experts is summarized as follows:

Table 7 Expert Self-Evaluation Results on Judgment Basis

Judgment Basis	Large		Medium		Small	
	Number	(%)	Number	(%)	Number	(%)
Practical Experience	11	0.47	12	0.52	0	0
Theoretical Analysis	21	0.91	2	0.08	0	0
Domestic and International References	8	0.34	14	0.60	1	0.04
Intuition	10	0.43	12	0.52	1	0.04

Weights were assigned to these bases as follows:

Table 8 Expert judgment basis and degree of influence are assigned

Practical Experience	Large	Medium	Small
Theoretical Analysis	0.5	0.4	0.3
Domestic and International References	0.3	0.2	0.1
Intuition	0.1	0.1	0.05
Practical Experience	0.1	0.1	0.05

The self-assessed familiarity of the experts with the questionnaire content is as follows:

Table 9 Expert familiarity self-assessment results

Familiarity	Very familiar	Familiar Very	Generally familiar	Not familiar	unfamiliar
Number	11	12	0	0	0
(%)	0.47	0.52	0	0	0

Familiarity was quantified as:

Table 10 Assignment of Familiarity Levels for Expert Questionnaire Content

Familiarity	Very familiar	Familiar Very	Generally familiar	Not familiar	unfamiliar
Expert self-assessment	1	0.8	0.6	0.4	0.2

The authority coefficient (Cr) was calculated using the following formulas:

1. Calculation of expert judgment basis:

$$Ca = ((11 \times 0.5 + 21 \times 0.3 + 8 \times 0.1 + 10 \times 0.1) + (12 \times 0.4 + 2 \times 0.2 + 14 \times 0.1 + 12 \times 0.1) + (1 \times 0.05 + 1 \times 0.05)) \div 23 = 0.934782609$$

2. Calculation of expert familiarity:

$$Cs = (11 \times 1 + 12 \times 0.8) \div 21 = 0.895652174$$

3. Calculation of authority coefficient:

$$Cr = (Ca + Cs) \div 2 = (0.934782609 + 0.895652174) \div 2 = 0.915217391$$

Research findings indicate that an expert panel with an authority coefficient $Cr > 0.7$ is considered to have high credibility. In this study, the authority coefficient of the expert panel was calculated to be 0.915, which is greater than 0.7. Therefore, it can be concluded that the experts consulted in this study had high authority, and the results derived from their evaluations are reliable.

Coordination Degree of Experts' Opinions on Primary Indicators

(3) Coordination Degree of Expert Opinions on Primary Indicators in the First Round

The Kendall W test results are as follows:

Table 11 Primary Indicators Kendall's Coefficient of Concordance (Kendall's W) Test

Number of Experts	Number of Evaluation Items	Kendall's Coefficient of Concordance (W)	χ^2 Statistic	p-value
23	7	0.632	87.26	0

The table above presents the results of the consistency test conducted during the Delphi method using Kendall's coefficient of concordance. This test is used to evaluate the consistency of scores provided by multiple experts. The Kendall coefficient ranges from 0 to 1, with the following interpretations generally applied:

Kendall coefficient < 0.2 : Indicates a low level of consistency.

Kendall coefficient between 0.2 and 0.4: Indicates a moderate level of consistency.

Kendall coefficient between 0.4 and 0.6: Indicates a medium level of consistency.

Kendall coefficient between 0.6 and 0.8: Indicates a high level of consistency.

Kendall coefficient between 0.8 and 1.0: Indicates a very high level of consistency. (Spssau, 2024)

The chi-square test is also applied to determine statistical significance. If the p-value < 0.05 , it indicates that the consistency is statistically significant, meaning the evaluations exhibit significant agreement. Conversely, a p-value ≥ 0.05 indicates no significant consistency.

In the first round of the evaluation for primary indicators, the experts' Kendall coefficient of concordance was 0.632, suggesting a high degree of consistency among the experts. This indicates that the evaluations from the 23 participants are strongly correlated, demonstrating high agreement and reliability. The chi-square test result ($p = 0.000$) confirms that, at the 95% confidence level, the expert evaluations show good coordination, and the results are valid and credible.

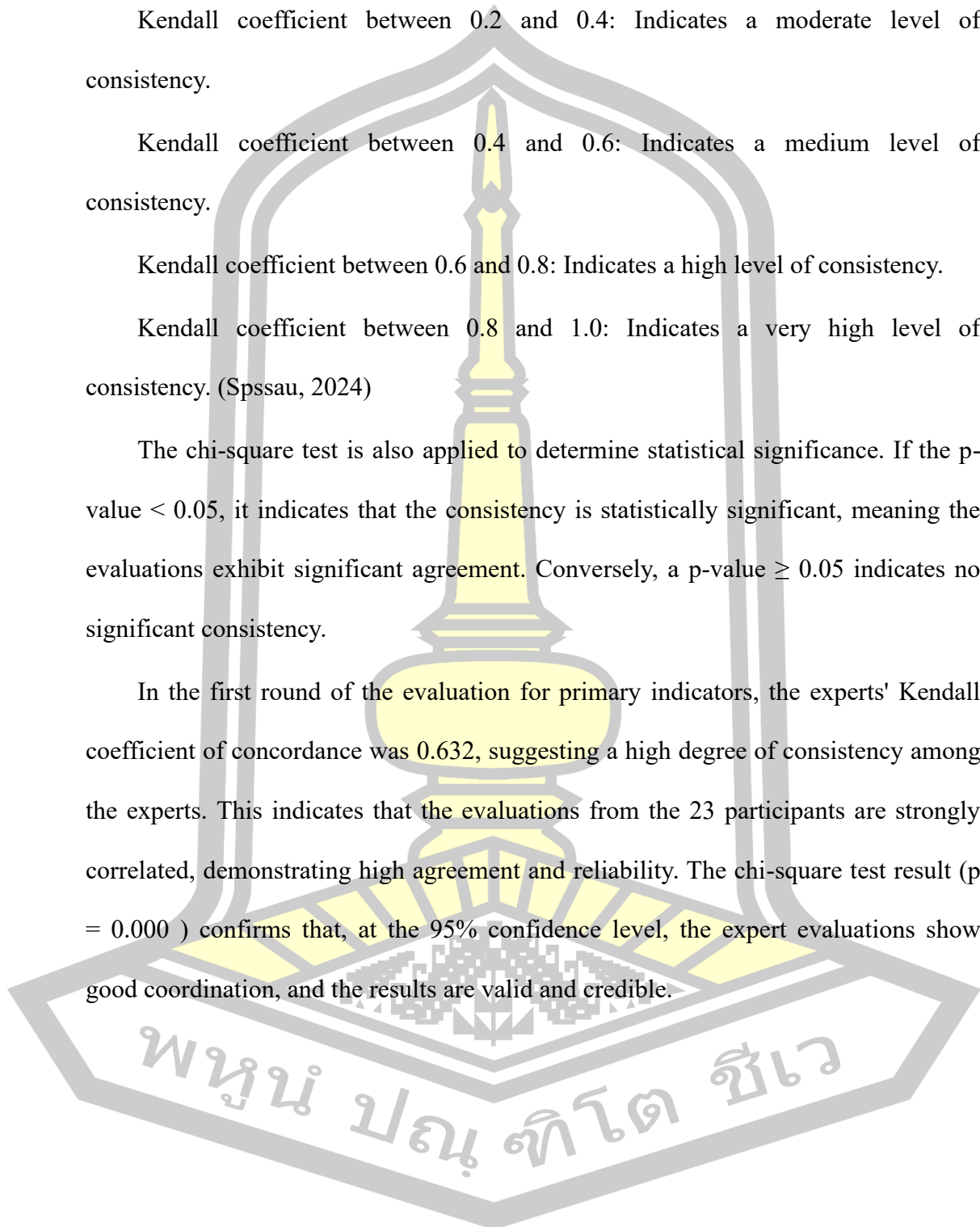


Table 12 Degree of Expert Opinion Concentration and Screening Judgment

Item	Mean	Standard Deviation	Coefficient of Variation (CV)	Full Score Frequency
Strength	3.304	0.559	0.169	0.043
Power	4.957	0.209	0.042	0.957
Speed	4.870	0.344	0.071	0.870
Endurance	3.783	0.736	0.195	0.174
Agility	4.087	0.848	0.208	0.391
Flexibility	2.957	1.261	0.426	0.130
Coordination	4.870	0.344	0.071	0.870

(4) Selection Criteria for Primary Indicators

Table 13 Selection Criteria for Primary Indicators

Item	Mean	Standard Deviation	Threshold Value
Arithmetic Mean	4.118	0.812	3.306
Coefficient of Variation (CV)	0.169	0.132	0.300
Full Score Frequency (%)	0.491	0.397	0.094

This study employs the "Threshold method" to screen the indicators. High-priority indicators are determined by the threshold formula:

$$\text{Threshold} = \text{Mean} - \text{Standard Deviation}$$

Indicators with scores below the threshold are eliminated.

For low-priority indicators, the threshold formula :

Threshold=Mean+Standard Deviation.

Indicators with scores above this threshold are eliminated. Specifically, mean and full-score ratio are used as high-priority criteria, while the coefficient of variation is used as the low-priority criterion. Screening is performed based on the concentration and variability of the indicators.

To prevent the removal of important indicators, it is stipulated that indicators failing to meet two or more criteria are eliminated. Moreover, the experts' suggestions are fully considered during the selection and revision process. Each indicator is assessed against the selection criteria. If two or more criteria are problematic for a given indicator, it should be removed. Conversely, if all criteria are met, the indicator is retained. In cases where one criterion is problematic, a comprehensive judgment is made.

For the primary indicators, based on Table 13 (Threshold Values for Evaluation Indicator Screening) and Table 12 (Expert Consensus and Screening Judgments), it is shown that the Flexibility indicator does not meet the criteria across two parameters:

Mean $2.957 < 3.306$,

Coefficient of Variation $0.426 > 0.300$.

Since two criteria are not satisfied, the Flexibility indicator is eliminated.

The full-score rate of strength ($0.043 < 0.094$) indicates that only one item does not meet the criteria; therefore, it is retained.

The revised primary indicators are as follows: strength, power, speed, endurance, agility, and coordination.

(5) Coordination of Expert Opinions on Secondary Indicators

Table 14 Secondary Indicators Kendall's Coefficient of Concordance (Kendall's W) Test

Number of Experts	Number of Evaluation Items	Kendall's Coefficient of Concordance (W)	χ^2 Statistic	p-value
23	35	0.667	521.55	0

The expert coordination coefficients for the secondary indicators is $0.667 > 0.6$, this suggests that the evaluations are consistent and have high reliability, indicating that the evaluations provided by the 23 experts are correlated. The statistical test result ($p=0.000$) further confirms that at a 95% confidence level, the coordination among the experts is strong, and the results are valid and reliable.

(6) Degree of Expert Consensus and Screening Judgments

Table 15 Degree of Expert Opinion Concentration and Screening Judgment

Item	Mean	Standard Deviation	Coefficient of Variation (CV)	Full Score Frequency
1. Pull-ups	3.826	1.029	0.269	0.304
2. Push-ups	3.391	1.270	0.374	0.261
3. Standing long jump	3.783	1.204	0.318	0.391
4. Bench press	3.217	1.166	0.362	0.174
5. Barbell clean and jerk	3.087	1.083	0.351	0.130

6. Vertical jump	3.261	1.054	0.323	0.174
7. Continuous incline barbell press machine	3.261	1.096	0.336	0.174
8. Overhead medicine ball throw	4.870	0.458	0.094	0.913
9. Forehand closed medicine ball throw	4.957	0.209	0.042	0.957
10. Backhand standing closed medicine ball throw	4.957	0.209	0.042	0.957
11. Crossover Change-of-Direction Run	4.870	0.344	0.071	0.870
12. Hexagonal reaction ball	4.957	0.209	0.042	0.957
13. 4x10-meter shuttle run	4.739	0.541	0.114	0.783
14. 28-meter sprint	3.261	1.137	0.349	0.174
15. 10-meter sprint	3.652	1.301	0.356	0.391
16. 20-meter sprint	4.696	0.635	0.135	0.783
17. 30-meter sprint	3.174	1.029	0.324	0.087
18. 400-meter sprint	3.696	1.105	0.299	0.304
19. 1500-meter run	3.087	1.083	0.351	0.130
20. Beep test	4.696	0.822	0.175	0.870
21. Plank	4.739	0.619	0.131	0.826
22. Wall sit test	4.783	0.518	0.108	0.826
23. Singles Baseline Shuttle Run	4.565	0.788	0.173	0.696
24. Burpee test	3.174	1.029	0.324	0.087
25. Spider test	4.696	0.635	0.135	0.783

26. Hexagon Jump with Both Feet	4.609	0.839	0.182	0.783
27. Sit and reach	3.217	1.204	0.374	0.174
28. Horizontal splits	2.826	0.937	0.331	0.043
29. Vertical split	3.261	1.054	0.323	0.174
30. 30s Double Unders Jump Rope Test	4.696	0.470	0.100	0.696
31. One-leg stance with eyes closed	4.696	0.559	0.119	0.739
32. Hand-eye coordination test	4.130	1.058	0.256	0.522
33. Tennis ball throw	2.913	1.083	0.372	0.130
34. Turn left foot and run forward	4.130	1.058	0.256	0.522
35. Turn right foot and run forward	4.391	0.839	0.191	0.565

(6) Secondary Indicator Screening Criteria

Table 16 Threshold Values for Secondary Indicator Screening

Item	Standard		Threshold Value
	Mean	Deviation	
Arithmetic Mean	4.007	0.746	3.261
Coefficient of Variation (CV)	0.232	0.116	0.347
Full Score Frequency (%)	0.496	0.321	0.175

The study adopts the "threshold method" for screening secondary indicators. The definition and methodology are identical to those described previously.

Based on Table 16 (Threshold Values for Secondary Indicator Screening) and Table 15 (Degree of Expert Opinion Concentration and Screening Judgment), the following results are obtained:

The bench press had a mean value of $3.217 < 3.261$, a coefficient of variation of $0.362 > 0.347$, and a full-score rate of $0.174 < 0.175$. Since all three criteria were not met, it was eliminated.

The barbell clean and jerk had a mean value of $3.087 < 3.261$, a coefficient of variation of $0.3512 > 0.347$, and a full-score rate of $0.130 < 0.175$. As none of the three criteria were met, it was eliminated.

The vertical jump had a mean value of $3.261 \leq 3.261$ and a full-score rate of $0.174 < 0.175$. Since two of the criteria were not met, it was eliminated.

The continuous incline barbell press machine had a mean value of $3.261 \leq 3.261$ and a full-score rate of $0.174 < 0.175$. As two of the criteria were not met, it was eliminated.

The 28-meter sprint had a mean value of $3.261 \leq 3.261$, a coefficient of variation of $0.349 > 0.347$, and a full-score rate of $0.174 < 0.175$. Since all three criteria were not met, it was eliminated.

The 29-meter sprint had a mean value of $3.174 < 3.261$ and a full-score rate of $0.087 < 0.175$. As two of the criteria were not met, it was eliminated.

The 1500-meter run had a mean value of $3.087 < 3.261$, a coefficient of variation of $0.351 > 0.347$, and a full-score rate of $0.130 < 0.175$. Since all three criteria were not met, it was eliminated.

The burpee test had a mean value of $3.174 < 3.261$ and a full-score rate of $0.087 < 0.175$. As two of the criteria were not met, it was eliminated.

The sit and reach had a mean value of $3.217 < 3.261$, a coefficient of variation of $0.374 > 0.347$, and a full-score rate of $0.174 < 0.175$. Since all three criteria were not met, it was eliminated.

The horizontal splits had a mean value of $2.826 < 3.261$ and a full-score rate of $0.043 < 0.175$. As two of the criteria were not met, it was eliminated.

The vertical split had a mean value of $3.261 \leq 3.261$ and a full-score rate of $0.174 < 0.175$. As two of the criteria were not met, it was eliminated.

The tennis ball throw had a mean value of $2.913 < 3.261$, a coefficient of variation of $0.372 > 0.347$, and a full-score rate of $0.130 < 0.175$. Since all three criteria were not met, it was eliminated.

The revised secondary indicators are as follows:

- ① Pull-ups
- ② Push-ups
- ③ Standing long jump
- ④ Overhead medicine ball throw
- ⑤ Forehand closed medicine ball throw
- ⑥ Backhand standing closed medicine ball throw
- ⑦ Crossover Change-of-Direction Run
- ⑧ Hexagonal reaction ball
- ⑨ 4x10-meter shuttle run
- ⑩ 10-meter sprint
- 11 20-meter sprint
- 12 400-meter sprint
- 13 Beep test
- 14 Plank exercise
- 15 Wall sit test
- 16 Singles Baseline Shuttle Run
- 17 Spider test
- 18 Hexagon Jump with Both Feet

- 19 30s Double Unders Jump Rope Test
- 20 One-leg stance with eyes closed
- 21 Hand-eye coordination test
- 22 Turn left foot and run forward
- 23 Turn right foot and run forward

4.2.2 Analysis of the Results from the Second-Round of the Delphi Questionnaire

From November 15 to November 18, 2024, the Second-Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players (Appendix C) was distributed.

① Development of the Second-Round Expert Consultation Questionnaire

The results from the first-round questionnaire analysis were used to create the second-round consultation questionnaire. The revised questionnaire was redistributed to the experts. In this round, the results of the first-round survey were fed back to the experts. Experts were asked to evaluate the second-round questionnaire and to assess the importance of each indicator. The collected questionnaires were then processed, organized, and analyzed to determine whether to add, remove, or adjust the indicators based on the threshold method and expert feedback.

② Identification of Consultation Experts

The consultation experts for the second round remained consistent with those from the first round. Detailed information about the experts is provided in Table 17.

(1) Analysis of the Results from the Second-Round Expert Questionnaire

The questionnaire results were entered into a database created using Microsoft Excel, and statistical analyses were conducted using SPSS software.

In the first round, experts were provided with a brief introduction to the research background, methodology, and their familiarity with the study. They were asked to score the importance of each indicator and provide their suggestions for modifications.

After collecting and analyzing the second-round questionnaires, the threshold method and expert feedback were employed to decide on the addition, removal, or modification of indicators.

① Expert Participation Rate

In the second round, 23 questionnaires were distributed and 23 were returned, achieving a response rate of 100%. All 23 questionnaires were valid, resulting in an effective recovery rate of 100%. The participation rate of the experts was high.

② Expert Authority Coefficient

The self-assessed judgment basis of experts is summarized as follows:

Table 17 Expert Self-Evaluation Results on Judgment Basis

Judgment Basis	Large		Medium		Small	
	Number	(%)	Number	(%)	Number	(%)
Practical Experience	11	0.47	12	0.52	0	0
Theoretical Analysis	21	0.91	2	0.08	0	0
Domestic and International References	8	0.34	14	0.60	1	0.04
Intuition	10	0.43	12	0.52	1	0.04

Weights were assigned to these bases as follows:

Table 18 Expert judgment basis and degree of influence are assigned

	Large	Medium	Small
Practical Experience			
Theoretical Analysis	0.5	0.4	0.3
Domestic and International References	0.3	0.2	0.1
Intuition	0.1	0.1	0.05
Practical Experience	0.1	0.1	0.05

The self-assessed familiarity of the experts with the questionnaire content is as follows:

Table 19 Expert familiarity self-assessment results

Familiarity	Very familiar	Familiar Very	Generally familiar	Not familiar	unfamiliar
Number	11	12	0	0	0
(%)	0.47	0.52	0	0	0

Familiarity was quantified as:

Table 20 Assignment of Familiarity Levels for Expert Questionnaire Content

Familiarity	Very familiar	Familiar Very	Generally familiar	Not familiar	unfamiliar
Expert self- assessment	1	0.8	0.6	0.4	0.2

The authority coefficient (Cr) was calculated using the following formulas:

Calculation of expert judgment basis:

$$Ca = ((11 \times 0.5 + 21 \times 0.3 + 8 \times 0.1 + 10 \times 0.1) + (12 \times 0.4 + 2 \times 0.2 + 14 \times 0.1 + 12 \times 0.1) + (1 \times 0.05 + 1 \times 0.05)) \div 23 = 0.934782609$$

Calculation of expert familiarity:

$$Cs = (11 \times 1 + 12 \times 0.8) \div 21 = 0.895652174$$

Calculation of authority coefficient:

$$Cr = (Ca + Cs) \div 2 = (0.934782609 + 0.895652174) \div 2 = 0.915217391$$

Research findings indicate that an expert panel with an authority coefficient $Cr > 0.7$ is considered to have high credibility. In this study, the authority coefficient of the expert panel was calculated to be 0.915, which is greater than 0.7. Therefore, it can be concluded that the experts consulted in this study had high authority, and the results derived from their evaluations are reliable.

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(7) Coordination Degree of Expert Opinions on Primary Indicators in the Second Round

The Kendall W test results are as follows:

Table 21 Primary Indicators Kendall's Coefficient of Concordance (Kendall's W) Test

Number of Experts	Number of Evaluation Items	Kendall's Coefficient of Concordance (W)	χ^2 Statistic	p-value
23	6	0.604	69.510	0.000

In the second round of the evaluation for primary indicators, the experts' Kendall coefficient of concordance was 0.604, suggesting a high degree of consistency among the experts. This indicates that the evaluations from the 23 participants are strongly correlated, demonstrating high agreement and reliability. The chi-square test result ($p = 0.000 < 0.05$) confirms that, at the 95% confidence level, the expert evaluations show good coordination, and the results are valid and credible.

Table 22 Degree of Expert Opinion Concentration and Screening Judgment

Item	Mean	Standard Deviation	Coefficient of Variation (CV)	Full Score Frequency
Strength	1.076	3.391	0.317	0.217
Power	0.288	4.913	0.059	0.913
Speed	0.825	4.043	0.204	0.348
Endurance	0.815	3.870	0.211	0.261
Agility	0.656	4.609	0.142	0.696
Coordination	0.518	4.783	0.108	0.826

(8) Selection Criteria for Primary Indicators

Table 23 Selection Criteria for Primary Indicators

Item	Mean	Standard Deviation	Threshold Value
Arithmetic Mean	4.268	0.596	3.672
Coefficient of Variation (CV)	0.174	0.091	0.265
Full Score Frequency (%)	0.543	0.305	0.239

For the primary indicators, based on Table 23 (Threshold Values for Evaluation Indicator Screening) and Table 22 (Expert Consensus and Screening Judgments), it is shown that the strength indicator does not meet the criteria across all three parameters: Mean $3.391 < 3.672$, Coefficient of Variation $0.317 > 0.265$, Full-Score Ratio $0.217 < 0.239$.

Since all three criteria are not satisfied, the strength indicator is eliminated.

The revised primary indicators are as follows: power, speed, endurance, agility, and coordination.

(9) Coordination of Expert Opinions on Secondary Indicators

Table 24 Secondary Indicators Kendall's Coefficient of Concordance (Kendall's W) Test

Number of Experts	Number of Evaluation Items	Kendall's Coefficient of Concordance (W)	χ^2 Statistic	p-value
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Number of Experts	Number of Evaluation Items	Kendall's Coefficient of Concordance (W)	χ^2 Statistic	p-value
23	23	0.578	292.435	0.000

The expert coordination coefficients for the secondary indicators is 0.578, indicating that the evaluations provided by the 23 experts are correlated. This suggests that the evaluations are consistent and have good reliability. The statistical test result ($p=0.000<0.05$) further confirms that at a 95% confidence level, the coordination among the experts is strong, and the results are valid and reliable.

