A COMPARATIVE ANALYSIS OF PSYCHOPHYSIOLOGICAL FACTORS AMONG TABLE TENNIS STATE PLAYERS IN MALAYSIA AND CHINA

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A COMPARATIVE ANALYSIS OF PSYCHOPHYSIOLOGICAL FACTORS AMONG TABLE TENNIS STATE PLAYERS IN MALAYSIA AND CHINA

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ABSTRACT

This study aimed to conduct a comparative analysis of psychophysiological factors among table tennis state players in Malaysia (Perak) and China (Yinchuan), focusing on demographic characteristics, physiological measures (BMI, heart rate, oxygen levels, VO2max), psychological factors (mental toughness, anxiety, concentration), and their interrelationships. A survey design approach was employed, with data collected using InBody BIA, Polar H10 sensors, oximeters, Multi-Stage Fitness Tests (MSFT), MTQ-18, CSAI-2R, and Grid Concentration Tasks. Statistical analyses, including t-tests, ANOVA, and Pearson correlations, revealed significant differences in several dimensions. The sample consisted of 60 elite-level athletes (30 from each country), aged between 18 and 25, with more than five years of competitive experience. Chinese players demonstrated younger age profiles, rigorous training schedules ($p < 0.05$), and higher oxygen recovery levels post-exercise ($p < 0.05$), while Malaysian players exhibited higher mean VO2max ($M = 9.33$, $SD = 6.68$) but with greater variability ($p > 0.05$). Psychological analysis showed that Malaysian players scored higher on mental toughness dimensions such as reboundability and concentration ($p > 0.05$), whereas Chinese players experienced higher somatic anxiety ($p > 0.05$). Correlation analyses highlighted significant relationships between physiological and psychological variables, such as the negative association between VO2max and post-exercise heart rate in Malaysian players ($r = -0.421$, $p < 0.05$) and the positive relationship between somatic anxiety and concentration in Chinese players ($r = 0.604$, $p < 0.05$). These outcomes reflect the impact of centralized versus decentralized training systems and their psychological implications at the elite level. The study highlights the importance of integrating tailored physiological and psychological training strategies to optimize athletic performance. Findings may inform national sports associations in designing holistic high-performance training modules. Future research should explore longitudinal effects of training regimens, expand the sample to diverse regions, and examine additional factors such as nutrition and environmental conditions to provide a comprehensive understanding of performance determinants.

ANALISIS PERBANDINGAN FAKTOR PSIKOFISIOLOGI DALAM KALANGAN PEMAIN PINGPONG NEGERI DI MALAYSIA DAN CHINA

ABSTRAK

Kajian ini bertujuan untuk menjalankan analisis perbandingan faktor psikofisiologi dalam kalangan pemain pingpong negeri di Malaysia (Perak) dan China (Yinchuan), memfokuskan kepada ciri demografi, ukuran fisiologi (BMI, kadar denyutan jantung, paras oksigen, VO2max), faktor psikologi (mental). ketangguhan, kebimbangan, penumpuan), dan perhubungan mereka. Pendekatan reka bentuk tinjauan telah digunakan dalam kajian ini, dengan data dikumpul menggunakan InBody BIA, penderia Polar H10, oksimeter, *Multi-Stage Fitness Tests* (MSFT), *MTQ-18, CSAI-2R* dan *Grid Concentration Tasks*. Analisis statistik, termasuk ujian-t, *ANOVA*, dan korelasi *Pearson*, mendedahkan perbezaan yang ketara dalam beberapa dimensi. Sampel kajian terdiri daripada 60 atlet bertaraf elit (30 dari setiap negara) yang berumur antara 18 hingga 25 tahun dan mempunyai pengalaman pertandingan melebihi lima tahun. Pemain China menunjukkan profil umur yang lebih muda, jadual latihan yang ketat ($p < 0.05$), dan tahap pemulihan oksigen yang lebih tinggi selepas latihan ($p < 0.05$), manakala pemain Malaysia mempamerkan min VO2max yang lebih tinggi ($M = 9.33$, $SD = 6.68$) tetapi dengan kebolehubahan yang lebih besar. ($p > 0.05$). Analisis psikologi menunjukkan pemain Malaysia mendapat markah yang lebih tinggi pada dimensi kekuatan mental seperti kebolehbalikan dan tumpuan ($p > 0.05$), manakala pemain China mengalami kebimbangan somatik yang lebih tinggi ($p > 0.05$). Analisis korelasi menunjukkan hubungan yang signifikan antara pembolehubah fisiologi dan psikologi, seperti perkaitan negatif antara VO2max dan kadar denyutan jantung selepas senaman dalam pemain Malaysia ($r = -0.421$, $p <0.05$) dan hubungan positif antara kebimbangan somatik dan tumpuan dalam pemain Cina ($r = 0.604$, $p < 0.05$). Penemuan ini mencerminkan kesan sistem latihan berpusat berbanding tidak berpusat serta implikasi psikologinya dalam kalangan atlet elit. Kajian itu menekankan kepentingan mengintegrasikan strategi latihan fisiologi dan psikologi yang disesuaikan untuk mengoptimumkan prestasi sukan. Hasil kajian boleh dimanfaatkan oleh persatuan sukan kebangsaan dalam merangka modul latihan berprestasi tinggi yang holistik. Penyelidikan masa depan harus meneroka kesan membujur rejimen latihan, mengembangkan sampel ke kawasan yang pelbagai, dan mengkaji faktor tambahan seperti pemakanan dan keadaan persekitaran untuk memberikan pemahaman yang komprehensif tentang penentu prestasi.