(10) Degree of Expert Consensus and Screening Judgments

Table 25 Degree of Expert Opinion Concentration and Screening Judgment

Item	Mean	Standard Deviation	Coefficient of Variation (CV)	Full Score Frequency
1. Pull-ups	3.652	0.714	0.196	0.130
2. Push-ups	3.565	0.788	0.221	0.174
3. Standing Long Jump	3.696	0.974	0.264	0.304
4. Overhead Medicine Ball Throw	4.826	0.388	0.080	0.826
5. Medicine Ball Throw with Forehand Closed Stance	4.783	0.422	0.088	0.783
6. Medicine Ball Throw with Backhand Closed Stance	4.957	0.209	0.042	0.957
7. Crossover Change-of-Direction Run	3.696	1.063	0.288	0.304

8.Hexagonal Reaction Ball	4.957	0.209	0.042	0.957
9.4x10 Meter Sprint	4.913	0.288	0.059	0.913
10.10 Meter Sprint	3.739	0.810	0.217	0.217
11.20 Meter Sprint	4.913	0.288	0.059	0.913
12.400-Meter Sprint	3.739	1.287	0.344	0.478
13.Beep Test	4.826	0.491	0.102	0.870
14.Wall-Sit Test	4.826	0.388	0.080	0.826
15. Plank	4.783	0.600	0.125	0.870
16.Singles Baseline Shuttle Run	3.957	0.767	0.194	0.261
17.Two-Foot Hexagonal Jump	4.870	0.458	0.094	0.913
18.Spider Test	3.870	0.815	0.211	0.261
19.30s Double-Under Jump Rope Test	4.000	0.853	0.213	0.348
20.Hand-Eye Coordination Test	4.130	0.815	0.197	0.391
21.Single-Leg Stand with Eyes Closed	4.870	0.344	0.071	0.870
22.Turn left foot and run forward	3.739	0.810	0.217	0.217
23.Turn right foot and run forward	3.696	0.822	0.222	0.217

(6) Secondary Indicator Screening Criteria

Table 26 Secondary Indicator Screening Criteria

Item	Mean	Standard Deviation	Threshold Value
	Arithmetic Mean	4.304	
Coefficient of Variation (CV)	0.158	0.087	0.245
Full Score Frequency (%)	0.565	0.319	0.246

The study adopts the "threshold method" for screening secondary indicators. The definition and methodology are identical to those described previously.

Based on Table 26 (Threshold Values for Secondary Indicator Screening) and Table 25 (Expert Consensus on Secondary Indicators), the following results are obtained:

For Pull-Ups, the mean value of $3.652 < 3.741$ and the full-score ratio of $0.130 < 0.246$ indicate that both criteria are not met. Hence, this indicator is eliminated.

For Push-Ups, the mean value of $3.565 < 3.741$ and the full-score ratio of $0.174 < 0.246$ indicate that both criteria are not met. Hence, this indicator is eliminated.

For Standing Long Jump, the mean value of $3.696 < 3.741$ and the coefficient of variation of $0.264 > 0.2448$ indicate that both criteria are not met. Hence, this indicator is eliminated.

For 10-Meter Sprint, the mean value of $3.739 < 3.741$ and the full-score ratio of $0.217 < 0.246$ indicate that both criteria are not met. Hence, this indicator is eliminated.

For 400-Meter Sprint, the mean value of $3.739 < 3.741$ and the coefficient of variation of $0.344 > 0.2448$ indicate that both criteria are not met. Hence, this indicator is eliminated.

For Crossover Change-of-Direction Run, the mean value of $3.696 < 3.741$ and the coefficient of variation of $0.288 > 0.2448$ indicate that both criteria are not met. Hence, this indicator is eliminated.

For Turn Left Foot and Run Forward, the mean value of $3.739 < 3.741$ and the full-score ratio of $0.217 < 0.246$ indicate that both criteria are not met. Hence, this indicator is eliminated.

For Turn Right Foot and Run Forward, the mean value of $3.696 < 3.741$ and the full-score ratio of $0.217 < 0.246$ indicate that both criteria are not met. Hence, this indicator is eliminated.

The revised secondary indicators are as follows:

- ① Overhead Medicine Ball Throw
- ② Medicine Ball Throw with Forehand Closed Stance
- ③ Medicine Ball Throw with Backhand Closed Stance
- ④ Hexagonal Reaction Ball Test
- ⑤ 4×10-Meter Shuttle Run
- ⑥ 20-Meter Sprint
- ⑦ Beep Test
- ⑧ Wall-Sit
- ⑨ Plank Hold
- ⑩ Singles Baseline Shuttle Run
- 11 Two-Foot Hexagonal Jum
- 12 Spider Test
- 13 30s Double-Under Jump Rope Test
- 14 Hand-Eye Coordination Test
- 15 Single-Leg Stance with Eyes Closed

4.2.3 Analysis of the Third-Round Expert Consultation Process

From November 20 to November 23, 2024, the Second-Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players (Appendix C) was distributed.

① Development of the Third Round Expert Consultation Questionnaire

The results from the first-round questionnaire analysis were used to create the second-round consultation questionnaire. The revised questionnaire was redistributed to the experts. In this round, the results of the first-round survey were fed back to the

experts. Experts were asked to evaluate the second-round questionnaire and to assess the importance of each indicator. The collected questionnaires were then processed, organized, and analyzed to determine whether to add, remove, or adjust the indicators based on the threshold method and expert feedback.

② Identification of Consultation Experts

The consultation experts for the second round remained consistent with those from the first round. Detailed information about the experts is provided in Table 27.

(2) Analysis of the Results from the Third Round Expert Questionnaire

The questionnaire results were entered into a database created using Microsoft Excel, and statistical analyses were conducted using SPSS software.

In the first round, experts were provided with a brief introduction to the research background, methodology, and their familiarity with the study. They were asked to score the importance of each indicator and provide their suggestions for modifications.

After collecting and analyzing the second-round questionnaires, the threshold method and expert feedback were employed to decide on the addition, removal, or modification of indicators.

① Expert Participation Rate

In the third round, 23 questionnaires were distributed and 23 were returned, achieving a response rate of 100%. All 23 questionnaires were valid, resulting in an effective recovery rate of 100%. The participation rate of the experts was high.

② Expert Authority Coefficient

The self-assessed judgment basis of experts is summarized as follows:

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Table 27 Expert Self-Evaluation Results on Judgment Basis

Judgment Basis	Large		Medium		Small	
	Number	(%)	Number	(%)	Number	(%)
Practical Experience	11	0.47	12	0.52	0	0
Theoretical Analysis	21	0.91	2	0.08	0	0
Domestic and International References	8	0.34	14	0.60	1	0.04
Intuition	10	0.43	12	0.52	1	0.04

Weights were assigned to these bases as follows:

Table 28 Expert judgment basis and degree of influence are assigned

Judgment Basis	Large	Medium	Small
Practical Experience	0.5	0.4	0.3
Theoretical Analysis	0.3	0.2	0.1
Domestic and International References	0.1	0.1	0.05
Intuition	0.1	0.1	0.05

The self-assessed familiarity of the experts with the questionnaire content is as follows:

Table 29 Expert familiarity self-assessment results

Familiarity	Very familiar	Familiar Very	Generally familiar	Not familiar	unfamiliar
Number	11	12	0	0	0
(%)	0.47	0.52	0	0	0

Familiarity was quantified as:

Table 30 Assignment of Familiarity Levels for Expert Questionnaire Content

Familiarity	Very familiar	Familiar Very	Generally familiar	Not familiar	unfamiliar
Expert self-assessment	1	0.8	0.6	0.4	0.2

The authority coefficient (Cr) was calculated using the following formulas:

Calculation of expert judgment basis:

$$Ca = ((11 \times 0.5 + 21 \times 0.3 + 8 \times 0.1 + 10 \times 0.1) + (12 \times 0.4 + 2 \times 0.2 + 14 \times 0.1 + 12 \times 0.1) + (1 \times 0.05 + 1 \times 0.05)) \div 23 = 0.934782609$$

Calculation of expert familiarity:

$$Cs = (11 \times 1 + 12 \times 0.8) \div 21 = 0.895652174$$

Calculation of authority coefficient:

$$Cr = (Ca + Cs) \div 2 = (0.934782609 + 0.895652174) \div 2 = 0.915217391$$

Research findings indicate that an expert panel with an authority coefficient $Cr > 0.7$ is considered to have high credibility. In this study, the authority coefficient of the expert panel was calculated to be 0.915, which is greater than 0.7. Therefore, it can be concluded that the experts consulted in this study had high authority, and the results derived from their evaluations are reliable.

(3) Coordination Degree of Expert Opinions on Primary Indicators in the Third Round

Table 31 Primary indicators at the second round Kendall's Coefficient of Concordance (Kendall's W) Test

Number of Experts	Number of Evaluation Items	Kendall's Coefficient of Concordance (W)	χ^2 Statistic	p-value
23	5	0.684	62.899	0.000

The coordination coefficient for primary indicators in the third round is 0.684 exceeds 0.6, indicating a strong correlation among the evaluations of the 23 experts. This suggests that the evaluations are highly consistent and reliable. The test result ($p = 0.000 < 0.05$) further confirms that at a 95% confidence level, the coordination of expert evaluations is excellent, and the results are valid and credible.

Table 32 Degree of Expert Opinion Concentration and Screening Judgment

Item	Mean	Standard Deviation	Coefficient of Variation (CV)	Full Score Frequency
Power	4.913	0.288	0.059	0.913
Speed	4.174	0.778	0.186	0.391
Endurance	3.826	0.650	0.170	0.130
Agility	4.087	0.733	0.179	0.304
Coordination	4.870	0.344	0.071	0.870

(4) Selection Criteria for Primary Indicator Items

Table 33 Selection Criteria for Primary Indicator Items

Item	Mean	Standard Deviation	Threshold Value
Arithmetic Mean	4.374	0.490	3.741
Coefficient of Variation (CV)	0.133	0.063	0.245
Full Score Frequency (%)	0.522	0.351	0.246

Based on the results presented in Table 33 and Table 32, which summarize the coefficient of variation for expert opinions in the second round, the endurance indicator had only one sub-criterion with a full-score ratio of 0.130, which does not meet the elimination standard of 0.246. Therefore, all primary indicators meet the established criteria and are retained.

(5) Coordination Degree of Expert Opinions on Secondary Indicators in the Second Round

Table 34 Secondary indicators in the Second Round Kendall's Coefficient of Concordance (Kendall's W) Test

Number of Experts	Number of Evaluation Items	Kendall's Coefficient of Concordance (W)	χ^2 Statistic	p-value
23	15	0.603	194.116	0

The coordination coefficient for secondary indicators in the third round is 0.63 exceeds 0.6, indicating a trend toward consistency in the evaluations of the 23 experts. This implies that the evaluations are correlated, demonstrating consistency and high reliability. The test result ($p=0.000$) confirms that at a 95% confidence level, the coordination of expert evaluations is excellent, and the results are valid and credible.

Table 35 Degree of Expert Opinion Concentration and Screening Judgment

Item	Mean	Standard Deviation	Coefficient of Variation (CV)	Full Score Frequency
1.Overhead Medicine Ball Throw	4.957	0.209	0.042	0.957
2.Medicine Ball Throw with Forehand Closed Stance	4.957	0.209	0.042	0.957
3.Medicine Ball Throw with Backhand Closed Stance	4.913	0.288	0.059	0.913
4.Hexagonal Reaction Ball Test	4.043	0.825	0.204	0.348
5.4x10 Meter Sprint	4.826	0.388	0.080	0.826
6.20 Meter Sprint	4.957	0.209	0.042	0.957
7.Beep Test	3.957	0.878	0.222	0.348
8.Wall Sit	3.870	0.757	0.196	0.217

Item	Mean	Standard Deviation	Coefficient of Variation (CV)	Full Score Frequency
9.Plank	3.870	0.694	0.179	0.174
10.Singles Baseline Shuttle Run	3.870	0.757	0.196	0.217
11.Two-Foot Hexagon Jump	3.913	0.848	0.217	0.304
12.Spider Test	4.957	0.209	0.042	0.957
13.30s Double Unders Jump Rope Test	3.870	0.869	0.225	0.304
14.Hand-Eye Coordination Test	4.870	0.344	0.071	0.870
15. Single-Leg Stance with Eyes Closed	3.957	0.767	0.194	0.261

(6) Secondary Indicator Screening Criteria for the Second Round

Table 36 Secondary Indicator Screening Criteria for the Second Round

Item	Mean	Standard Deviation	Threshold Value
Arithmetic Mean	4.386	0.520	3.866
Coefficient of Variation (CV)	0.134	0.079	0.213
Full Score Frequency (%)	0.574	0.339	0.235

According to the results of the variation coefficient investigation from Table.36 and Table.35 in the third round of expert Delphi consultation, the following observations are made:

① The variation coefficient for the Beep Test is 0.222, which is greater than 0.213, and only one criterion is unmet; therefore, it does not meet the deletion standard.

② The full-score ratio for Plank is 0.174, which is less than 0.235, and only one criterion is unmet; therefore, it does not meet the deletion standard.

③ The full-score ratio for Wall Sit is 0.217, which is less than 0.235, and only one criterion is unmet; therefore, it does not meet the deletion standard.

④ The full-score ratio for Singles Baseline Shuttle Run is 0.217, which is less than 0.235, and only one criterion is unmet; therefore, it does not meet the deletion standard.

⑤ The variation coefficient for Two-Foot Hexagonal Jump is 0.217, which is greater than 0.213, and only one criterion is unmet; therefore, it does not meet the deletion standard.

⑥ The variation coefficient for 30s Double Unders Jump Rope Test is 0.225, which is greater than 0.213, and only one criterion is unmet; therefore, it does not meet the deletion standard.

⑦ The full-score ratio for Hand-Eye Coordination Test is 0.870, and only one criterion is unmet; therefore, it does not meet the deletion standard.

In conclusion, all secondary indicators meet the required standards.

The second round of the Delphi expert consultation demonstrates a high degree of consensus. Through the two rounds of Delphi expert consultation, this study successfully developed the Preliminary Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players, as detailed in Appendix E.

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PHASE 2.

4.3 Analysis of Test Data (Test)

The data collection for this study was conducted from November 25 to December 9, 2024, targeting male university tennis players in China. Participants were drawn from two provinces, Shaanxi and Shanghai, and included players from six universities with high-level sports teams: Shanghai University, Shanghai University of Sport, Xi'an Physical Education University, Xi'an University of Electronic Science and Technology, Northwest A&F University, and Xi'an University of Architecture and Technology. A total of 53 male university tennis players participated in the study.

All participants were male tennis players aged 18–24, free of injuries, and holding a Level 2 or Level 1 certification from the Chinese Tennis Athlete Qualification System. Participation in the testing was entirely voluntary. The test content was based on the Preliminary Indicator System for Specialized Physical Fitness of Chinese Male Level 2 and Level 1 Tennis Players, consisting of 15 indicators.

4.3.1 Descriptive Statistical Analysis

This study conducts statistical and analytical evaluations of the participants based on basic information and physical characteristics.

Basic Information of Male Professional Tennis Players

(1) Data and analysis regarding their demographics, athletic background, and qualification levels are summarized to provide foundational insights into the sample population.

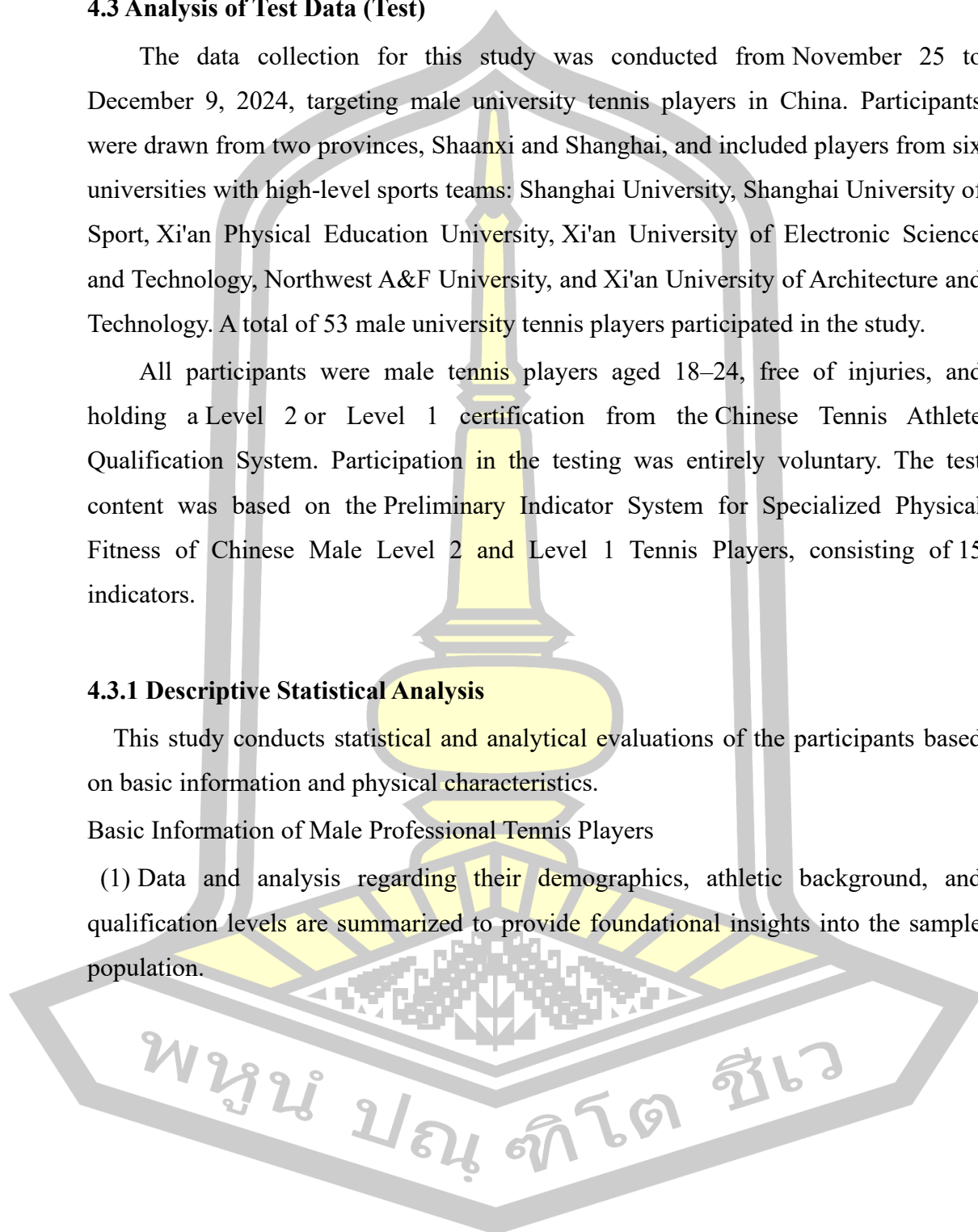


Table 37 Basic Information of Male Tennis Players(1)

Item	Category	Frequency	Percentage (%)
Ethnic	Han Ethnicity	43	18.9
	Ethnic Minorities	10	81.1
Athlete Classification	Level 1 Athlete	22	41.5
	Level 2 Athlete	31	58.5
University	Xi'an Physical Education University	13	24.5
	Shanghai University	6	11.3
	Xi'an University of Electronic Science and Technology	6	11.3
	Northwest A&F University	10	18.9
	Xi'an University of Architecture and Technology	4	7.5
	Shanghai University of Sport	14	26.4

In terms of demographic information, a statistical analysis was conducted on the ethnicity, athlete classification, and university affiliation of 53 male university tennis players. The analysis is as follows:

1. Ethnic Distribution

Among the surveyed athletes, the majority were of Han ethnicity, totaling 43 individuals, which accounted for 81.1% of the total sample. Minority ethnic groups comprised 10 athletes, representing 18.9% of the total.

2. Athlete Classification

The distribution of athlete classifications was predominantly at the level-2, comprising 31 individuals, or 58.5% of the total. Level-1 athletes accounted for 41.5% (22 individuals).

3. University Distribution

The athletes were primarily drawn from six universities. The highest representation came from Shanghai University of Sport, with 14 athletes, accounting for 26.4% of the total. This was followed by Xi'an Physical Education University, which contributed 13 athletes, representing 24.5%. Northwest A&F University had 10 athletes, making up 18.9% of the total. Other universities, such as Shanghai University, Xi'an University of Electronic Science and Technology, and Xi'an University of Architecture and Technology, had relatively fewer participants, with 6 athletes (11.3%) each from the first two institutions and 4 athletes (7.5%) from the latter.

Table 38 Basic Information of Male Tennis Players(2)

Item	Maximum Value	Minimum Value	Mean ± Standard Deviation
Age (years)	18	24	19.51±1.28
Height (cm)	168	197	180.70±5.730
Arm Length (cm)	66	200	173.33±25.654
Leg Length (cm)	97	150	110.24±11.572
Weight (kg)	53	99	72.00±10.194

The physical morphological characteristics of 53 athletes were statistically analyzed, including age, height, arm length, leg length, and body weight. The results are as follows:

1. Age: The athletes' ages ranged from 18 to 24 years, with an average age of 19.51 ± 1.28 years.
2. Height: The athletes' height ranged from 168 cm to 197 cm, with an average height of 180.70 ± 5.730 cm.
3. Arm Length: The arm length showed a wide range, spanning from 66 cm to 200 cm, with an average arm length of 173.33 ± 25.654 cm.
4. Leg Length: The leg length ranged from 97 cm to 150 cm, with an average leg length of 110.24 ± 11.572 cm.
5. Body Weight: The body weight of the athletes ranged from 53 kg to 99 kg, with an average body weight of 72.00 ± 10.194 kg.

4.3.2 Reliability and Validity Testing

The detailed information regarding the testing data is as follows:

Table 39 Reliability Test Overview Table(1)

Item	Corrected item-total correlation (CITC) \square	Alpha if Item Deleted	Cronbach Alpha
1.Overhead Medicine Ball Throw	0.572	0.843	0.856
2.Medicine Ball Throw with Forehand Closed Stance	0.641	0.840	
3.Medicine Ball Throw with Backhand Closed Stance	0.626	0.840	
4.Hexagonal Reaction Ball Tes	0.377	0.854	
5.4x10 Meter Sprint	0.523	0.846	
6.20 Meter Sprint	0.433	0.851	

Item	Corrected item-total correlation (CITC) \square	Alpha if Item Deleted	Cronbach Alpha
7.Beep Test	0.524	0.846	
8.Plank	0.343	0.855	
9.Wall Sit	0.382	0.854	
10.Spider Test	0.641	0.840	
11.Singles Baseline Shuttle Run	0.625	0.840	
12.Two-Foot Hexagon Jump	0.650	0.839	
13.30s Double Unders Jump Rope Test	0.657	0.839	
14.Hand-Eye Coordination Test	0.502	0.847	
15. Single-Leg Stance with Eyes Closed	-0.066	0.876	

Generally, if Cronbach's Alpha falls between 0.8 and 0.9, it is considered acceptable, indicating high reliability. If it exceeds 0.9, the internal reliability of the scale is deemed very high. However, if it is less than 0.7, it suggests significant issues in the design of the indicators, and a redesign should be considered (Xie Ke, 2020). Evaluation of the Reliability and Validity of the TPACK Ability Scale for Physical Education Normal Students. *Journal of Shaoguan University*, 41(12), 58–63. As shown in the table above, the overall Cronbach's Alpha for the 15 indicators is 0.856, which is greater than 0.7, indicating a high level of data reliability. However,

by examining the Corrected Item-Total Correlation (CITC) and the Alpha if Item Deleted, it is observed that the CITC value for the "Single-Leg Stance with Eyes Closed" is -0.066, which is less than 0.3, and the Alpha if Item Deleted value is 0.876, which is higher than the overall Alpha value of 0.856. This suggests that removing this indicator would improve the overall reliability. Therefore, the "Single-Leg Stance with Eyes Closed" indicator was removed, and a new reliability analysis was conducted, as shown in the table below:

Table 40 Summary Table of Reliability Tests (2)

Item	Corrected item-total correlation (CITC)	Alpha if Item Deleted	Cronbach Alpha
1.Overhead Medicine Ball Throw	0.574	0.866	0.876
2.Medicine Ball Throw with Forehand Closed Stance	0.630	0.863	
3.Medicine Ball Throw with Backhand Closed Stance	0.645	0.862	
4.Hexagonal Reaction Ball Tes	0.397	0.874	
5.4x10 Meter Sprint	0.535	0.868	
6.20 Meter Sprint	0.442	0.872	
7.Beep Test	0.521	0.868	
8.Plank	0.368	0.876	

Item	Corrected item-total correlation (CITC) \square	Alpha if Item Deleted	Cronbach Alpha
9.Wall Sit	0.389	0.875	
10.Spider Test	0.650	0.862	
11.Singles Baseline Shuttle Run	0.625	0.863	0.866
12.Two-Foot Hexagon Jump	0.653	0.862	
13.30s Double Unders Jump Rope Test	0.641	0.862	
14.Hand-Eye Coordination Test	0.491	0.870	0.814

It can be observed that after removing item E3, the overall Cronbach's Alpha increased to 0.876, which is greater than the previous value of 0.856. Additionally, the Corrected Item-Total Correlation (CITC) values are all greater than 0.3, and the "Alpha if Item Deleted" values are all less than or equal to 0.876. This indicates that the reliability of the overall dataset improved after removing item E3. Furthermore, the Cronbach's Alpha for each primary indicator is also greater than 0.8, demonstrating a high level of reliability.

4.3.3 Validity Testing (Exploratory Factor Analysis)

Exploratory Factor Analysis (EFA) was conducted to examine the structure of the evaluation indicators. Before performing the EFA, it was necessary to carry out the

Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity as shown in the following table:

Table 41 KMO and Bartlett's Test of Sphericity

KMO	0.769
Approximate χ^2	391.721
Bartlett's Test of Sphericity	df
	91
	P Value
	<0.001

The KMO values between 0.7 to 0.79 are middling and values between 0.6 to 0.69 are mediocre. KMO values less than 0.6 indicate the sampling is not adequate and the remedial action should be taken. If the value is less than 0.5, the results of the factor analysis undoubtedly won't be very suitable for the analysis of the data. If the sample size is < 300 the average communality of the retained items has to be tested. An average value > 0.6 is acceptable for sample size < 100, an average value between 0.5 and 0.6 is acceptable for sample sizes between 100 and 200 (Shrestha, N. 2021, Tabachnick, B.G. & Fidell, L.S. 2013, Guttman, L. 1954, Kaiser, H.F. 1970).

As shown in the table.41, the KMO value is greater than 0.7, and Bartlett's Test of Sphericity is less than 0.01, indicating that the indicator system is suitable for factor analysis.

The factor analysis specific results of the analysis are as follows:

Table 42 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Percentage of Variance	Cumulative %	Total	Percentage of Variance	Cumulative %	Total	Percentage of Variance	Cumulative %
1	5.496	39.260	39.260	5.496	39.260	39.260	2.580	18.429	18.429
2	2.007	14.287	53.547	2.007	14.287	53.547	2.315	16.533	34.962
3	1.399	9.991	63.538	1.399	9.991	63.538	2.288	16.339	51.301
4	1.230	8.783	72.321	1.230	8.783	72.321	2.244	16.032	67.333
5	1.085	7.748	80.069	1.085	7.748	80.069	1.783	12.736	80.069
6	0.519	3.710	83.779						
7	0.492	3.511	87.290						
8	0.411	2.938	90.228						
9	0.362	2.583	92.811						
10	0.262	1.871	94.682						
11	0.228	1.628	96.310						
12	0.217	1.550	97.859						
13	0.176	1.258	99.117						
14	0.124	0.883	100.000						

Extraction Method: Principal Component Analysis

Communalities greater than 0.80 are considered high and items with communalities lower than 0.40 may indicate an item is not related to other items or the CFA is

underfactored (Lian, J., Kiely, K. M., & Anstey, K. J. 2022, Costello & Osborne, 2005).

From Table.42, it can be observed that the indicator system extracted a total of five factors. The cumulative variance explained by the five rotated factors reached 80.069%, which exceeds the standard threshold of 60%. This indicates that the extraction of five factors is reasonable. Next, further exploration will be conducted to examine the specific indicators included in each factor. Details are provided in the Rotated Component Matrix below:

Table 43 Rotated Component Matrix

Item	Components					Common Factor Variance
	1 Power	2 Speed	3 Endurance	4 Agility	5 Coordination	
1.Overhead Medicine Ball Throw	0.884					0.883
2.Medicine Ball Throw with Forehand Closed Stance	0.664					0.739
3.Medicine Ball Throw with Backhand Closed Stance	0.822					0.834
4.Hexagonal Reaction Ball Test		0.873				0.809
5.4x10 Meter Sprint		0.739				0.698
6.20 Meter Sprint		0.833				0.762
7.Beep Test			0.816			0.819
8.Wall Sit			0.751			0.734
9.Plank			0.901			0.839
10.Singles Baseline Shuttle Run				0.844		0.818

11. Two-Foot Hexagon Jump	0.819	0.804
12. Spider Test	0.776	0.780
13. 30s Double Unders Jump Rope Test	0.781	0.830
14. Hand-Eye Coordination Test	0.892	0.859
Extraction	Method: Principal Component	Analysis

Rotation Method: Kaiser Normalization with Varimax Rotation

Through the above analysis, it can be seen that the factor "Power" includes: Overhead Medicine Ball Throw, Medicine Ball Throw with Forehand Closed Stance, Medicine Ball Throw with Backhand Closed Stance.

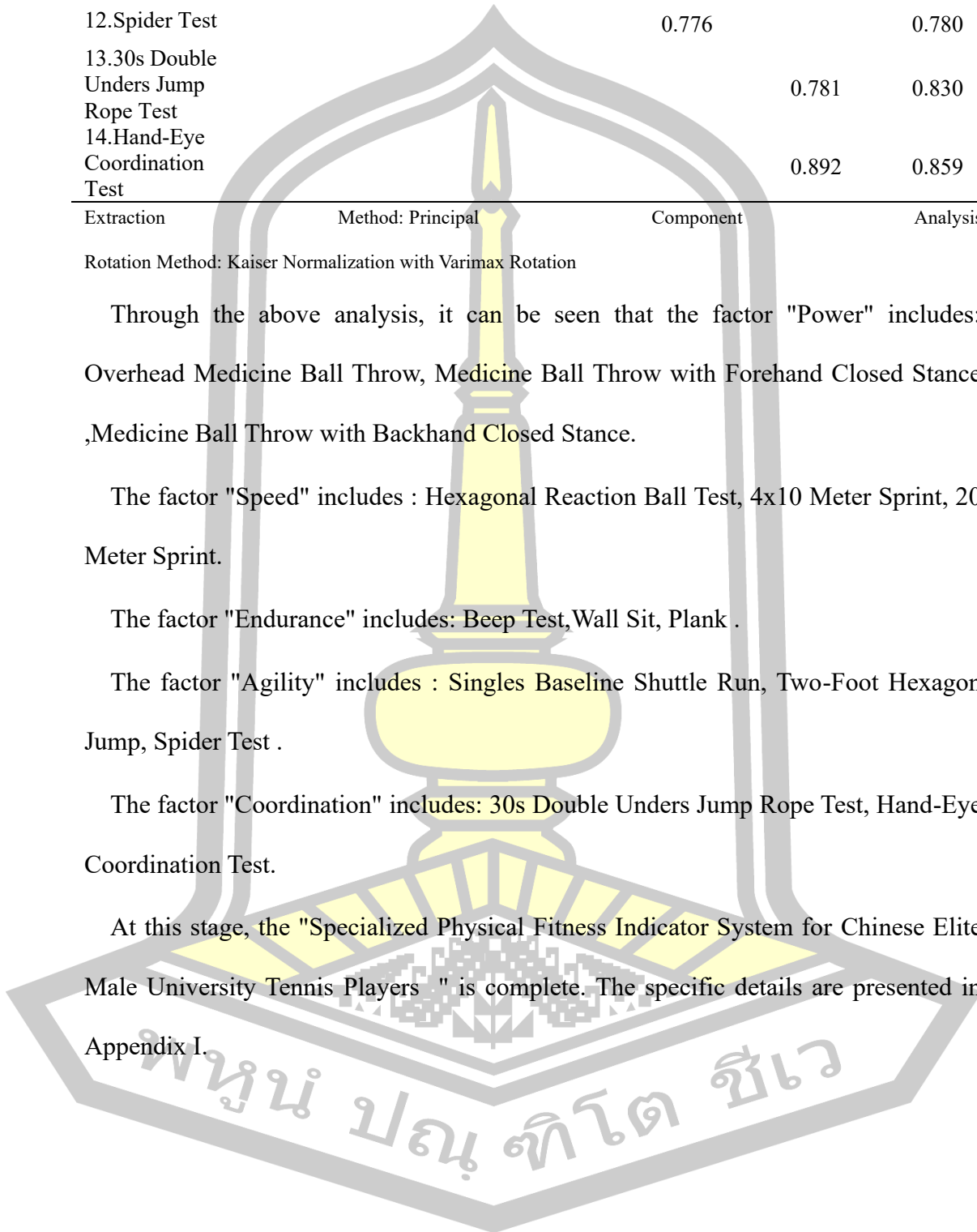
The factor "Speed" includes : Hexagonal Reaction Ball Test, 4x10 Meter Sprint, 20 Meter Sprint.

The factor "Endurance" includes: Beep Test, Wall Sit, Plank .

The factor "Agility" includes : Singles Baseline Shuttle Run, Two-Foot Hexagon Jump, Spider Test .

The factor "Coordination" includes: 30s Double Unders Jump Rope Test, Hand-Eye Coordination Test.

At this stage, the "Specialized Physical Fitness Indicator System for Chinese Elite Male University Tennis Players " is complete. The specific details are presented in Appendix I.



4.4 Determination of Weights

Since a single weight determination method has inherent limitations, combining methods can comprehensively account for various data characteristics, enabling the final evaluation results to more accurately reflect actual conditions. Therefore, this study employs a combination of Principal Component Analysis (PCA) and the Entropy Weight Method. This approach removes redundant information among variables while leveraging the information contained within the data itself to determine weights. This allows for a more effective quantification of physical fitness for male tennis athletes and optimally utilizes the strengths of both methods. The detailed procedure is as follows:

1. Determining the Weights of Primary Indicators Using Principal Component Analysis

The weight of each primary indicator is calculated by dividing the percentage variance of each rotated factor by the cumulative percentage variance of all five factors:

$$W_i = V_i / \sum V_i \quad (1)$$

Where W_i represents the weight of the primary indicator, and V_i is the percentage variance of the factor after rotation.

2. Determining the Weights of Indicators Within Each Factor Using the Entropy Weight Method.

For each factor, the weights of the corresponding indicators are calculated using the entropy weight method: W_{ij} .

Where W_{ij} represents the weight of the jj -th indicator within the ii -th factor.

3. Calculating Composite Weights

The composite weight CW_{ij} for each indicator is calculated by multiplying the weight of each indicator within a factor by the weight of the factor:

$$CW_{ij} = W_i \times W_{ij} \quad (2)$$

Where CW_{ij} represents the composite weight of the j -th indicator within the i -th factor for overall physical fitness.

4. Constructing the Comprehensive Physical Fitness Model for Male Tennis Athletes

Based on the above weights, the comprehensive physical fitness model for male tennis athletes is formulated as:

$$P = X_{ij} \times CW_{ij} \quad (3)$$

Where P represents the comprehensive physical fitness score of a male tennis athlete, and X_{ij} denotes the score of a given athlete on the j indicator under the i factor.

For ease of statistical analysis, this study assigns numerical codes to each secondary indicator as follows:

Category A (Medicine Ball Throws):

- A1: Overhead Medicine Ball Throw,
- A2: Medicine Ball Throw with Forehand Closed Stance,
- A3: Medicine Ball Throw with Backhand Closed Stance.

Category B (Speed and Agility Tests):

- B1: Hexagonal Reaction Ball Test,
- B2: 4×10 Meter Sprint,
- B3: 20-Meter Sprint.

Category C (Endurance and Core Strength Tests):

- C1: Beep Test,
- C2: Wall Sit,
- C3: Plank .

Category D (Agility and Coordination Tests):

D1: Singles Baseline Shuttle Run,

D2: Two-Foot Hexagon Jump,

D3: Spider Test.

Category E (Coordination and Skill-Based Tests):

E1: 30-Second Double Unders Jump Rope Test,

E2: Hand-Eye Coordination Test.

Table 44 Combination Weight Table

	First-Level Indicator Weight	Second-Level Indicator Weigh	Combined Weight	
Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players	Power	A1	0.2803	0.0579
		A2	0.3750	0.0774
		A3	0.3447	0.0712
	Speed	B1	0.4388	0.0895
		B2	0.2350	0.0480
		B3	0.3262	0.0666
	Endurance	C1	0.2356	0.0472
		C2	0.4280	0.0857
		C3	0.3364	0.0673
	Agility	D1	0.3267	0.0752
		D2	0.2823	0.0650
		D3	0.3910	0.0900
	Coordination	E1	0.5433	0.0864
		E2	0.4567	0.0726

Therefore, the comprehensive physical fitness evaluation model for male tennis players is as follows:

$$P = 0.0579X_{11} + 0.0774X_{12} + 0.0712X_{13} + 0.0895X_{21} + 0.0480X_{22} + 0.0666X_{23} + 0.0472X_{31} + 0.0857X_{32} + 0.0673X_{33} + 0.0752X_{41} + 0.0650X_{42} + 0.0900X_{43} + 0.0864X_{51} + 0.0726X_{52} \quad (4)$$

4.5 Development of Individual Performance Evaluation Standards

An evaluation scale refers to the rules for converting measured values (raw scores) into standardized scores. These rules can be represented mathematically or presented in the form of score conversion tables or grading charts. This study aims to establish a scientific, comprehensive, and precise evaluation standard for single indicators. Based

on the characteristics of different types of tests, the scoring standards for single indicators were developed using the following methods:

1. Progressive Scoring Method: The progressive scoring method is suitable for indicators that are sensitive to improvements in performance and exhibit linear characteristics of progress.
2. Percentile Method: The percentile method is applicable to indicators with complex data distributions or significant individual differences. This method classifies scores based on the relative position of an individual's performance within the group, allowing each performance level to intuitively reflect the relative ranking of individual scores.

4.5.1 Normality Test

This study first conducted normality tests on the raw data of measurable types.

Table 45 Normality Test Results

Item	Sample Size	Mean	Standard Deviation	Skewness	Kurtosis	Kolmogorov-Smirnov	
						D	P Value
A1	53	9.372	1.147	0.257	-0.618	0.078	0.591
A2	53	9.931	1.600	0.418	-0.102	0.073	0.678
A3	53	9.595	1.446	0.629	-0.055	0.108	0.126
B1	53	0.918	0.228	0.116	-1.193	0.097	0.248
B2	53	9.515	0.580	0.350	-0.303	0.079	0.567
B3	53	3.358	0.222	-0.052	-0.686	0.080	0.532
C1	53	59.566	17.222	0.922	0.257	0.158	0.002**
C2	53	3.111	2.486	1.177	0.351	0.263	0.000**
C3	53	2.471	1.573	1.450	1.193	0.243	0.000**
D1	53	4.701	0.327	-0.370	-0.598	0.088	0.395
D2	53	12.385	1.608	-0.028	-0.758	0.090	0.346
D3	53	17.053	0.822	-0.699	-0.369	0.153	0.003**

* p<0.05 ** p<0.01

Normality testing is a fundamental step in quantitative data analysis to determine whether a dataset follows a normal distribution. The selection of the appropriate test

depends on the sample size: for small samples ($n < 50$), the Shapiro-Wilk (S-W) test is recommended, whereas for large samples ($n > 50$), the Kolmogorov-Smirnov (K-S) test is more appropriate (The SPSSAU project . 2025; Drezner, Z., & Zerom, O. T. D. 2010 ; Kline, R. B. 2011 ; Lilliefors, H. 1967).

① Assessing Statistical Significance: The test result should be examined for statistical significance, typically using p-values. If $p < 0.05$ or $p < 0.01$, the deviation from normality is considered statistically significant.

② Interpreting Significant Results: If the test result is significant, it indicates that the data do not follow a normal distribution. In such cases, if comparisons between different groups are required, non-parametric tests should be considered as an alternative analytical approach.

③ Interpreting Non-Significant Results: If $p > 0.05$, the dataset can be considered to have a normal distribution, allowing the use of parametric statistical methods for further analysis.

④ Practical Considerations for Normality Testing: Due to the stringent requirements of normality tests, achieving perfect normality is often challenging. In practical applications, if the absolute kurtosis value is less than 10 and the absolute skewness value is less than 3, the dataset can be considered approximately normal, even if it does not perfectly meet normality criteria.

⑤ Final Evaluation and Conclusion: Based on the test results, a comprehensive assessment should be conducted to determine whether parametric or non-parametric methods are suitable for subsequent analyses.

Based on the above analysis, it can be concluded that the 12 indicators are acceptable as approximately normally distributed. Therefore, these 12 indicators were used to establish scoring scales based on progressive scoring tables. The units for E1 and E2 are counts, which belong to categorical data; thus, scoring tables for these were determined using the percentile method.

4.5.2 Steps for Progressive Scoring Evaluation

Based on the previous analysis, A1, A2, A3, B1, B2, B3, C1, C2, C3, D1, D2, and D3 used the progressive scoring method to create individual scoring scales. The specific steps are as follows:

- (1) Perform normality tests on the raw data and calculate the mean (\bar{X}) and standard deviation (S).
- (2) Determine the full-score point and pass-score point for the progressive scoring scale, along with their corresponding raw scores. The corresponding raw observed values can be determined by adding or subtracting the mean with the standard deviation corresponding to excellent and pass rates.
- (3) Set the probability unit (S) for full scores and passing scores based on practical conditions. For instance, if 5% of the scores achieve full marks, the probability unit is 1.64S. Similarly, if the failure rate is 5%, the probability unit for the pass score is also 1.64S.
- (4) High-priority indicators are evaluated using Formula (5) to calculate the full-score points and passing-score points for the D values.

$$D = 5 + u = 5 + \frac{x_i - \bar{x}}{S} \quad (5)$$

For low-priority indicators, the full-score points and passing-score points are calculated using Formula (6).

$$D = 5 + u = 5 - \frac{x_i - \bar{x}}{S} \quad (6)$$

- (5) Establish the progressive scoring equation:

$$\begin{cases} y_p = kD_p^2 - Z \\ y_f = kD_f^2 - Z \end{cases} \quad (7)$$

Where y_p represents the passing score, and D_p is the corresponding D value for the passing score. Similarly, y_f denotes the full score, and D_f is the corresponding D value for the full score.

The values of k and Z are determined by solving the above system of equations.

- (6) Calculate the D values for each item score based on the formula $y = kD^2 - Z$.

$$D = \sqrt{\frac{y_i + Z}{k}} \quad (8)$$

- (7) Based on formulas (9) and (10), the actual observed values corresponding to the progressive scoring values for high-priority and low-priority indicator items were calculated.

$$x_i = (D - 5) \times S + \bar{x} \quad (9)$$

$$x_i = (5 - D) \times S + \bar{x} \quad (10)$$

4.5.2.1 High-Priority Indicator Evaluation Table

According to the steps outlined above, the evaluation table for each high-priority indicator item was organized as follows:

Table 46 High-Priority Indicator Evaluation Table

	A1	A2	A3	C1	C2	C3
100	11.25	12.56	11.97	87.81	5.36	5.03
95	10.89	12.05	11.51	82.36	5.07	4.39
90	10.51	11.52	11.03	76.63	4.37	4.14
85	10.10	10.95	10.52	70.56	4.06	3.48
80	9.67	10.35	9.97	64.08	3.33	3.21
75	9.21	9.70	9.39	57.10	2.60	2.52
70	8.70	8.99	8.75	49.49	2.24	2.21
65	8.14	8.21	8.04	41.02	1.47	1.48
60	7.49	7.31	7.22	31.32	1.07	1.13
55	6.71	6.22	6.24	19.63	0.25	0.34
50	5.65	4.74	4.91			
0	<4.55	<3.20	<3.51	<3.73	<0.07	<0.08

4.5.2.2 Evaluation Table for Low-Priority Indicators

Based on the steps outlined above, the evaluation tables for each low-priority indicator were developed as follows:

Table 47 Evaluation Table for Low-Priority Indicators

	B1	B2	B3	D1	D2	D3
100	0.54	8.56	2.99	4.16	8.37	14.59
95	0.67	8.89	3.12	4.35	9.43	15.31
90	0.78	9.18	3.23	4.51	10.30	15.86
85	0.88	9.43	3.33	4.65	11.07	16.32
80	0.98	9.67	3.42	4.79	11.75	16.72
75	1.06	9.89	3.50	4.91	12.38	17.09
70	1.14	10.09	3.58	5.02	12.96	17.42
65	1.22	10.28	3.65	5.13	13.50	17.74
60	1.29	10.47	3.72	5.24	14.01	18.03
55	1.36	10.64	3.79	5.34	14.50	18.31
50	1.43	10.81	3.85	5.43	14.97	18.57
45	1.49	10.97	3.91	5.52	15.41	18.82
40	1.55	11.13	3.97	5.61	15.84	19.06
35	1.61	11.28	4.03	5.69	16.25	19.30
30	1.67	11.42	4.09	5.78	16.65	19.52
25	1.72	11.56	4.14	5.86	17.04	19.74
20	1.78	11.70	4.19	5.93	17.41	19.95

15	1.83	11.84	4.25	6.01	17.78	20.15
10	1.88	11.97	4.30	6.08	18.13	20.35
5	1.93	12.09	4.34	6.15	18.48	20.54
0	1.98	12.22	4.39	6.22	18.82	20.73

4.5.3 Steps for Percentile Method Evaluation

Based on the above analysis, E1 and E2 were scored using the percentile method to develop individual scoring scales. The specific steps are as follows:

- (1) Create a Frequency Distribution Table
- (2) Use the following formula (11) to compute the actual observed values for each percentile:

$$P_x = L_x + \frac{i}{F_x} \left(\frac{X \cdot N}{100} - C_x \right) \quad (11)$$

In the formula:

P_x represents the actual observed value corresponding to the X -th percentile;

L_x is the lower limit of the group where the X -th percentile is located;