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LIST OF ABBREVIATIONS

AGR	Autogenic Relaxation
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
CSAI-2R	Competitive State Anxiety Inventory-2 Revised
HR	Heart Rate
HRV	Heart Rate Variability
ITTF	International Table Tennis Federation
MTQ	Mental Toughness Questionnaire
MSFT	Multi-Stage Fitness Test
PMR	Progressive Muscle Relaxation
SDT	Self-Determination Theory
Vo2max	Maximal Oxygen Uptake

LIST OF APPENDIX

A Sample Questionnaire and Assessment Forms

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides a comprehensive overview of the study, beginning with the background and context in which the research is situated. It explores the development of competitive table tennis in both Malaysia and China, and highlights the growing academic interest in psychophysiological factors affecting athletic performance. The chapter proceeds to detail the problem statement, research rationale, objectives, research questions, and hypotheses that form the foundation of the investigation.

Furthermore, this chapter introduces the conceptual framework that guides the comparative analysis, defines key operational terms used throughout the study, and outlines the limitations encountered during the research process. The significance of the study is also emphasized, particularly in relation to its potential

contribution to the field of sports science and physical education, especially in training design, performance optimization, and athlete psychology.

1.2 Background of the Study

In recent decades, table tennis has evolved from a simple recreational activity into a high-performance sport characterized by its speed, precision, and intense physical and mental demands (Galas et al. 2023). With its inclusion in major international competitions, such as the Olympics and World Championships, the sport has gained global prestige and recognition. This evolution has not only elevated the technical standards of the game but also intensified the need to understand the underlying factors that contribute to elite performance. Among these factors, psychophysiological characteristics—comprising both physiological and psychological components—have emerged as key determinants of competitive success (Zhang et al., 2023). These elements influence how athletes prepare, perform, and recover, and they vary across different national systems, cultural contexts, and developmental structures.

This study explores the psychophysiological landscape of table tennis by comparing state-level athletes from Malaysia and China—two countries with differing approaches to sports training and development. While China is widely acknowledged as a global powerhouse in table tennis, largely due to its state-sponsored, rigorously structured programs, Malaysia represents a developing model that seeks to balance academic and athletic commitments within a multi-ethnic society. By examining physiological metrics such as heart rate, VO_2 max, BMI, and oxygen saturation alongside psychological variables like anxiety, mental toughness, and concentration,

this research aims to uncover the multifaceted nature of performance in table tennis. In doing so, it highlights how physical readiness, mental conditioning, and socio-cultural influences converge to shape athlete development and success in competitive sports.

1.2.1 The Evolution and Globalisation of Table Tennis

Table tennis, commonly referred to as ping pong, began as a recreational pastime among England's upper-class society during the late 19th century. Initially perceived as a parlor game played indoors with improvised equipment such as books for nets and champagne corks for balls, the game soon evolved into a structured sport. Mousset et al. (2021) noted that its transformation from a playful imitation of lawn tennis into a codified competitive activity was facilitated by the establishment of formal rules and standardized equipment, including celluloid balls and wooden paddles. This transition marked the genesis of table tennis as a recognized sport and laid the groundwork for its international dissemination.