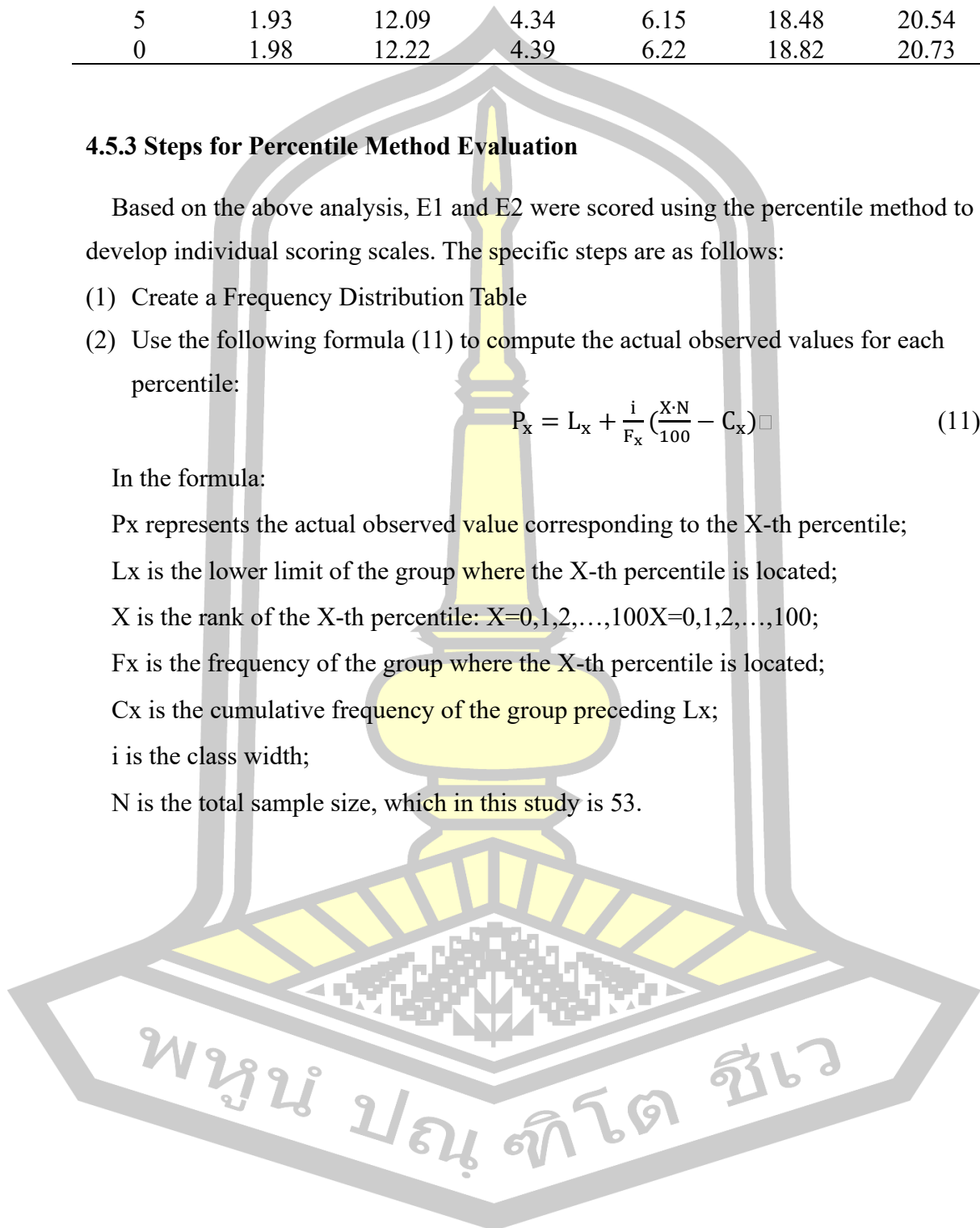
X is the rank of the X -th percentile: $X=0,1,2,\dots,100$

F_x is the frequency of the group where the X -th percentile is located;

C_x is the cumulative frequency of the group preceding L_x ;

i is the class width;

N is the total sample size, which in this study is 53.



4.5.3.1 Percentile Value Scale

Based on the steps outlined above, the evaluation scale for the percentile method was organized as follows:

Table 48 Percentile Value Scale

Score	E1	E2	Score	E1	E2
100	60	33	45	38	
95	57	32	40	36	24
90	55	31	35	35	
85	54	30	30	31	23
80	52	29	25	27	22
75	51	28	20	24	21
70	47	27	15	22	20
65	44	26	10	20	19
60	43		5		18
55		25	0	19	16
50	40				

4.6 Establishment of the Comprehensive Evaluation Standards

To present the physical fitness of male tennis players in a more intuitive, comprehensive, objective, and systematic manner, a comprehensive scoring system for physical fitness was developed. After determining the evaluation scales for each individual item, the comprehensive physical fitness scores of 53 tennis players were calculated using Formula (4). These scores were then subjected to a normality test. The results indicated that the scores followed a normal distribution.

Based on these results, the deviation method was employed to classify the scores into five levels: "Excellent," "Good," "Average," "Pass," and "Fail." The specific classification results are as follows:

Table 49 Normality Test Results for Comprehensive Physical Fitness Scores

Name	Sample Size n	Mean	Standard Deviation	Kolmogorov-Smirnov	
				D value	P value
Comprehensive Physical Fitness Score	53	73.326	5.334	0.092	0.313

As shown in the table above, the sample mean is 73.326, with a standard deviation of 5.334. The p-value of the K-S test is 0.313 (>0.05), indicating that the data

conforms to a normal distribution. Therefore, the deviation method is used to classify the physical fitness score levels.

The deviation method is typically applicable to indicators with relatively uniform data distribution and is used to measure the difference between individual performance and the group mean. By analyzing the deviation of individual scores from the mean score, this method enables a relative evaluation of athletes at different performance levels, reflecting their position within the group. Chan, W. S. (2014).

Table 50 Theoretical Percentage Table of Evaluation Levels

Evaluation Level	Deviation Standard	%
Excellent	$\bar{X} + 1.28S$	10%
Good	$\bar{X} + 0.67S \sim \bar{X} + 1.28S$	15%
Average	$\bar{X} \pm 0.67S$	50%
Pass	$\bar{X} - 0.67S \sim \bar{X} - 1.28S$	15%
Fail	$\bar{X} - 1.28S$	10%

Based on the deviation method, the grading standards for this study were established, and the numerical boundary points for each grade were calculated. The specific details are presented in the following table:

Table 51 Comprehensive Physical Fitness Evaluation Grading Standards

	Excellent	Good	Average	Pass	Fail
%	>90%	75%-90%	25%-75%	10%-25%	<10%
Score	>80.15	80.14-76.90	76.89-69.75	69.74-66.50	<66.50

Based on the evaluation scale and the determination of the evaluation grade, a comprehensive and objective assessment of the physical fitness of male professional tennis players can be conducted. This, in turn, assists tennis coaches in formulating more detailed and targeted training plans for the physical fitness of tennis players, thereby enhancing their overall performance.

PHASE 3.

4.7 Verification of the Comprehensive Evaluation Standard through re-substitution validation (R-testing)

To ensure the authenticity and reliability of the evaluation standard, a re-testing process of the comprehensive evaluation standard was conducted using a sampling survey method. On December 16 and December 17, 2024, 30 tennis players were randomly selected from Xi'an Physical Education University and Shanghai University of Sport for testing. The sample included 15 second-level athletes, and 15 first-level athletes. The final comprehensive scores were quantified, as shown in Table 52.

Table 52 Re-test Results of Comprehensive Evaluation

Serial Number	Age	Competitive Level	Comprehensive Score	Comprehensive Grade
1	20	2	72	Average
2	20	2	77	Good
3	21	2	71	Average
4	19	2	72	Average
5	20	2	73	Average
6	18	2	72	Average
7	19	2	70	Average
8	18	2	70	Average
9	19	2	65	Pass
10	19	2	73	Average
11	21	2	77	Good
12	19	2	71	Average
13	20	2	76	Good
14	29	2	74	Average
15	19	2	76	Good
16	20	1	82	Excellent
17	20	1	89	Excellent
18	22	1	90	Excellent
19	23	1	84	Excellent
20	20	1	85	Excellent
21	21	1	91	Excellent
22	19	1	90	Excellent
23	20	1	89	Excellent
24	22	1	86	Excellent
25	21	1	90	Excellent
26	20	1	91	Excellent
27	20	1	89	Excellent
28	21	1	88	Excellent
29	22	1	89	Excellent
30	19	1	85	Excellent

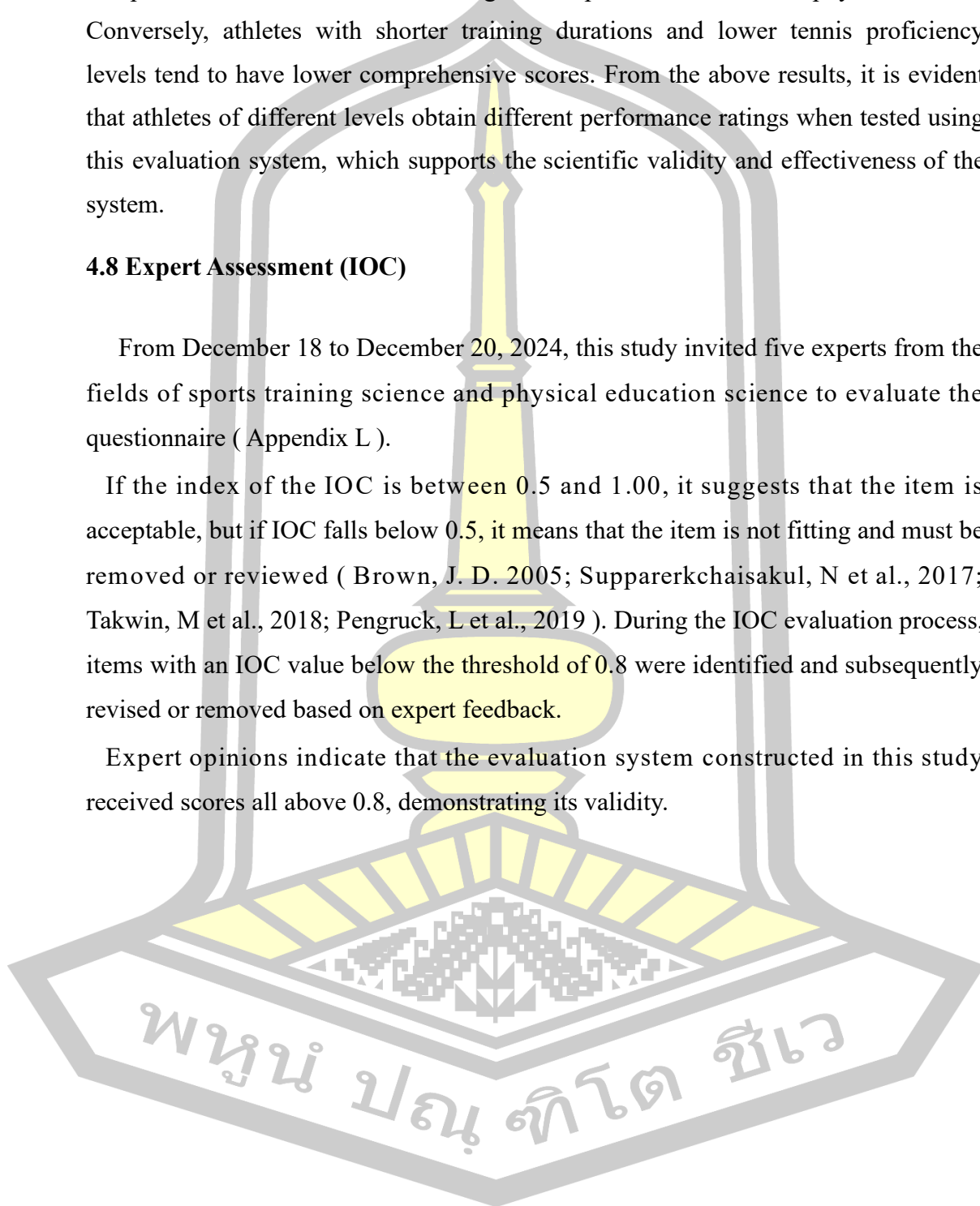
From the results of the re-testing, it can be observed that athletes with higher competitive levels tend to achieve higher comprehensive scores in physical fitness. Conversely, athletes with shorter training durations and lower tennis proficiency levels tend to have lower comprehensive scores. From the above results, it is evident that athletes of different levels obtain different performance ratings when tested using this evaluation system, which supports the scientific validity and effectiveness of the system.

4.8 Expert Assessment (IOC)

From December 18 to December 20, 2024, this study invited five experts from the fields of sports training science and physical education science to evaluate the questionnaire (Appendix L).

If the index of the IOC is between 0.5 and 1.00, it suggests that the item is acceptable, but if IOC falls below 0.5, it means that the item is not fitting and must be removed or reviewed (Brown, J. D. 2005; Supparekchaisakul, N et al., 2017; Takwin, M et al., 2018; Pengruck, L et al., 2019). During the IOC evaluation process, items with an IOC value below the threshold of 0.8 were identified and subsequently revised or removed based on expert feedback.

Expert opinions indicate that the evaluation system constructed in this study received scores all above 0.8, demonstrating its validity.



CHAPTER V

CONCLUSION, DISCUSSION, AND SUGGESTIONS

Introduction

To comprehensively and scientifically assess the specialized physical fitness for Chinese Elite Male University Tennis Players and to provide a solid and precise scientific foundation for the training of male tennis athletes, this study is dedicated to constructing a specialized physical fitness evaluation system that is both comprehensive and highly targeted. The development of this system is not only a deepening of current tennis training theories and practices but also an essential response to the individualized training needs of athletes. Previous studies have demonstrated that in tennis, various components of physical fitness play an important role (Lambrich et al., 2022). A scientifically sound and well-structured evaluation system can holistically and multidimensionally reflect an athlete's overall physical fitness profile, thereby providing clear guidance and a feedback mechanism for the formulation and adjustment of training plans.

As a sport that integrates speed, strength, endurance, agility, and coordination, tennis imposes specific physical demands on athletes. However, there is currently a lack of systematic research on a scientific evaluation system tailored to the specialized physical fitness of Chinese Elite Male University Tennis Players, and quantitative standards remain scarce. This deficiency inevitably limits the optimization of training effectiveness and the full realization of athletes' potential.

In response to this gap, this study employs a combination of research methodologies, including a literature review to synthesize previous findings, the Delphi method to integrate expert insights from the field, and mathematical and statistical analysis to meticulously construct a specialized physical fitness evaluation system for Chinese Elite Male University Tennis Players. This system not only encompasses critical dimensions such as strength, speed, endurance, agility, and coordination but also ensures comprehensiveness and accuracy through refined test indicator design, weight allocation, the establishment of individual evaluation

standards, and the formulation of a comprehensive evaluation standard. This rigorous process reflects a commitment to scientific precision while demonstrating a profound understanding of the specialized characteristics of tennis as a sport.

This chapter conducts an in-depth discussion based on the research findings corresponding to the three objectives of this study and concludes with a summary of the research conclusions.

1. Conclusion

Phase 1: Preparation

1. Preliminary Screening of Indicators

The first objective of this study is to investigate the specialized physical fitness indicators of Chinese Elite Male University Tennis Players .

Through an extensive review of the literature, this study systematically compiled existing measurement and evaluation indicators related to specialized physical fitness in tennis. The identified primary and secondary indicators of specialized physical fitness for tennis players were organized into the questionnaire titled "Expert Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players ."

To ensure the alignment of the "Expert Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players " with the research objectives, five experts were selected to conduct an Item-Objective Congruence (IOC) index test. During the IOC evaluation process, items with an IOC value below the threshold of 0.6 were identified and subsequently revised or removed based on expert feedback. After refinement, all remaining items achieved IOC values above the specified threshold, demonstrating acceptable content validity for the measurement tool. The validation results confirmed the alignment between the items and research objectives.

Based on the feedback from IOC experts, the "Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players. Round 1" was developed (Appendix A).

2. Establishment of the Preliminary Indicator System Using the Delphi Method

(1) First Round of the Delphi Expert Questionnaire

The "Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players . Round 1" was distributed to experts, and the results of the first round were analyzed. The Kendall's coefficient of concordance for primary indicators was 0.674, while the coefficient for secondary indicators was 0.578, indicating a relatively high level of agreement among experts.

The threshold method was applied to screen the items, resulting in the identification of five primary indicators: Power, Speed, Endurance, Agility, Coordination.

Fifteen secondary indicators were finalized: 1. Overhead Medicine Ball Throw, 2. Medicine Ball Throw with Forehand Closed Stance, 3. Medicine Ball Throw with Backhand Closed Stance, 4. Hexagonal Reaction Ball Test, 5. 4×10 Meter Sprint, 6. 20-Meter Sprint, 7. Beep Test, 8. Plank, 9. Wall Sit, 10. Singles Sideline Shuttle Run, 11. Hexagonal Jump Test, 12. Spider Test, 13. 30s Double Unders Jump Rope Test, 14. Hand-Eye Coordination Test, 15. Single-Leg Stand with Eyes Closed.

Based on the results, a revised version of the questionnaire, "Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players . Round 2," was developed.

(2) Second Round of the Delphi Expert Questionnaire

The "Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players . Round 2" was distributed, and statistical analysis of the second round of responses was conducted. The Kendall's coefficient of concordance for primary indicators increased to 0.684, and the coefficient for secondary indicators rose to 0.603, indicating a stronger consensus among experts.

The threshold method was again applied to screen the items, and it was found that all experts agreed with the results from the first round, signifying the conclusion of the Delphi rounds.

After analyzing the results from both rounds of Delphi expert questionnaires, the study successfully established the "Preliminary Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players ."

Phase 2: Establish an Evaluation System

Construction of the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players

The second objective of this study is to construct a specialized physical fitness evaluation system for Chinese Elite Male University Tennis Players .

1. Athlete Recruitment and Testing Based on the Preliminary Indicator System

Based on the "Preliminary Indicator System for Specialized Physical Fitness of Chinese Elite Male University Tennis Players ," athletes were recruited for experimental testing.

Between November 9 and December 9, 2024, Chinese Elite Male University Tennis Players were selected from six universities in Xi'an and Shanghai to participate in the testing.

2. Statistical Analysis, Reliability Testing (Cronbach's Alpha), and Validity Testing (Exploratory Factor Analysis) of the Athlete Performance Data

(1) Reliability Analysis

The overall Cronbach's Alpha for the 15 indicators was 0.856, exceeding the recommended threshold of 0.7, indicating a high level of data reliability. However, an evaluation of Corrected Item-Total Correlation (CITC) and Alpha if Item Deleted revealed that:

The CITC value for Indicator 15 (Blindfolded Single-Leg Stance) was $-0.066 < 0.3$.

The Alpha if Item Deleted for Indicator 15 was $0.876 > 0.856$, suggesting that removing this indicator would improve overall reliability.

Thus, Indicator 15 (Blindfolded Single-Leg Stance) was removed, and a new reliability analysis was conducted.

Following the removal of Indicator 15, the recalculated Cronbach's Alpha increased to $0.876 > 0.856$, with all CITC values exceeding 0.3, and Alpha if Item Deleted values all ≤ 0.876 . This confirmed that the removal of Indicator

15enhanced the overall data reliability. Additionally, the Cronbach's Alpha for each primary indicator exceeded 0.8, further indicating a high level of reliability.

(2) Validity Analysis

To assess the validity of the indicator system, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity were conducted:

KMO value > 0.7 , confirming the suitability of the dataset for factor analysis.

Bartlett's Test of Sphericity p-value < 0.01 , indicating significant correlations among variables.

Exploratory Factor Analysis extracted five factors, with the cumulative variance explained after factor rotation reaching 80.105%, exceeding the 60% threshold, demonstrating the appropriateness of extracting five factors.

From the rotated component matrix, it was observed that:

Factor Power included : Overhead Medicine Ball Throw, Forehand Closed Stance Medicine Ball Throw, Backhand Closed Stance Medicine Ball Throw.

Factor Speed included : Singles Sideline Shuttle Run, 4×10-Meter Shuttle Run, 20-Meter Sprint.

Factor Endurance included: Beep Test, Plank Test, Wall Sit Test.

Factor Agility included: Hexagonal Reaction Ball Test, Spider Test, Two-Foot Hexagonal Jump.

Factor Coordination included: Double-Under Jump Rope, Hand-Eye Coordination Test.

These factor structures were highly consistent with the initial indicator design, confirming that the indicator system is a valid and reliable tool for assessing the specialized physical fitness of Chinese Elite Male University Tennis Players .

At this stage, the "Specialized Physical Fitness Indicator System for Chinese Elite Male University Tennis Players " was successfully constructed. Details are provided in Appendix K.

3. Quantitative Evaluation of the Physical Fitness of Chinese Elite Male University Tennis Players Using Principal Component Analysis and the Entropy Weight Method

To quantify the physical fitness of Chinese Elite Male University Tennis Players , this study applied a combination of Principal Component Analysis (PCA) and the Entropy Weight Method (EWM). This approach:

Eliminated redundant information between variables.

Assigned indicator weights based on the intrinsic information content of the data.

4. Formation of the Comprehensive Physical Fitness Evaluation Model for Chinese Elite Male University Tennis Players

Through the above methodologies, this study successfully established the Comprehensive Physical Fitness Evaluation Model for Chinese Elite Male University Tennis Players :

$$P = 0.0579X_{11} + 0.0774X_{12} + 0.0712X_{13} + 0.0895X_{21} + 0.0480X_{22} + 0.0666X_{23} + 0.0472X_{31} + 0.0857X_{32} + 0.0673X_{33} + 0.0752X_{41} + 0.0650X_{42} + 0.0900X_{43} + 0.0864X_{51} + 0.0726X_{52}$$

4. Establishment of Individual Performance Evaluation Standards

First, a normality test was conducted on the raw data for the measurement-type indicators. The results indicated that 13 indicators could be considered approximately normally distributed; therefore, a progressive scoring scale (cumulative grading method) was adopted to establish the scoring system for these 13 indicators.

For E1 ("30-Second Double Unders Jump Rope Test") and E2 ("Hand-Eye Coordination Test"), both of which are measured in counts and classified as count data, a percentile-based scoring scale (percentile method) was used to establish the evaluation criteria.

5. Establishment of the Comprehensive Evaluation Standard

A normality test was conducted on the composite physical fitness scores:

Sample mean: 73.326

Standard deviation: 5.334

K-S test p-value: 0.313 (>0.05)

Since the p-value exceeded 0.05, the data were considered to follow a normal distribution. Therefore, the deviation method was employed to categorize the physical fitness evaluation levels.

At this stage, the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players was successfully established.

Phase 3: Verification

The third objective of this study was to validate the scientific rigor and rationality of the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

1. Re-test

On December 13 and December 15, 2024, a total of 15 randomly selected tennis players from Xi'an Physical Education University and Shanghai University of Sport participated in validation testing. The sample consisted of:

5 students from tennis elective courses (without athlete classification certificates) , 5 athletes classified as National Level 2, 5 athletes classified as National Level 1.

Each participant's performance was quantified using the established Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players.

The results of the back-substitution verification demonstrated that athletes with higher competitive levels attained higher composite physical fitness scores, whereas those with fewer years of training and lower athletic classifications had lower composite scores. This evidence confirmed that the comprehensive evaluation standard exhibits accuracy, rationality, reliability, and applicability.

2. Item-Objective Congruence (IOC) Test

Between December 25 and December 30, 2024, five sports science experts were invited to conduct an Item-Objective Congruence (IOC) index test for the Specialized Physical Fitness Evaluation Standard for Chinese Elite Male University Tennis Players developed in this study.(Appendix.K)

During the IOC evaluation process, items with an IOC value below the threshold of 0.8 were identified and subsequently revised or removed based on expert feedback. After refinement, all remaining items achieved IOC values above the specified threshold, demonstrating acceptable content validity for the measurement tool.

The IOC results confirmed that the Specialized Physical Fitness Evaluation Standard for Chinese Elite Male University Tennis Players developed in this study is scientifically valid and effective.

2. Discussion

1. Literature-Based Discussion

The findings align with and extend prior research on sport-specific fitness evaluation. While earlier studies (Smith et al., 2018; ITF, 2019) emphasized physical fitness as a determinant of tennis performance, existing frameworks predominantly adopted generic metrics (e.g., VO₂ max, vertical jump) lacking sport-specificity. Our system addresses this gap by integrating tennis-relevant indicators such as Overhead Medicine Ball Throw (power transfer during serves) and *5-10-5 Agility Drill (lateral movement efficiency), aligning with Fernández-Fernández et al. (2021), who highlighted the need for task-specific assessments.

Notably, the prioritization of agility (weight: 0.2302) over power or speed diverges from traditional tennis literature (Kovacs, 2007), which often emphasizes explosive strength. This discrepancy may reflect evolving tactical demands in modern tennis, where rapid directional changes and reactive agility (e.g., return-of-serve adjustments) increasingly dictate match outcomes. The study's mixed-methods approach—combining Delphi-derived expert consensus with psychometric validation—resolves methodological criticisms of purely qualitative or isolated quantitative studies (Williams et al., 2020), offering a replicable model for sport-specific evaluation.

2. Benchmark Comparison

Compared to established systems (e.g., ITF's Player Development Framework), this framework introduces three innovations:

Granularity: The 5-domain structure (agility, power, speed, endurance, coordination) surpasses the ITF's broad "movement competency" category by disaggregating coordination as a standalone domain, critical for stroke precision under fatigue.

Weighting Precision: Traditional systems often assign equal weights to fitness components. By contrast, our entropy-weighted PCA revealed agility as the dominant

factor (23.02%), reflecting its disproportionate impact on elite performance in Chinese athletes.

Practicality: Unlike lab-centric protocols (e.g., isokinetic dynamometry), field tests like the 20-Meter Sprint and Plank Test align with resource constraints in Chinese universities, enhancing scalability.

However, the lower emphasis on endurance (20.02%) compared to European models (Reid et al., 2018) suggests cultural differences in training philosophies, possibly due to shorter match formats (e.g., best-of-three sets) dominating Chinese collegiate circuits.

3. Contextualization

The system's design acknowledges unique challenges within China's collegiate tennis landscape:

Talent Pipeline Pressures: With limited professional pathways, universities serve as critical talent incubators. The classification standards enable coaches to identify athletes with "high-agility, moderate-power" profiles suited for singles play versus "balanced endurance-coordination" doubles specialists.

Resource Optimization: In contrast, the sensor systems prevalent in Western academies (Fuchs et al., 2020) offer higher testing precision and can provide more detailed motion data. At present, the testing methods adopted in this system are relatively traditional. While they effectively address the common budget constraints in Chinese universities, in the long run, it is advisable to learn from Western experiences to optimize and upgrade the existing system. Gradually introducing more advanced technological tools for testing will enhance the accuracy and comprehensiveness of evaluations, better adapting to the development needs of modern sports science.

Cultural Relevance: The inclusion of Hexagon Jump (coordination) resonates with traditional Chinese motor skill pedagogy, easing adoption by coaches accustomed to multi-directional drill-based training.

Nevertheless, regional variability in training infrastructure (e.g., coastal vs. inland universities) may necessitate adaptive implementation, warranting future multi-center validation.

4. Theoretical Discussion

The study advances sports science theory through:

Hybrid Methodology: By fusing Delphi (subjective expertise) with EFA/PCA (objective dimensionality reduction), the framework operationalizes the "theory-praxis loop" proposed by Bourdon et al. (2017), bridging the qualitative-quantitative divide in athletic assessment.

Reconceptualizing Agility: The dominance of agility challenges classical periodization models (Issurin, 2016) that prioritize strength-speed periodization, advocating for "agility-centric mesocycles" in tennis training blocks.

Entropy-Weighted Hierarchies: The entropy weight method's integration with PCA introduces a novel approach to resolving multicollinearity in fitness indicators, extending Chen & Zhang's (2019) work on multivariate sports analytics.

Critically, the system's reliability (Cronbach's $\alpha=0.876$; IOC=0.95) validates its utility as a dynamic monitoring tool, supporting the "athlete-centered evaluation" paradigm (Baker et al., 2021). Future research should explore longitudinal correlations between composite scores (e.g., athletes scoring >85th percentile in agility) and tournament outcomes to refine predictive validity.

3. Suggestion

(1) Application and Optimization of the Selected Secondary Indicators

The secondary indicators identified in this study serve not only as testing tools for evaluating specialized physical fitness but also as a scientific reference for coaches to develop training programs. Moving forward, these indicators should be promoted and applied in training practices, and feedback from practical applications should be utilized to further optimize the scoring standards and training strategies.

(2) Integration of Specialized Physical Fitness Evaluation Standards into Training Programs

Coaches should place great emphasis on the development of Chinese Elite Male University Tennis Players . Given the competitive characteristics of tennis, the specialized physical fitness evaluation standards should be integrated into daily training plans, forming a training model centered on scientific assessment. This approach will enable a comprehensive enhancement of athletes' physical fitness and competitive performance. Additionally, specific training for agility, power, and speed should be prioritized to maximize overall athletic performance.

(3) Expanding the Sample Size for a More Representative Evaluation System

This study has preliminarily established a specialized physical fitness evaluation standard for Chinese Elite Male University Tennis Players . However, as the sample population was drawn from only six universities, the study population remains relatively limited, and the findings cannot fully represent the overall level of male university tennis players across China. Future research should expand the sample size to include a broader range of regions and athletes of different ages and competitive levels, in order to establish a more widely applicable and comprehensive evaluation system.

(4) Incorporating Advanced Technology for Precision Analysis

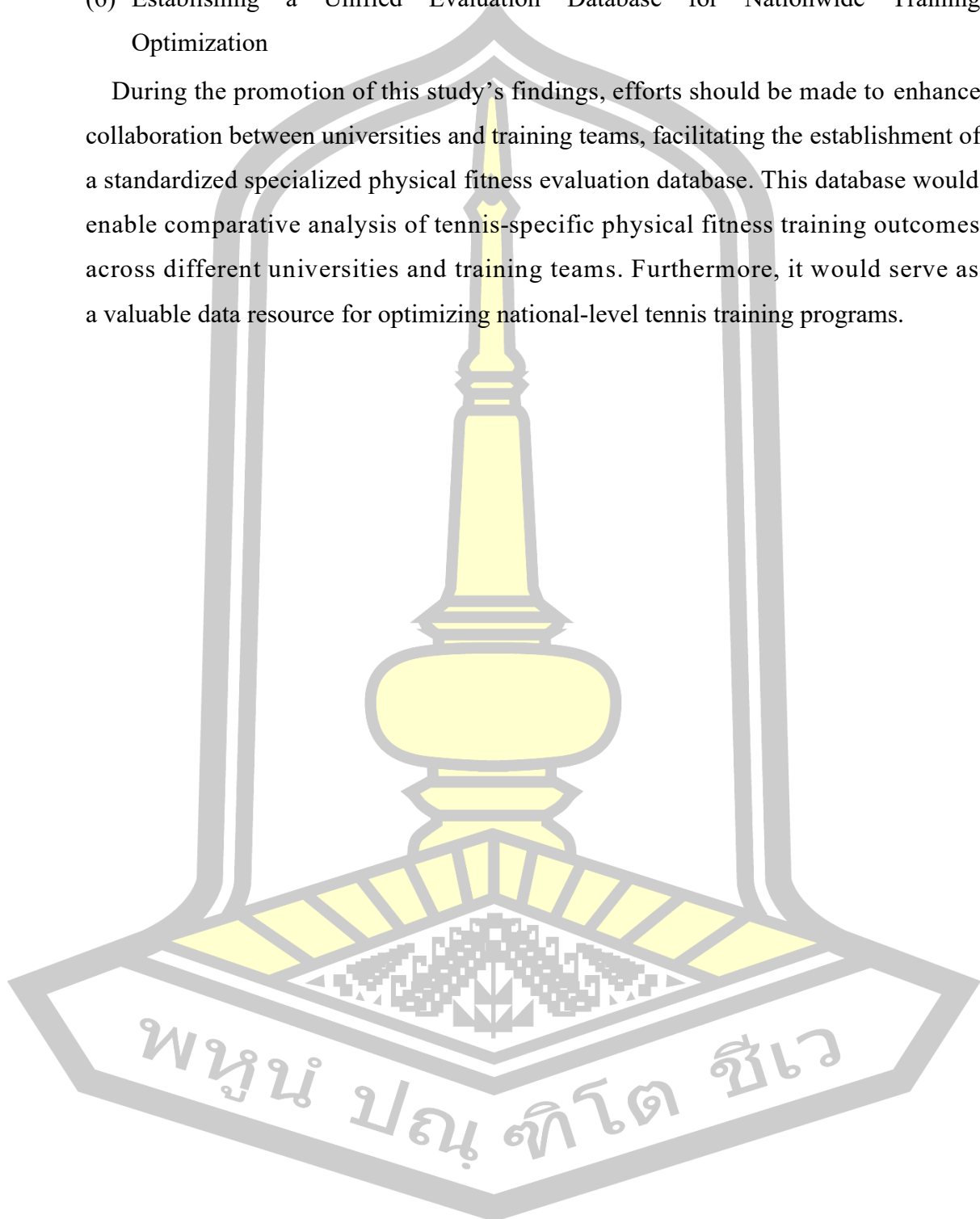
Future research should consider integrating technological tools, such as sports performance monitoring devices and biomechanical analysis tools, to conduct dynamic and refined assessments of specialized physical fitness. Moreover, a correlation analysis between specialized physical fitness evaluation and competitive performance should be conducted to further explore their relationship, providing theoretical support for optimizing specialized training programs.

(5) In-Depth Research and the Establishment of a Female Athlete Evaluation System

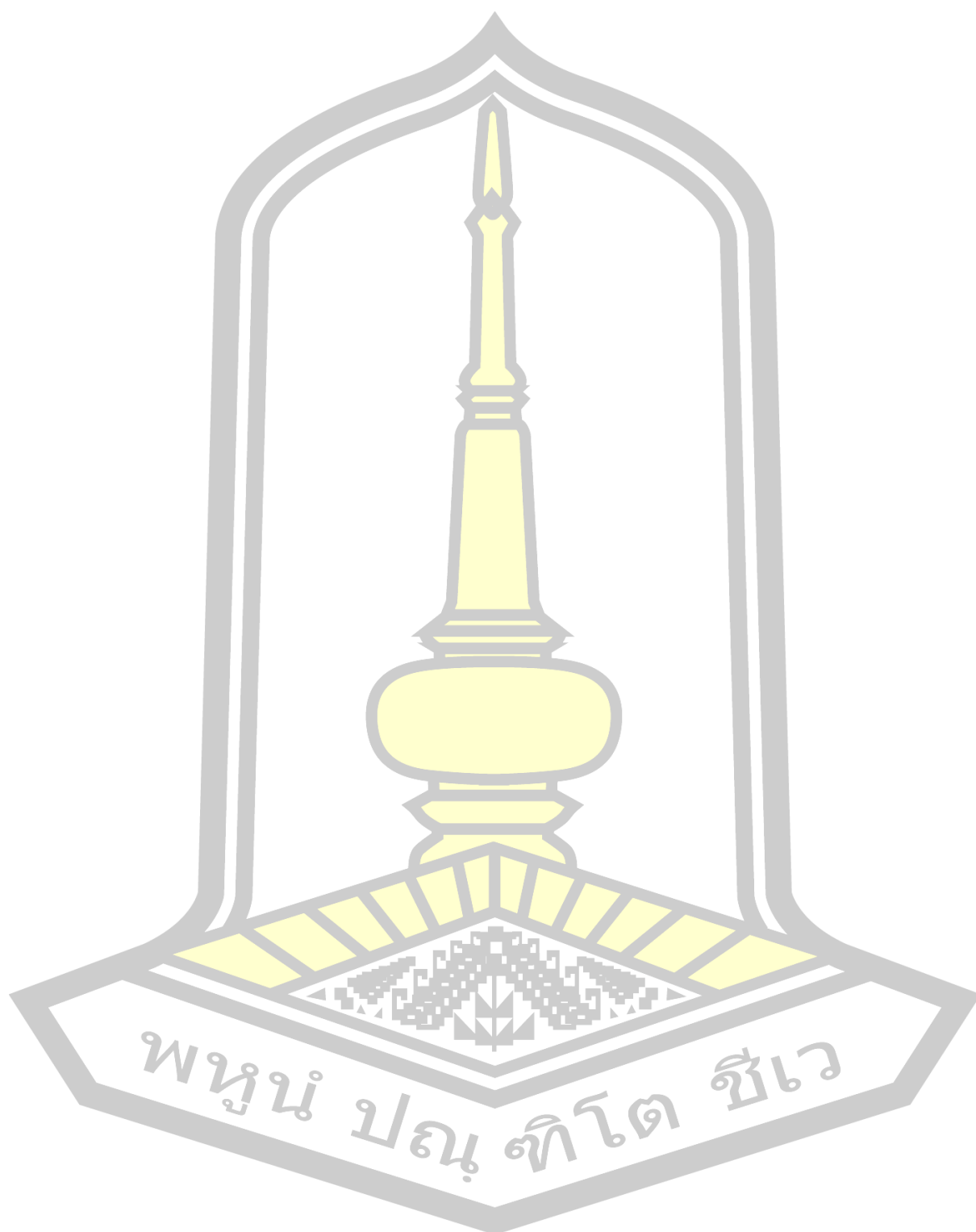
Due to the physiological differences between male and female athletes (Yanovich et al., 2008; Billaut et al., 2003; Kang et al., 2002; Knapik et al., 2001), this study focused exclusively on Chinese Elite Male University Tennis Players. Future research should extend to the female athlete population to develop a corresponding indicator system and evaluation framework. Establishing a comprehensive evaluation system for both male and female tennis players will contribute to a more holistic and scientifically robust assessment framework for the sport.

(6) Establishing a Unified Evaluation Database for Nationwide Training Optimization

During the promotion of this study's findings, efforts should be made to enhance collaboration between universities and training teams, facilitating the establishment of a standardized specialized physical fitness evaluation database. This database would enable comparative analysis of tennis-specific physical fitness training outcomes across different universities and training teams. Furthermore, it would serve as a valuable data resource for optimizing national-level tennis training programs.



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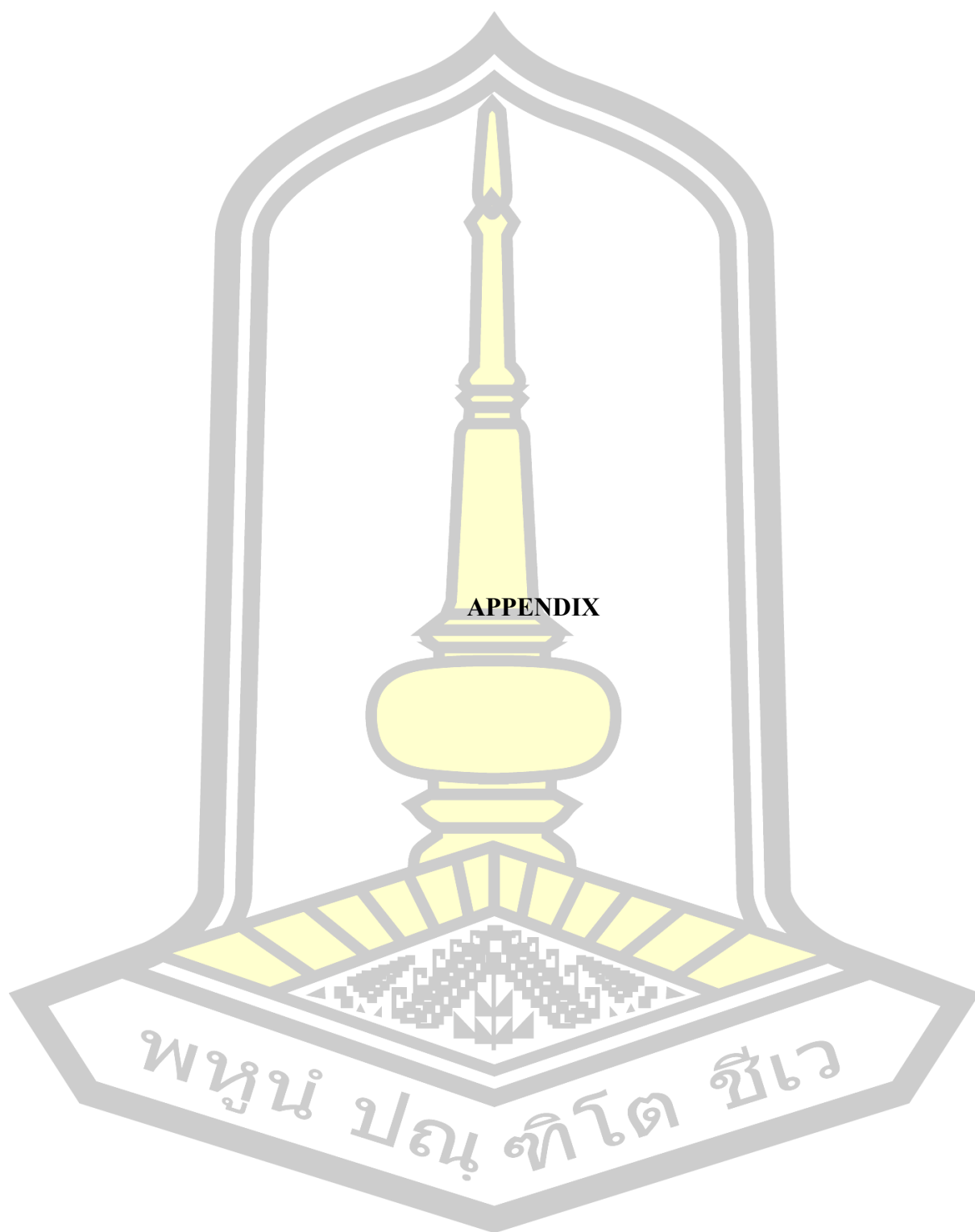
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APPENDIX

พหุ ประจักษ์ วิทยา

Appendix A

Quality assessment of research tools (IOC)

Experts are invited to express their views on the attached questionnaire. Please enter (√) in your comment column and write down your comment, providing some useful suggestions for me to further consider and improve.

Part 1 : Importance Evaluation Table of Primary Indicators in the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

Part 2 : Importance Evaluation Table of Secondary Indicators in the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

Note: A Likert scale was used, and responses were given on a 3-point scale. The scoring criteria are as follows:

-1: Strongly Disagree, 0: Neutral, 1: Agree

Issue	Comment			Suggestion
	+1	0	-1	
Part 1. Evaluation Table for the Importance Degree of Primary Indicators				
1. Strength				
2. Power				
3. Speed				
4. Endurance				
5. Agility				
6. Flexibility				
7. Coordination				
Part 2. Evaluation Table for the Importance Degree of Secondary Indicators				
Strength	1. Pull-Up			
	2. Push-Up			
	3. Standing Long Jump			
	4. Bench Press			
	5. Barbell Clean and Jerk			

	6. Vertical Jump				
power	7. Continuous Inclined Barbell Press				
	8. Overhead Medicine Ball Throw				
	9. Forehand Closed-Stance Medicine Ball Throw				
	10. Backhand Closed-Stance Medicine Ball Throw				
Speed	11. Crossover Change-of-Direction Run				
	12. Hexagonal Reaction Ball				
	13. 4x10-meter Shuttle run				
	13. 28-meter Sprint				
	14. 10-meter Sprint				
	15. 20-meter Sprint				
Endurance	16. 30-meter Sprint				
	17. 400-meter Sprint				
	18. 1500-meter Run				
	19. Beep Test				
	20. Wall squat test				
Agility	21. Plank Exercise				
	23. Singles Baseline Shuttle Run				
	24. Burpee Test				
	25. Hexagon Jump with Both Feet				
Flexibility	26. Spider Test				
	27. Sit and reach				
	28. Horizontal splits				
Coordination	29. Vertical split				
	30. 30s Double-Under Jump Rope Test				
	31. Hand-eye coordination test				
	32. One-leg stance with				

	eyes closed				
	33. Tennis ball throw				
	34. Turn left foot and run forward				
	35. Turn right foot and run forward				

Table 2. Questionnaire Validity Assessment

	Very reasonable	Comparatively reasonable	Generally reasonable	Less reasonable	Very unreasonable
Structural Validity					
Content Validity					
Overall Validity					
Based on your assessment of the questionnaire's validity, please rate according to the following scale: Very reasonable, Comparatively reasonable, Generally reasonable, Less reasonable, Very unreasonable, and mark with a '√'					



Appendix B

The First -Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players

Dear experts:

I am (Lei Lei, PhD candidate, Health and Sport Science, Educational Faculty, Maharakham University) currently conducting research titled “Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using a Mixed-Methods Research Approach”.

The questionnaire consists of 2 parts, totaling 56 items. Completing the questionnaire will take about 10-15 minutes. The researcher will collect the questionnaires either in person or online.

If you feel uncomfortable with any questions, you have the right not to answer those questions. You also have the right to withdraw from this project at any time without prior notice. Refusal to participate in the research or withdrawal from the project will not impact you in any way.

The information in your questionnaire will be kept. Not disclosed to the public on an individual basis, only the overall research results will be reported. Researcher will destroy relevant information after the research is completed. In this research, you will not receive any compensation or any fees.

If you have questions about the research Please contact us at (Lei Lei- Health and Sport Science. Educational Faculty, Maharakham University, Phone: +8619802920104)

If you have not performed as stated or want to know your rights while participating in this research, please contact "Committee on Ethics for Research in Humans Maharakham University Division of Research" Tel. 043-754416, 1758

Sincerely.

Researcher: Lei Lei
Faculty adviser:

1. Expert Information

(1) Gender: Male Female

(2) Age:

 35 years and below 36-50 years 51 years and above

(3) Highest Academic Qualification:

 Bachelor's Master's Doctorate

(4) Academic Title:

 Lecturer Associate Professor Professor

(5) Research Field:

(6) The university or institution where you are employed is:

2. Questionnaire content

This table outlines the significance of the primary, secondary, and tertiary physical fitness indicators specifically for Chinese Elite Male University Tennis Players . I kindly request that you utilize your extensive experience to evaluate the importance of each indicator listed in the attached evaluation form. Please indicate your assessment by placing a “√” in the appropriate box, with the five levels from left to right representing the following scores: Strongly Agree (5 Points), Agree (4 Points), Neutral (3 Points), Disagree (2 Points), Strongly Disagree (1 Point). If you believe it is necessary to add additional indicators, I kindly request that you add them in the revision section at the bottom of the form and assign the corresponding scores. I greatly appreciate your support and expertise, and I sincerely thank you for taking the time to contribute to this research.

Table 1. Evaluation Table for the Importance Degree of Primary Indicators

NO	Primary Indicator	Importance Level				
		Strongly Agree (5 Points)	Agree (4 Points)	Neutral (3 Points)	Disagree (2 Points)	Strongly Disagree (1 Points)
1.	Strength					
2.	Power					
3.	Speed					
4.	Endurance					
5.	Agility					
6.	Flexibility					
7.	Coordinate					

Indicators You Consider Necessary to Add:

Indicators You Consider Necessary to Modify:

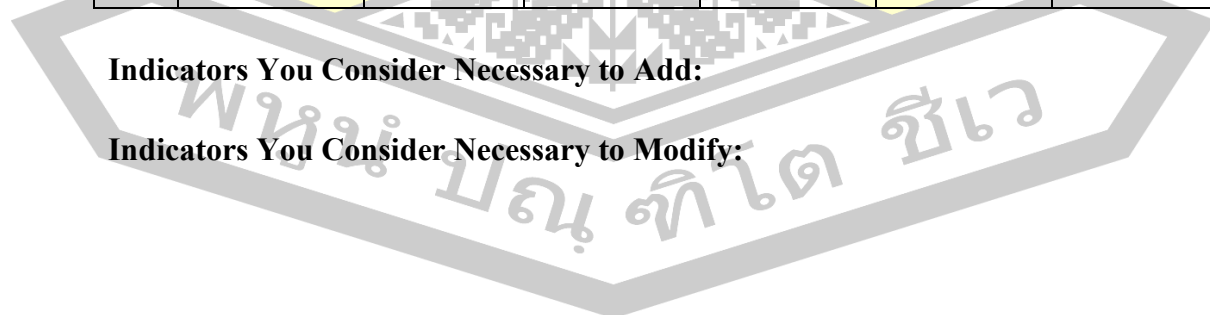


Table 2. Evaluation Table for the Importance Degree of Tertiary Indicators

Primary Indicator	Secondary Indicators	Importance Level				
		Strongly Agree (5 Points)	Agree (4 Points)	Neutral (3 Points)	Disagree (2 Points)	Strongly Disagree (1 Points)
Strength	Pull-ups					
	Push-ups					
	Standing long jump					
	Bench press					
	Barbell clean and jerk					
	Vertical jump					
Power	Overhead medicine ball throw					
	Forehand closed medicine ball throw					
	Backhand standing closed medicine ball throw					
Speed	Crossover Change-of-Direction Run					
	Hexagonal reaction ball					
	4×10-meter sprint					
	28-meter sprint					
	20-meter sprint					

	30-meter sprint					
Endurance	400-meter sprint					
	1500 meter run					
	Beep test					
	Wall sit test					
	Plank					
	Agility	Singles Baseline Shuttle Run				
Burpee test						
Hexagon Jump with Both Feet						
Sit and reach						
Horizontal splits						
Vertical split						
Spider test						
Coordination		30s Double-Under Jump Rope Test				
	Hand-eye coordination test					
	Tennis ball throw					
	One-leg stance with eyes closed					

	Turn left foot and run forward					
	Turn right foot and run forward					

Indicators You Consider Necessary to Add:

Indicators You Consider Necessary to Modify:

Table 3. Questionnaire Validity Assessment

	Very reasonable	Comparatively reasonable	Generally reasonable	Less reasonable	Very unreasonable
Structural Validity					
Content Validity					
Overall Validity					

Based on your assessment of the questionnaire's validity, please rate according to the following scale: Very reasonable, Comparatively reasonable, Generally reasonable, Less reasonable, Very unreasonable, and mark with a '√'

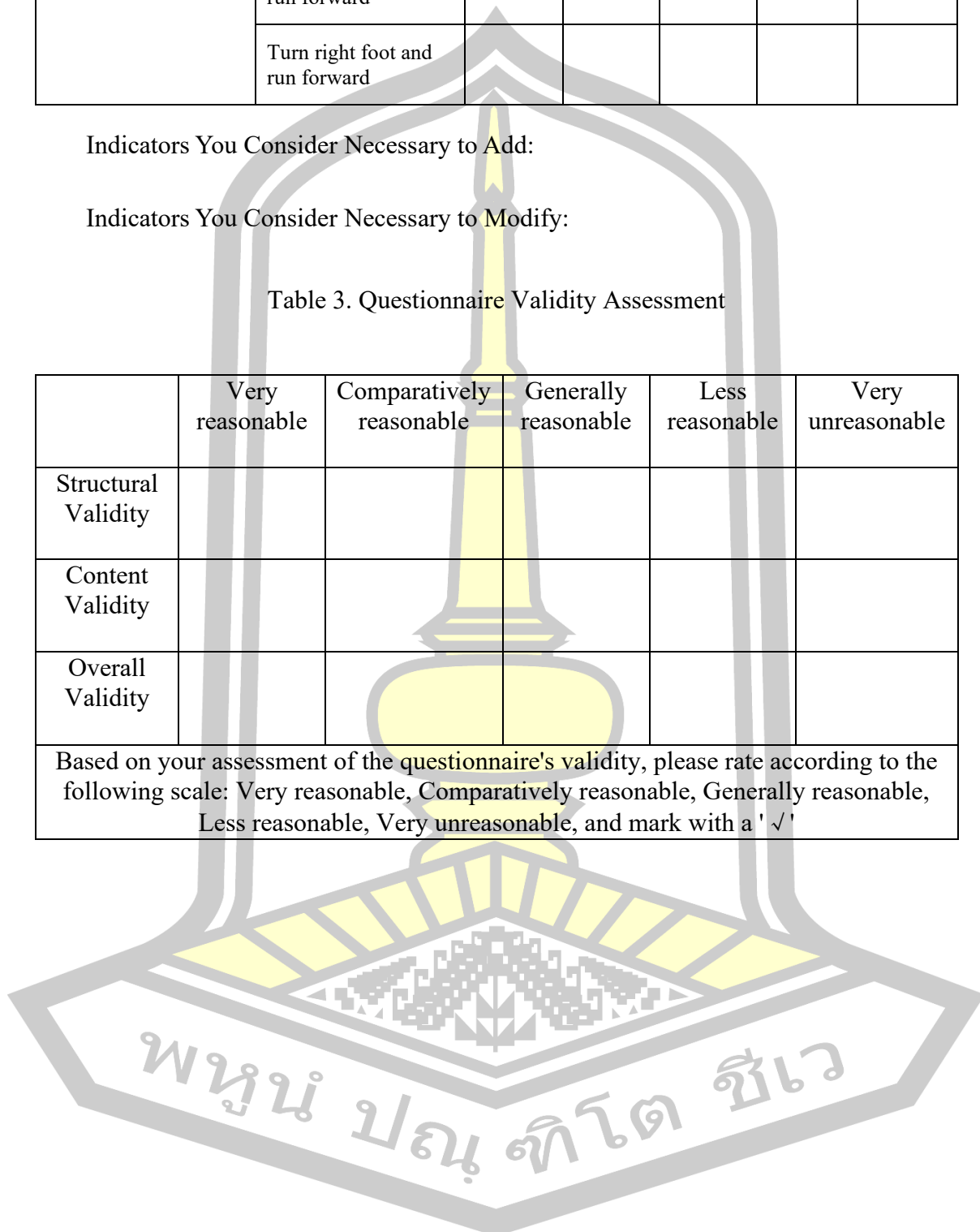


Table 4. Expert Familiarity Survey

Item	Very Familiar 5	Familiar 4	Somewhat Familiar 3	Less Familiar 2	Not Familiar at All 1
Your Level of Familiarity with This Study					
Based on your level of familiarity, please rate according to the following scale: Very Familiar, Familiar, Somewhat Familiar, Less Familiar, Not Familiar at All, and mark with a '√'.					

Table 5. Basis for Problem Judgment

Basis for Judgment	Factors Influencing Judgment		
	Large	Medium	Small
Theoretical Analysis			
Practical Experience			
Reference to Domestic and Foreign Literature			
Intuitive Feeling			
Please select the level of influence (Large, Medium, Small) based on your own judgment and mark with a "√".			

Expert sign:

Thank you again for taking the valuable time out of your busy schedule to fill in this questionnaire

Appendix C

The Second-Round Delphi Questionnaire for Screening Specialized Physical Fitness Indicators of Chinese Elite Male University Tennis Players

Dear experts:

I am (Lei Lei, PhD candidate, Health and Sport Science, Educational Faculty, Maharakham University) currently conducting research titled “Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using a Mixed-Methods Research Approach” .

The questionnaire consists of 2 parts, totaling 38 items. Completing the questionnaire will take about 10-15 minutes. The researcher will collect the questionnaires either in person or online.

If you feel uncomfortable with any questions, you have the right not to answer those questions. You also have the right to withdraw from this project at any time without prior notice. Refusal to participate in the research or withdrawal from the project will not impact you in any way.

The information in your questionnaire will be kept. Not disclosed to the public on an individual basis, only the overall research results will be reported. Researcher will destroy relevant information after the research is completed. In this research, you will not receive any compensation or any fees.

If you have questions about the research Please contact us at (Lei Lei- Health and Sport Science. Educational Faculty, Maharakham University, Phone: +8619802920104)

If you have not performed as stated or want to know your rights while participating in this research, please contact "Committee on Ethics for Research in Humans Maharakham University Division of Research" Tel. 043-754416, 1758

Sincerely.

Researcher: Lei Lei

Faculty adviser:

3. Expert Information

(1) Gender: Male Female

(2) Age:

 35 years and below 36-50 years 51 years and above

(3) Highest Academic Qualification:

 Bachelor's Master's Doctorate

(4) Academic Title:

 Lecturer Associate Professor Professor

(5) Research Field:

(7) The university or institution where you are employed is:

4. Questionnaire content

This table outlines the significance of the primary, secondary, and tertiary physical fitness indicators specifically for Chinese Elite Male University Tennis Players . I kindly request that you utilize your extensive experience to evaluate the importance of each indicator listed in the attached evaluation form. Please indicate your assessment by placing a “√” in the appropriate box, with the five levels from left to right representing the following scores: Strongly Agree (5 Points), Agree (4 Points), Neutral (3 Points), Disagree (2 Points), Strongly Disagree (1 Point). If you believe it is necessary to add additional indicators, I kindly request that you add them in the revision section at the bottom of the form and assign the corresponding scores. I greatly appreciate your support and expertise, and I sincerely thank you for taking the time to contribute to this research.

Table 1. Evaluation Table for the Importance Degree of Primary Indicators

NO	Primary Indicator	Importance Level				
		Strongly Agree (5 Points)	Agree (4 Points)	Neutral (3 Points)	Disagree (2 Points)	Strongly Disagree (1 Points)
8.	Strength					
9.	Power					
10.	Speed					
11.	Endurance					
12.	Agility					
13.	Coordinate					

Indicators You Consider Necessary to Add:

Indicators You Consider Necessary to Modify:

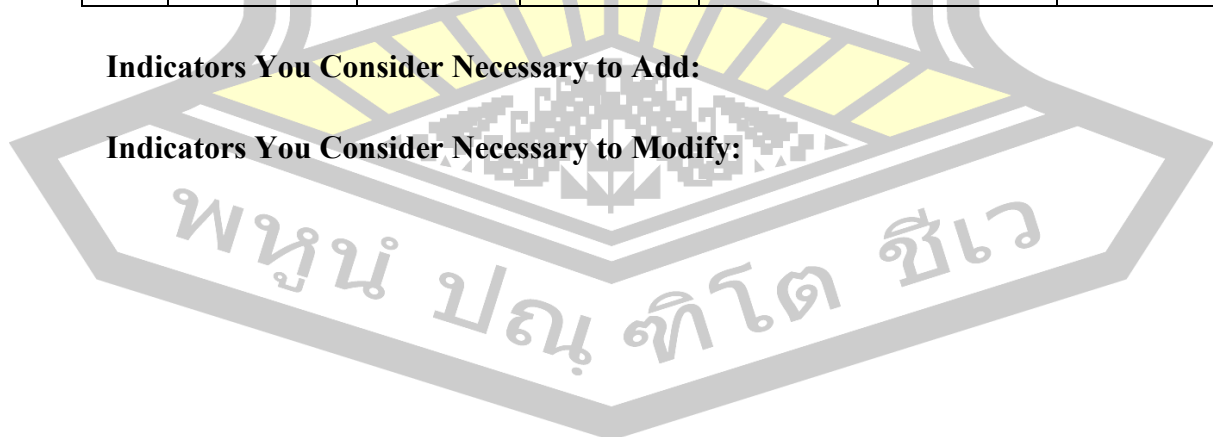


Table 2. Evaluation Table for the Importance Degree of Tertiary Indicators

Primary Indicator	Secondary Indicators	Importance Level				
		Strongly Agree (5 Points)	Agree (4 Points)	Neutral (3 Points)	Disagree (2 Points)	Strongly Disagree (1 Points)
Strength	Pull-ups					
	Push-ups					
	Standing long jump					
Power	Overhead medicine ball throw					
	Forehand closed medicine ball throw					
	Backhand standing closed medicine ball throw					
Speed	Crossover Change-of-Direction Run					
	Hexagonal reaction ball					
	4×10-meter sprint					
	20-meter sprint					
	400-meter sprint					
	Beep test					
	Wall sit test					

Endurance	Plank					
Agility	Singles Baseline Shuttle Run					
	Hexagon Jump with Both Feet					
	Spider test					
Coordination	30s Double-Under Jump Rope Test					
	Hand-eye coordination test					
	One-leg stance with eyes closed					
	Turn left foot and run forward					
	Turn right foot and run forward					

Indicators You Consider Necessary to Add:

Indicators You Consider Necessary to Modify:

Table 3. Questionnaire Validity Assessment

	Very reasonable	Comparatively reasonable	Generally reasonable	Less reasonable	Very unreasonable
Structural Validity					
Content Validity					
Overall Validity					
Based on your assessment of the questionnaire's validity, please rate according to the following scale: Very reasonable, Comparatively reasonable, Generally reasonable, Less reasonable, Very unreasonable, and mark with a '√'					

Table 4. Expert Familiarity Survey

Item	Very Familiar	Familiar	Somewhat Familiar	Less Familiar	Not Familiar at All
	5	4	3	2	1
Your Level of Familiarity with This Study					
Based on your level of familiarity, please rate according to the following scale: Very Familiar, Familiar, Somewhat Familiar, Less Familiar, Not Familiar at All, and mark with a '√'.					

Table 5. Basis for Problem Judgment

Basis for Judgment	Factors Influencing Judgment		
	Large	Medium	Small
Theoretical Analysis			
Practical Experience			
Reference to Domestic and Foreign Literature			
Intuitive Feeling			
Please select the level of influence (Large, Medium, Small) based on your own judgment and mark with a "√".			

Expert sign:

Thank you again for taking the valuable time out of your busy schedule to fill in this questionnaire!



Appendix D

The Third-Round Delphi Questionnaire for Screening Specialized Physical

Fitness Indicators of Chinese Elite Male University Tennis Players

Dear experts:

I am (Lei Lei, PhD candidate, Health and Sport Science, Educational Faculty, Mahasarakham University) currently conducting research titled “Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using a Mixed-Methods Research Approach” .

The questionnaire consists of 2 parts, totaling 31 items. Completing the questionnaire will take about 10-15 minutes. The researcher will collect the questionnaires either in person or online.

If you feel uncomfortable with any questions, you have the right not to answer those questions. You also have the right to withdraw from this project at any time without prior notice. Refusal to participate in the research or withdrawal from the project will not impact you in any way.

The information in your questionnaire will be kept. Not disclosed to the public on an individual basis, only the overall research results will be reported. Researcher will destroy relevant information after the research is completed. In this research, you will not receive any compensation or any fees.

If you have questions about the research Please contact us at (Lei Lei- Health and Sport Science. Educational Faculty, Mahasarakham University, Phone: +8619802920104)

If you have not performed as stated or want to know your rights while participating in this research, please contact "Committee on Ethics for Research in Humans Mahasarakham University Division of Research" Tel. 043-754416, 1758

Sincerely.

Researcher: Lei Lei

Faculty adviser:

- Part 1. Expert Information
- (1) Gender: Male Female
- (2) Age:
- 35 years and below 36-50 years 51 years and above
- (3) Highest Academic Qualification:
- Bachelor's Master's Doctorate
- (4) Academic Title:
- Lecturer Associate Professor Professor
- (5) Research Field:
- (8) The university or institution where you are employed is:

Part 2. Questionnaire content

This table outlines the significance of the primary, secondary, and tertiary physical fitness indicators specifically for Chinese Elite Male University Tennis Players. I kindly request that you utilize your extensive experience to evaluate the importance of each indicator listed in the attached evaluation form. Please indicate your assessment by placing a “√” in the appropriate box, with the five levels from left to right representing the following scores: Strongly Agree (5 Points), Agree (4 Points), Neutral (3 Points), Disagree (2 Points), Strongly Disagree (1 Point). If you believe it is necessary to add additional indicators, I kindly request that you add them in the revision section at the bottom of the form and assign the corresponding scores. I greatly appreciate your support and expertise, and I sincerely thank you for taking the time to contribute to this research.

Table 1. Evaluation Table for the Importance Degree of Primary Indicators

NO	Primary Indicator	Importance Level				
		Strongly Agree (5 Points)	Agree (4 Points)	Neutral (3 Points)	Disagree (2 Points)	Strongly Disagree (1 Points)
14.	Power					
15.	Speed					
16.	Endurance					
17.	Agility					
18.	Coordinate					

Indicators You Consider Necessary to Add:

Indicators You Consider Necessary to Modify:

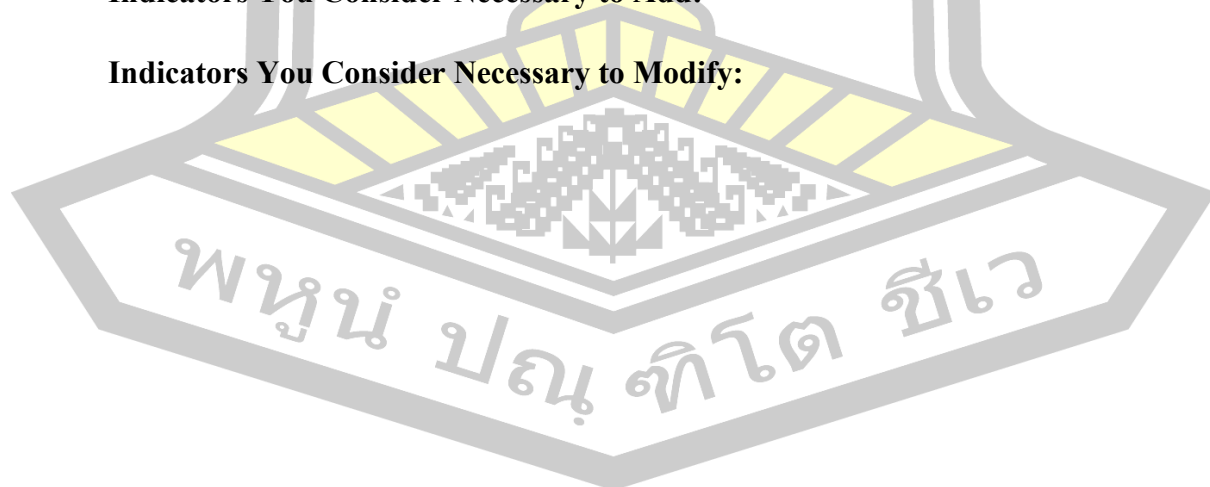


Table 2. Evaluation Table for the Importance Degree of Tertiary Indicators

Primary Indicator	Secondary Indicators	Importance Level				
		Strongly Agree (5 Points)	Agree (4 Points)	Neutral (3 Points)	Disagree (2 Points)	Strongly Disagree (1 Point)
Power	1. Overhead medicine ball throw					
	2. Forehand closed medicine ball throw					
	3. Backhand standing closed medicine ball throw					
Speed	4. Hexagonal reaction ball					
	5. 4×10-meter sprint					
	6. 20-meter sprint					
Endurance	7. Beep test					
	8. Wall sit test					
	9. Plank					
Agility	10. Singles baseline shuttle run					
	11. Spider test					
	12. Hexagon Jump with Both Feet					
	13. 30s Double-Under Jump Rope Test					

Coordination	14. Hand-eye coordination test					
	15. One-leg stance with eyes closed					

Indicators You Consider Necessary to Add:

Indicators You Consider Necessary to Modify:

Table 3. Questionnaire Validity Assessment

	Very reasonable	Comparatively reasonable	Generally reasonable	Less reasonable	Very unreasonable
Structural Validity					
Content Validity					
Overall Validity					

Based on your assessment of the questionnaire's validity, please rate according to the following scale: Very reasonable, Comparatively reasonable, Generally reasonable, Less reasonable, Very unreasonable, and mark with a '√'

Table 4. Expert Familiarity Survey

Item	Very Familiar 5	Familiar 4	Somewhat Familiar 3	Less Familiar 2	Not Familiar at All 1
Your Level of Familiarity with This Study					
Based on your level of familiarity, please rate according to the following scale: Very Familiar, Familiar, Somewhat Familiar, Less Familiar, Not Familiar at All, and mark with a '√'.					

Table 5. Basis for Problem Judgment

Basis for Judgment	Factors Influencing Judgment		
	Large	Medium	Small
Theoretical Analysis			
Practical Experience			
Reference to Domestic and Foreign Literature			
Intuitive Feeling			
Please select the level of influence (Large, Medium, Small) based on your own judgment and mark with a "√".			

Expert sign:

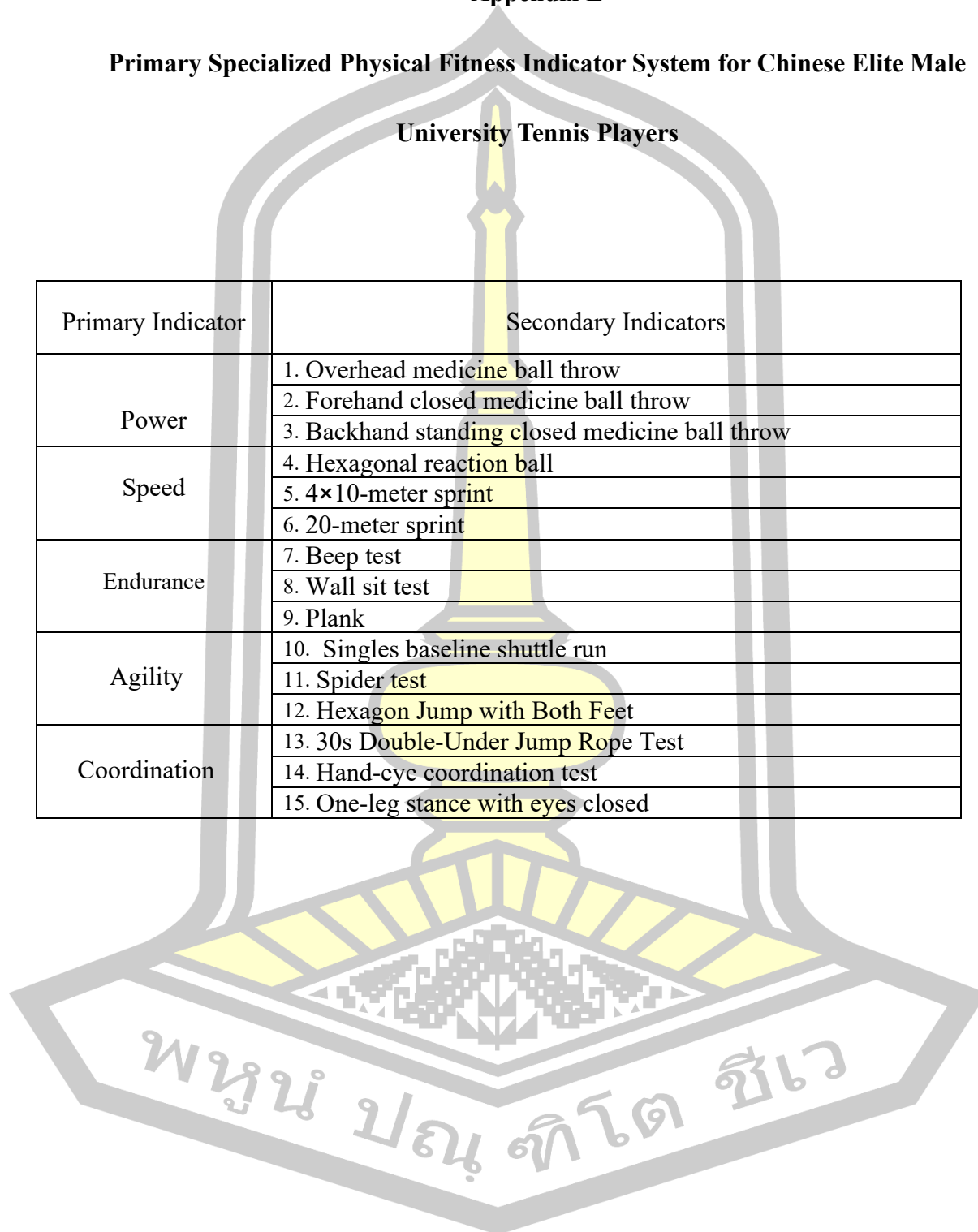
Thank you again for taking the valuable time out of your busy schedule to fill in this questionnaire !

Appendix E

Primary Specialized Physical Fitness Indicator System for Chinese Elite Male

University Tennis Players

Primary Indicator	Secondary Indicators
Power	1. Overhead medicine ball throw
	2. Forehand closed medicine ball throw
	3. Backhand standing closed medicine ball throw
Speed	4. Hexagonal reaction ball
	5. 4×10-meter sprint
	6. 20-meter sprint
Endurance	7. Beep test
	8. Wall sit test
	9. Plank
Agility	10. Singles baseline shuttle run
	11. Spider test
	12. Hexagon Jump with Both Feet
Coordination	13. 30s Double-Under Jump Rope Test
	14. Hand-eye coordination test
	15. One-leg stance with eyes closed



Appendix F

Test Indicators and Methods

Primary and Secondary Indicators, Testing Tools, and Measurement Units

Primary Indicator	Secondary Indicator	Testing Tools	Measurement Unit (to two decimal places)
Power	1. Overhead Medicine Ball Throw	Medicine ball (3kg soft medicine ball), measuring tape	Meters
	2. Forehand Closed-Stance Medicine Ball Throw	Medicine ball (3kg soft medicine ball), measuring tape	Meters
	3. Backhand Closed-Stance Medicine Ball Throw	Medicine ball (3kg soft medicine ball), measuring tape	Meters
Speed	1. Hexagonal Reaction Ball Test	Hexagonal reaction ball	Seconds
	2. 4×10m Sprint	Marker cones, stopwatch	Seconds
	3. 20m Sprint	Marker cones, stopwatch	Seconds
Endurance	1. Beep Test (Leger Shuttle Run)	Leger run audio, marker cones, stopwatch	Leger audio broadcast rounds
	2. Wall Sit	Stopwatch	Minutes
	3. Plank	Yoga mat, stopwatch	Minutes
Agility	1. Singles Sideline Swing Shuttle Run	Stopwatch	Seconds
	2. Hexagonal Jump	Hexagonal training rings, stopwatch	Seconds
	3. Spider Test	Tennis balls, stopwatch	Seconds
Coordination	1. 30s Double Under Jump Rope Test	Jump rope, stopwatch	Count (misjumps not counted)
	2. Hand-Eye Coordination Test	Tennis ball, stopwatch	Number of successful rounds
	3. Blindfolded Single-Leg Stand	Blindfold, stopwatch	Seconds
Total: 15 Indicators Testing Tools Summary: 1. Medicine ball (3kg soft medicine ball), 2. Measuring tape, 3. Marker cones, 4. Stopwatch, 5. Leger run audio, 6. Yoga mat, 7. Hexagonal training rings, 8. Jump rope, 9. Tennis ball, 10. Blindfold, 11. Hexagonal reaction ball (7cm diameter)			

Testing Procedures and Requirements

1. Overhead Medicine Ball Throw



Testing Requirements: The participant assumes a side stance, mimicking a serve motion, holding the ball in their dominant hand. Starting from the trophy position, they bend their knees, push off the ground, extend their hips and shoulders, and throw the ball forward. The distance of the throw is measured.

Key Considerations: The participant must not step on or over the line before releasing the ball.

Testing Tools: Medicine ball (3kg soft medicine ball), measuring tape.

Measurement Unit: Meters (two decimal places).

2. Forehand Closed-Stance Medicine Ball Throw



Testing Requirements: (Right-handed example) The participant stands in a closed stance with their left shoulder facing the target. Holding the ball with both hands, they push off the ground, rotate their torso, and throw the ball towards the target.

Key Considerations: Feet must not cross the line before releasing the ball.

Testing Tools: Medicine ball (3kg soft medicine ball), measuring tape.

Measurement Unit: Meters (two decimal places).

3. Backhand Closed-Stance Medicine Ball Throw



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Testing Requirements: (Right-handed example) The participant stands in a closed stance with their right shoulder facing the target. Holding the ball with both hands, they push off the ground, rotate their torso, and throw the ball towards the target.

Key Considerations: Feet must not cross the line before releasing the ball.

Testing Tools: Medicine ball (3kg soft medicine ball), measuring tape.

Measurement Unit: Meters (two decimal places).

4. Hexagonal Reaction Ball Test



Testing Method: The hexagonal reaction ball is dropped from a height of 2m in a near-free-fall manner. The participant stands 2m away and attempts to catch the ball as quickly as possible upon its first bounce. The test is conducted three times, and the best result is recorded.

Key Considerations: To ensure a true free fall, one tester drops the ball while another records the time.

Testing Tools: Hexagonal reaction ball (7cm diameter), stopwatch.

Measurement Unit: Seconds (two decimal places).

5. 4×10m Sprint

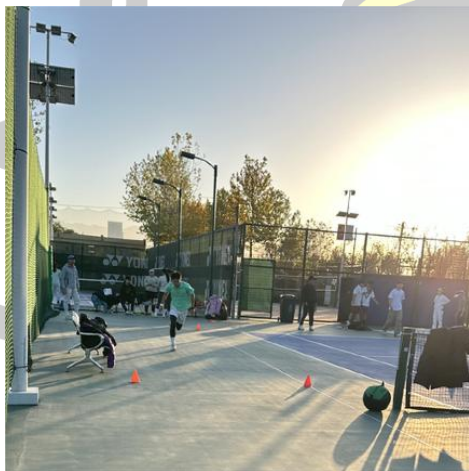


Testing Method: Two marker cones are placed at a 10m distance. The participant sprints between them in the pattern A-B-A-B-A, covering a total of 40m.

Testing Tools: Marker cones, stopwatch.

Measurement Unit: Seconds (two decimal places).

6. 20m Sprint



Testing Method: The participant sprints from the starting point to the finish line without slowing down.

Testing Tools: Marker cones, stopwatch.

Measurement Unit: Seconds (two decimal places).

7. Beep Test (Leger Shuttle Run)



Testing Method: The participant runs back and forth along a 20m track following a progressively increasing audio signal. The test continues until the participant voluntarily stops or fails to reach the required distance four times in a row.

Testing Tools: Leger run audio, marker cones, audio device.

Measurement Unit: Number of completed rounds.

8. Wall Sit



Testing Method: The participant maintains a 90-degree knee bend against a wall, with thighs parallel to the floor and arms either at their sides or raised.

Key Considerations: The participant must maintain a strict 90-degree knee angle.

Testing Tools: Stopwatch.

Measurement Unit: Seconds (two decimal places).

9. Plank

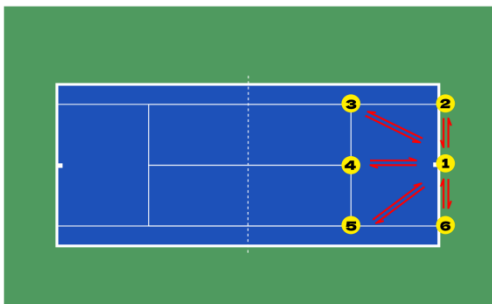


Testing Method: The participant assumes a forearm plank position, maintaining a neutral spine without excessive arching or hip elevation.

Testing Tools: Stopwatch.

Measurement Unit: Seconds (two decimal places).

10. Spider Test



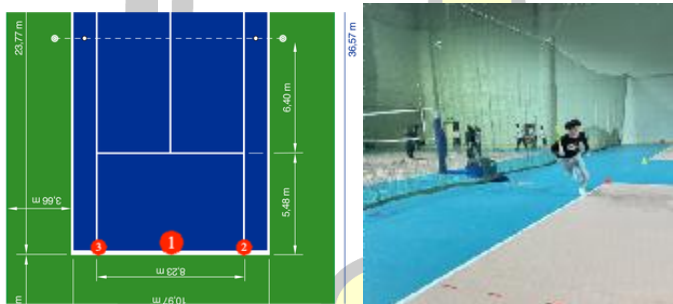
Testing Method: The participant retrieves tennis balls from six designated spots, returning them to the starting point as quickly as possible.

Key Considerations: If a ball falls off the racket, the test must be restarted.

Testing Tools: Stopwatch.

Measurement Unit: Seconds (two decimal places).

11. Singles Sideline Shuttle Run



Testing Method: The participant runs between designated positions on the court, executing forehand and backhand swings at marked points.

Key Considerations: No split steps during directional changes.

Testing Tools: Tennis racket, stopwatch.

Measurement Unit: Seconds (two decimal places).

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12. Hexagonal Jump



Testing Method: The participant jumps in a predefined sequence through a hexagonal training ring pattern.

Testing Tools: Hexagonal training rings, stopwatch.

Measurement Unit: Seconds (two decimal places).

13. 30-Second Double Under Jump Rope Test



Testing Method: The participant performs double under jumps continuously for 30 seconds.

Testing Tools: Jump rope, stopwatch.

Measurement Unit: Number of successful jumps.

14. Hand-Eye Coordination Test



Testing Method: The participant alternates throwing a tennis ball against a wall and catching it with the opposite hand within 30 seconds.

Testing Tools: Tennis ball, stopwatch.

Measurement Unit: Number of successful rounds.

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Appendix G

Clarification documents for the Expert

Dear all Expert:

Because I (Lei Lei, PhD candidate, Health and Sport Science. Educational Faculty, Maharakham University) conducting research on "Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using a Mixed-Methods Research Approach ".

I would like to invite you to participate in this research. You may not directly benefit from participating in this research project. However, the findings will be of significant assistance to the scientific training, selection, and research of Chinese Elite Male University Tennis Players .

If you decide to participate in the research, the researcher will ask you to answer a expert questionnaire for the selection of specialized physical fitness evaluation indicators for Chinese Elite Male University Tennis Players .

If you feel uncomfortable with any questions, you have the right not to answer those questions. You also have the right to withdraw from this project at any time without prior notice. Refusal to participate in the research or withdrawal from the project will not impact you in any way.

The information in your questionnaire will be kept. Not disclosed to the public on an individual basis, only the overall research results will be reported. Researcher will destroy relevant information after the research is completed. In this research, you will not receive any compensation or any fees.

If you have questions about the research Please contact us at (Lei Lei- Health and Sport Science. Educational Faculty, Maharakham University, Phone: +8619802920104)

If you have not performed as stated or want to know your rights while participating in this research, please contact "Committee on Ethics for Research in Humans Maharakham University Division of Research" Tel. 043-754416, 1758

Sincerely.

Researcher: Lei Lei

Faculty adviser:

Appendix H

Clarification documents for the volunteers who Experiment

(Answering questionnaires must over 18 years old)

Dear all Subject

Because I (Lei Lei, PhD candidate, Health and Sport Science. Educational Faculty, Maharakham University) conducting research on "Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using a Mixed-Methods Approach ". You may not benefit directly from participating in this research project. However, the findings will be of significant assistance to the scientific training, selection, and research of Chinese Elite Male University Tennis Players .

After being recommended by your coach, you are eligible to be a volunteer for this study. If you decide to participate in this study, you will be asked to provide your basic personal information. If you feel uncomfortable or uncomfortable with certain questions, you have the right not to answer them.

You and 52 other athletes will participate in a physical fitness test project. The test requirements and details are as follows: (1) Wear the appropriate sports attire and footwear that you usually wear for physical activity. (2) Maintain your regular diet on the day of the test but refrain from eating one hour before the test. (3) Complete the assigned test items at the designated location according to the test requirements. To ensure you perform at your normal level, you may repeat the test if your performance is unsatisfactory during the initial attempt. (4) Follow the instructions of field staff to complete the test during the test.

You also have the right to withdraw from the program at any time without prior notice. And not participating in or withdrawing from the research project will not affect you in any way. Your Basic personal information will be retained and not disclosed to the public. Your Basic personal information will only be used for this

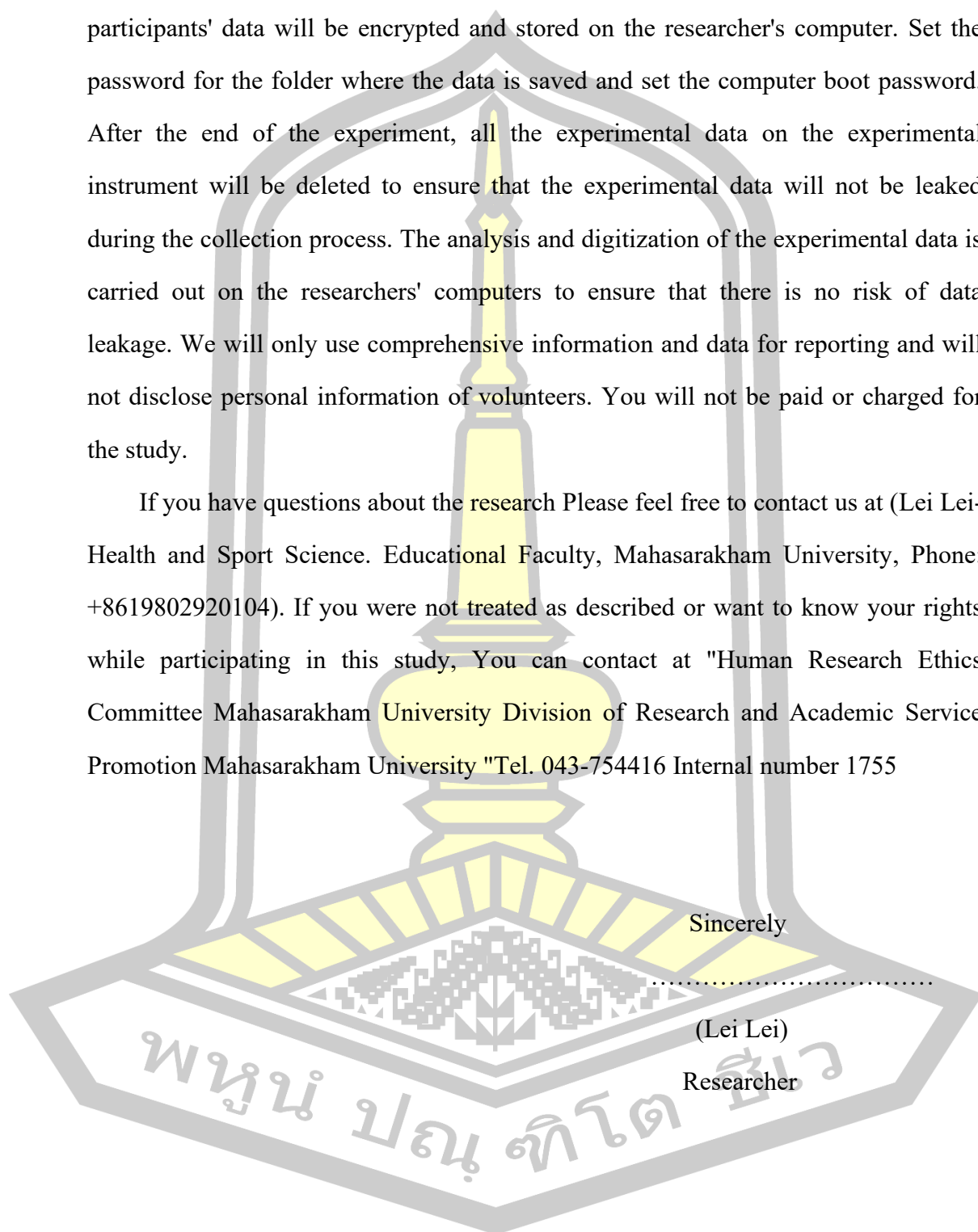
study, and the relevant data will be destroyed after the study is completed. All participants' data will be encrypted and stored on the researcher's computer. Set the password for the folder where the data is saved and set the computer boot password. After the end of the experiment, all the experimental data on the experimental instrument will be deleted to ensure that the experimental data will not be leaked during the collection process. The analysis and digitization of the experimental data is carried out on the researchers' computers to ensure that there is no risk of data leakage. We will only use comprehensive information and data for reporting and will not disclose personal information of volunteers. You will not be paid or charged for the study.

If you have questions about the research Please feel free to contact us at (Lei Lei-Health and Sport Science. Educational Faculty, Maharakham University, Phone: +8619802920104). If you were not treated as described or want to know your rights while participating in this study, You can contact at "Human Research Ethics Committee Maharakham University Division of Research and Academic Service Promotion Maharakham University "Tel. 043-754416 Internal number 1755

Sincerely

(Lei Lei)

Researcher



Appendix I

Informed consent form for research from volunteers

(For volunteers over 18 years old)

I (Mr/Miss.) Surname

Age.....Year.

House number Village No. Sub-district

District province.....

Convenient phone

Read the explanation / listen to the explanation from Miss. Lei Lei about volunteering in the research project on "Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using a Mixed-Methods Approach", the explanatory text consists of Full details about the purpose of the research, details of the research. That I have to do and be treated, the benefits that I may gain from the research and the risks that may arise from participating in the study. Including guidelines for questions that may arise throughout. It has also received an explanation and an answer to any questions from the research project leader.

As well as the testimony from the researcher that will keep my information confidential. In addition, not anonymously or private information individually to the public. The results of the research will be presented in the form of an overview that is a summary of the research results for academic purposes only.

"In participating as a volunteer of this research project I join voluntarily." And I can withdraw from this study at any time. If I wish which will not have any effect and will not lose any rights in study or work that I will receive in the future.

sign..... Volunteers

(.....)

Date.....

sign..... witness

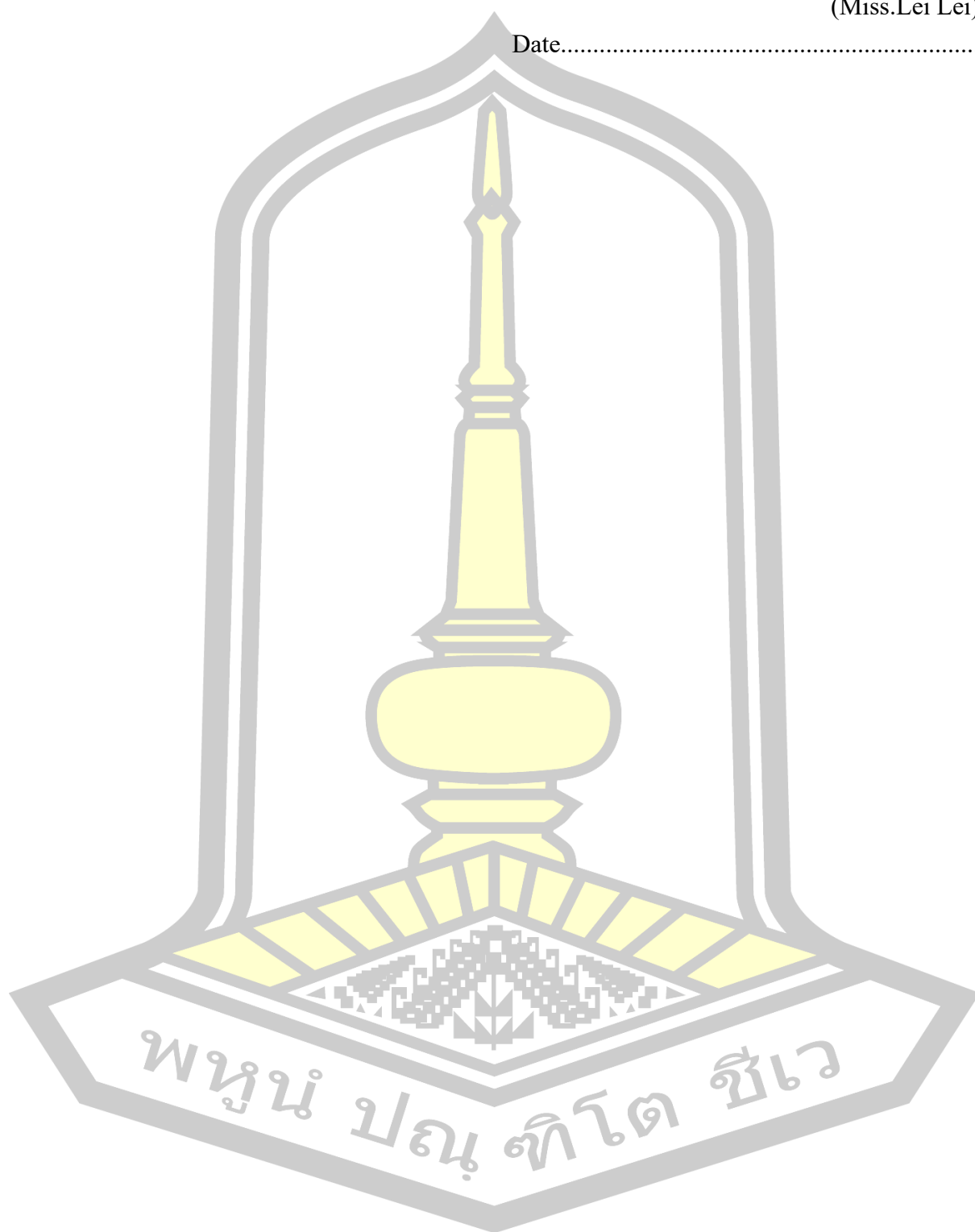
(.....)

Date.....

sign..... researcher

(Miss.Lei Lei)

Date.....



Appendix J

Study informed consent from the volunteer head coach

I (Mr.) Surname

Age.....Year.

House number Village No. Sub-district

District province.....

Convenient phone

Read the explanation / listen to the explanation from Miss. Lei Lei about volunteering in the research project on " Constructing a Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players Using a Mixed-Methods Approach", the explanatory text consists of Full details about the purpose of the research, details of the research. I agree with the value of the study, I am aware of the benefits to be gained and the risks that may arise from participating in the study. Include guidelines for possible problems. Explanations and answers to any questions from the head of the research project were also received.

The researcher promised to keep confidential information about my tennis team. In addition, anonymous or private information may not be made available to the public alone. The findings will be presented in the form of an overview, which is a summary of the findings for academic purposes only.

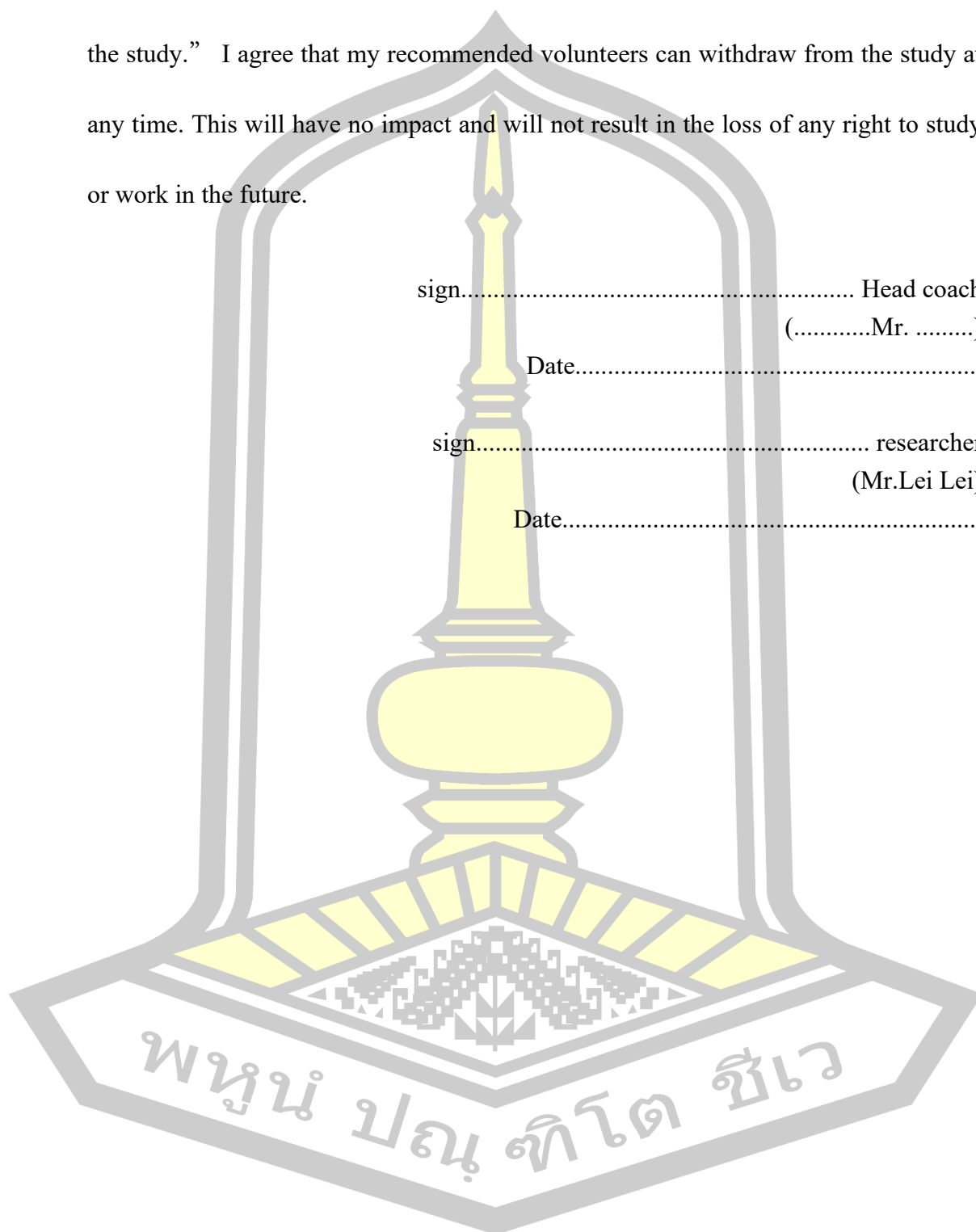
"As the volunteer's referrer and coach, I gave them permission to participate in the study." I agree that my recommended volunteers can withdraw from the study at any time. This will have no impact and will not result in the loss of any right to study or work in the future.

sign..... Head coach
(.....Mr.)

Date.....

sign..... researcher
(Mr.Lei Lei)

Date.....

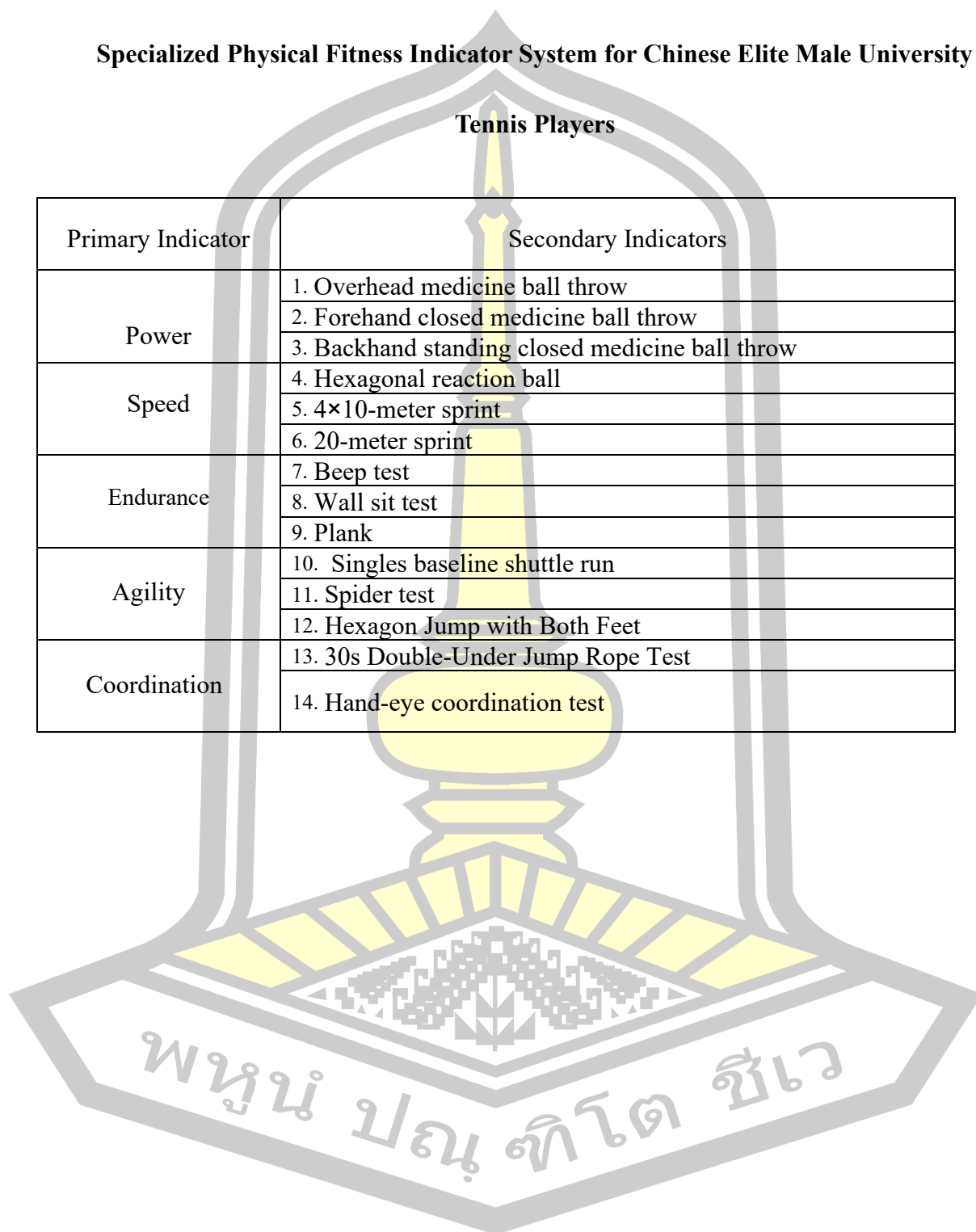


Appendix K

Specialized Physical Fitness Indicator System for Chinese Elite Male University

Tennis Players

Primary Indicator	Secondary Indicators
Power	1. Overhead medicine ball throw
	2. Forehand closed medicine ball throw
	3. Backhand standing closed medicine ball throw
Speed	4. Hexagonal reaction ball
	5. 4×10-meter sprint
	6. 20-meter sprint
Endurance	7. Beep test
	8. Wall sit test
	9. Plank
Agility	10. Singles baseline shuttle run
	11. Spider test
	12. Hexagon Jump with Both Feet
Coordination	13. 30s Double-Under Jump Rope Test
	14. Hand-eye coordination test



Appendix L

Quality assessment of research tools (IOC)

Experts are invited to express their views on the attached questionnaire. Please enter (√) in your comment column and write down your comment, providing some useful suggestions for me to further consider and improve.

Part 1 : Importance Evaluation Table for the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

Part 2 : Importance Evaluation Table for Single-Performance Evaluation Standards in the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

Part 3 : Importance Evaluation Table for Comprehensive Performance Evaluation Standards in the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

Note: A Likert scale was used, and responses were given on a 3-point scale. The scoring criteria are as follows:

-1: Strongly Disagree, 0: Neutral, 1: Agree

Issue		Comment			Suggestion
		+1	0	-1	
Part 1. Evaluation Table for the Importance Degree of Indicators System					
Primary Indicators	1. Power				
	2. Speed				
	3. Endurance				
	4. Agility				
	5. Coordination				
Primary Indicators	Secondary Indicators				
	1. Overhead Medicine Ball Throw				
	2. Forehand Closed-Stance Medicine Ball Throw				
	3. Backhand Closed-Stance Medicine Ball Throw				
Speed	4. Hexagonal Reaction Ball				
	5. 4x10-meter Shuttle run				
	6. 20-meter Sprint				
	7. Beep Test				

	8. Wall squat test				
	9. Plank Exercise				
Agility	10. Singles baseline round trip				
	11. Hexagon Jump with Both Feet				
	12. Spider Test				
Coordination	13. 30s Double unders				
	14. Hand-eye coordination test				

Part 2 : Importance Evaluation Table for Single-Performance Evaluation Standards in the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

Table 2. Single Performance Evaluation Standard 1

Score	Overhead medicine ball throw	Forehand closed medicine ball throw	Backhand standing closed medicine ball throw	Beep test	Wall sit test	Plank
100	11.25	12.56	11.97	87.81	5.36	5.03
95	10.89	12.05	11.51	82.36	5.07	4.39
90	10.51	11.52	11.03	76.63	4.37	4.14
85	10.10	10.95	10.52	70.56	4.06	3.48
80	9.67	10.35	9.97	64.08	3.33	3.21
75	9.21	9.70	9.39	57.10	2.60	2.52
70	8.70	8.99	8.75	49.49	2.24	2.21
65	8.14	8.21	8.04	41.02	1.47	1.48
60	7.49	7.31	7.22	31.32	1.07	1.13
55	6.71	6.22	6.24	19.63	0.25	0.34
50	5.65	4.74	4.91			
0	<4.55	<3.20	<3.51	<3.73	<0.07	<0.08

Table 3. Single Performance Evaluation Standard 2

Score	Hexagonal reaction ball	4×10 meter sprint	20-meter sprint	Singles sideline shuttle run	Hexagon Jump with Both Feet	Spider test
100	0.54	8.56	2.99	4.16	8.37	14.59
95	0.67	8.89	3.12	4.35	9.43	15.31
90	0.78	9.18	3.23	4.51	10.30	15.86
85	0.88	9.43	3.33	4.65	11.07	16.32
80	0.98	9.67	3.42	4.79	11.75	16.72
75	1.06	9.89	3.50	4.91	12.38	17.09
70	1.14	10.09	3.58	5.02	12.96	17.42
65	1.22	10.28	3.65	5.13	13.50	17.74
60	1.29	10.47	3.72	5.24	14.01	18.03
55	1.36	10.64	3.79	5.34	14.50	18.31
50	1.43	10.81	3.85	5.43	14.97	18.57
45	1.49	10.97	3.91	5.52	15.41	18.82
40	1.55	11.13	3.97	5.61	15.84	19.06
35	1.61	11.28	4.03	5.69	16.25	19.30
30	1.67	11.42	4.09	5.78	16.65	19.52
25	1.72	11.56	4.14	5.86	17.04	19.74
20	1.78	11.70	4.19	5.93	17.41	19.95
15	1.83	11.84	4.25	6.01	17.78	20.15
10	1.88	11.97	4.30	6.08	18.13	20.35
5	1.93	12.09	4.34	6.15	18.48	20.54
0	1.98	12.22	4.39	6.22	18.82	20.73



Table 3. Single Performance Evaluation Standard 3

Score	30's Double unders	Hand-eye coordination test	Score	30's Double unders	Hand-eye coordination test
100	60	33	45	38	
95	57	32	40	36	24
90	55	31	35	35	
85	54	30	30	31	23
80	52	29	25	27	22
75	51	28	20	24	21
70	47	27	15	22	20
65	44	26	10	20	19
60	43		5		18
55		25	0	19	16
50	40				

Issue	Comment			Suggestion
	+1	0	-1	
Part 2. Evaluation Table for the Importance Degree of Single-Performance Evaluation Standards				
Power	1. Overhead Medicine Ball Throw			
	2. Forehand Closed-Stance Medicine Ball Throw			
	3. Backhand Closed-Stance Medicine Ball Throw			
Speed	4. Hexagonal Reaction Ball			
	5. 4x10-meter Shuttle run			
	6. 20-meter Sprint			
Endurance	7. Beep Test			
	8. Wall squat test			
	9. Plank			
Agility	10. Singles baseline round trip			
	11. Hexagon Jump with Both Feet			

	12. Spider Test				
Coordination	13. 30s Double unders				
	14. Hand-eye coordination test				

Part 3 : Importance Evaluation Table for Comprehensive Performance Evaluation Standards in the Specialized Physical Fitness Evaluation System for Chinese Elite Male University Tennis Players .

Table 4. Table of Comprehensive Physical Fitness Evaluation Grade Standards

	Excellent	Good	Average	Pass	Fail
%	>90%	75%-90%	25%-75%	10%-25%	<10%
Score	>80.15	80.14-76.90	76.89-69.75	69.74-66.50	<66.50

Issue	Comment			Suggestion
	+1	0	-1	
Part 3. Evaluation Table for the Importance Degree of Comprehensive Evaluation Grade Standards				
1. Excellent				
2. Good				
3. Average				
4. Pass				
5. Fail				

Appendix M
Ethics Certificate



**MAHASARAKHAM UNIVERSITY ETHICS COMMITTEE FOR
RESEARCH INVOLVING HUMAN SUBJECTS**

Certificate of Approval

Approval number: 677-609/2024

Title : Construction of a Mixed-Method-Based Specialized Physical Fitness Evaluation System for Chinese Male National Level 2 Tennis Players.

Principal Investigator : Lei Lei

Responsible Department : Faculty of Education

Research site : Xian city, Shannxi province, China

Review Method : Expedited Review

Date of Manufacture : 31 October 2024

Expire : 30 October 2025

This research application has been reviewed and approved by the Ethics Committee for Research Involving Human Subjects, Maharakham University, Thailand. Approval is dependent on local ethical approval having been received. Any subsequent changes to the consent form must be re-submitted to the Committee.

Ratree S.
.....
(Assistant Professor Ratree Sawangjit)
Chairman

Approval is granted subject to the following conditions: (see back of this Certificate)

All approved investigators must comply with the following conditions:

1. Strictly conduct the research as required by the protocol;
2. Use only the information sheet, consent form (and recruitment materials, if any), interview outlines and/or questionnaires bearing the Institutional Review Board's seal of approval ; and return one copy of such documents of the first subject recruited to the Institutional Review Board (IRB) for the record (if applicable);
3. Report to the Institutional Review Board any serious adverse event or any changes in the research activity within five working days;
4. Provide reports to the Institutional Review Board concerning the progress of the research upon the specified period of time or when requested;
5. If the study cannot be finished within the expire date of the approval certificate, the investigator is obliged to reapply for approval at least two month before the date of expiration.
6. All the above approved documents are expired on the same date of the previously approved protocol (Protocol Number.....)

* A list of the Institutional Review Board members (names and positions) present at the meeting of Institutional Review Board on the date of approval of this study has been attached (per requested). All approved documents will be forwarded to the principal investigator.

๒๗/๖๐๙

ECMSU01-05.03 (English)

Clarification documents for the experts who answered the questionnaires

To All Experts

I am (Lei Lei, PhD candidate, Health and Sport Science, Educational Faculty, Mahasarakham University) currently conducting research titled “Construction of a Mixed-Method-Based Specialized Physical Fitness Evaluation System for Chinese Male National Level 2 Tennis Players”. The objective of this research is:

1. To investigate the specialized physical fitness indicators of Chinese male Level 2 tennis players.
2. To construct an evaluation system for the specialized physical fitness of Chinese male level 2 tennis players.
3. To verify the scientific validity and rationality of the specialized physical fitness evaluation system for Chinese male level 2 tennis players.

You may not directly benefit from participating in this research project. However, the findings will be of significant assistance to the scientific training, selection, and research of male national level 2 tennis players in China.

If you decide to participate in the research, the researcher will ask you to answer a expert questionnaire for the selection of specialized physical fitness evaluation indicators for Chinese male national level 2 tennis players. The questionnaire consists of 3 parts, totaling 24 items. Completing the questionnaire will take about 10-15 minutes. The researcher will collect the questionnaires either in person or online.

If you feel uncomfortable with any questions, you have the right not to answer those questions. You also have the right to withdraw from this project at any time without prior notice. Refusal to participate in the research or withdrawal from the project will not impact you in any way.

The information in your questionnaire will be kept. Not disclosed to the public on an individual basis, only the overall research results will be reported. Researcher will destroy relevant information after the research is completed. In this research, you will not receive any compensation or any fees.

If you have questions about the research Please contact us at (Lei Lei- Health and Sport Science, Educational Faculty, Mahasarakham University, Phone: +8619802920104)

If you have not performed as stated or want to know your rights while participating in this research, please contact "Committee on Ethics for Research in Humans Mahasarakham University Division of Research" Tel. 043-754416, 1758

Sincerely

.....
(Lei Lei)

Researcher



Clarification documents for the volunteers who Experiment
(answering questionnaires must over 18 years old)

Dear all Subject

Because I (Lei Lei, PhD candidate, Health and Sport Science. Educational Faculty, Mahasarakham University) conducting research on "Construction of a Mixed-Method-Based Specialized Physical Fitness Evaluation System for Chinese Male National Level 2 Tennis Players ". You may not benefit directly from participating in this research project. However, the findings will be of significant assistance to the scientific training, selection, and research of male national level 2 tennis players in China.

After being recommended by your coach, you are eligible to be a volunteer for this study. If you decide to participate in this study, you will be asked to provide your basic personal information. If you feel uncomfortable or uncomfortable with certain questions, you have the right not to answer them.

You and 46 other athletes will participate in a physical fitness test project. The test requirements and details are as follows: (1) Wear the appropriate sports attire and footwear that you usually wear for physical activity. (2) Maintain your regular diet on the day of the test but refrain from eating one hour before the test. (3) Complete the assigned test items at the designated location according to the test requirements. To ensure you perform at your normal level, you may repeat the test if your performance is unsatisfactory during the initial attempt. (4) Follow the instructions of field staff to complete the test during the test.

You also have the right to withdraw from the program at any time without prior notice. And not participating in or withdrawing from the research project will not affect you in any way. Your Basic personal information will be retained and not disclosed to the public. Your Basic personal information will only be used for this study, and the relevant data will be destroyed after the study is completed. All participants' data will be encrypted and stored on the researcher's computer. Set the password for the folder where the data is saved and set the computer boot password. After the end of the experiment, all the experimental data on the experimental instrument will be deleted to ensure that the experimental data will not be leaked during the collection process. The analysis and digitization of the experimental data is carried out on the researchers' computers to ensure that there is no risk of data leakage. We will only use comprehensive information and data for reporting and will not disclose personal information of volunteers. You will not be paid or charged for the study.

If you have questions about the research Please feel free to contact us at (Lei Lei- Health and Sport Science. Educational Faculty, Mahasarakham University, Phone: +8619802920104). If you were not treated as described or want to know your rights while participating in this study, You can contact at "Human Research Ethics Committee Mahasarakham University Division of Research and Academic Service Promotion Mahasarakham University "Tel. 043-754416 Internal number 1755

Sincerely

.....
(Lei Lei)

Researcher



Informed consent form for research from experts

I (Mr/Miss.) Surname Age.....Year.
 House number Village No. Sub-district District
 province.....
 Convenient phone

Read the explanation / listen to the explanation from Miss. Lei Lei about volunteering in the research project on "Construction of a Mixed-Method-Based Specialized Physical Fitness Evaluation System for Chinese Male National Level 2 Tennis Players ", the explanatory text consists of Full details about the purpose of the research, details of the research. That I have to do , the benefits that I may gain from the research and the risks that may arise from participating in the study. Including guidelines for questions that may arise throughout. It has also received an explanation and an answer to any questions from the research project leader.

As well as the testimony from the researcher that will keep my information confidential. In addition, not anonymously or private information individually to the public. The results of the research will be presented in the form of an overview that is a summary of the research results for academic purposes only.

"In participating as a volunteer of this research project I join voluntarily." And I can withdraw from this study at any time. If I wish which will not have any effect and will not lose any rights in study or work that I will receive in the future.

sign..... Volunteers

(.....)

Date.....

sign..... witness

(.....)

Date.....

sign..... researcher

(Miss.Lei Lei)

Date.....



**Informed consent form for research from volunteers
(For volunteers over 18 years old)**

I (Mr/Miss.) Surname Age.....Year.
 House number Village No. Sub-district District
 province.....
 Convenient phone

Read the explanation / listen to the explanation from Miss. Lei Lei about volunteering in the research project on "Construction of a Mixed-Method-Based Specialized Physical Fitness Evaluation System for Chinese Male National Level 2 Tennis Players ", the explanatory text consists of Full details about the purpose of the research, details of the research. That I have to do and be treated, the benefits that I may gain from the research and the risks that may arise from participating in the study. Including guidelines for questions that may arise throughout. It has also received an explanation and an answer to any questions from the research project leader.

As well as the testimony from the researcher that will keep my information confidential. In addition, not anonymously or private information individually to the public. The results of the research will be presented in the form of an overview that is a summary of the research results for academic purposes only.

"In participating as a volunteer of this research project I join voluntarily." And I can withdraw from this study at any time. If I wish which will not have any effect and will not lose any rights in study or work that I will receive in the future.

sign..... Volunteers
 (.....)
 Date.....

sign..... witness
 (.....)
 Date.....

sign..... researcher
 (Miss.Lei Lei)
 Date.....



BIOGRAPHY

NAME	Lei Lei
DATE OF BIRTH	April 27, 1991
PLACE OF BIRTH	Xianyang City, Shaanxi Province, China
ADDRESS	No. 258 Taoyuan North Road, Lianhu District, Xi'an City, Shaanxi Province, China
POSITION	2016 Engage in Physical Education Teaching
PLACE OF WORK	Xi'an University of Technology
EDUCATION	<p>2009 to 2013 Bachelor's Degree, Field of Physical Education, Admitted to the College Xi'an Physical Education University</p> <p>2013 to 2016 Master's Degree, Field of Sports Kinesiology, Admitted to the Graduate School of Xi'an Physical Education University</p> <p>2022 to 2025 Doctor of Philosophy Program in Exercise and sport Science, Mahasarakham University</p>