The early 20th century witnessed the rapid spread of table tennis across Europe and into Asia. The formation of national table tennis associations, followed by the establishment of the International Table Tennis Federation (ITTF) in 1926, provided a global platform for standardization and competition. The first official World Table Tennis Championships were held in the same year, affirming the sport's growing legitimacy and appeal. Its eventual inclusion in the 1988 Seoul Olympics further elevated its status, transforming it from a recreational activity to a professional sport embraced by millions around the world. Today, table tennis is played in over

200 countries and is widely regarded for its accessibility, low-cost equipment, and appeal to individuals across all age groups and skill levels.

China’s embrace and subsequent transformation of table tennis stand out as a defining chapter in the sport's globalization. Initially introduced to China in the early 20th century by Westerners, the game gradually gained popularity among Chinese students and sports clubs. However, it was during the 1950s that the Chinese government began systematically integrating table tennis into its national sports agenda. Boucher and Pope (2022) argue that China’s elevation of the sport to a tool of nation-building and soft diplomacy contributed to its immense success on the global stage. Table tennis was not merely seen as a sport but as a strategic cultural asset capable of uniting the population and representing the nation internationally. The term “national ball” became synonymous with table tennis, reinforcing its symbolic value and strategic importance in Chinese society.

China's state-driven model introduced comprehensive athlete identification and development systems through sports schools and regional training centers (Haugen, 2021). These institutions nurtured young talents with access to scientific coaching methods, psychological conditioning, and world-class facilities. As a result, China has produced generations of elite players, such as Deng Yaping, Zhang Jike, and Ma Long, who have collectively dominated world championships and Olympic events. According to He and Liu (2023), China’s sustained investment in research-based training, biomechanics, and mental skills coaching has cemented its place as the global powerhouse in table tennis, with unmatched consistency and international accolades.

Malaysia's development of table tennis, while not as dominant, reflects its commitment to cultivating a strong multi-ethnic sports culture post-independence. The sport was introduced during British colonial rule and gradually became part of the national sports scene. In the decades following independence in 1957, Malaysia began to institutionalize table tennis through the formation of clubs, school-level competitions, and regional tournaments. The establishment of the Table Tennis Association of Malaysia (TTAM) in the mid-20th century marked a pivotal moment in formalizing the sport's governance and talent pipeline. TTAM has since worked to standardize coaching, introduce age-group competitions, and strengthen ties with the ITTF, thereby raising the profile of Malaysian table tennis on both the regional and international levels.

Malaysia's table tennis development has largely emphasized inclusivity and participation, aligning with its multicultural ethos. National initiatives, such as the SUKMA Games and MSSM (Malaysian Schools Sports Council) competitions, provide platforms for youth involvement across diverse backgrounds. However, as pointed out by Ahmad and Gan (2021), Malaysia's decentralized approach—while encouraging broader participation—often lacks the high-intensity, centralized training models observed in countries like China. This difference in training infrastructure and policy focus contributes to performance disparities at the elite level, despite the presence of talented athletes.

The continued globalisation of table tennis has created an increasingly competitive environment, fostering international comparisons of training efficiency, coaching styles, and athlete development strategies. Nations with well-established infrastructure and support systems, such as China, often outperform others in terms of medal counts and world rankings. However, countries like Malaysia are making

strides through regional competitions, international exposure, and grassroots development. These comparative trajectories not only highlight varying sports philosophies but also underscore the importance of understanding how sociocultural, economic, and institutional factors shape sporting success.

Given the growing complexity of international competition and athlete preparation, the study of psychophysiological and psychological factors in table tennis has gained increasing relevance. In an era where milliseconds matter and mental resilience often determines outcomes, examining the training systems and athlete experiences of countries like China and Malaysia offers valuable insights into the broader dynamics of global sports performance (Chowdhury, 2024). The evolving landscape of table tennis serves as a microcosm of how sport, culture, and science intersect, thereby providing an ideal context for this comparative research.

1.2.2 The Role of Psychophysiological Factors in Table Tennis Performance

Table tennis, often underestimated for its complexity, is in fact a highly dynamic sport that demands a unique combination of speed, precision, and psychological acuity (Zhang et al., 2023). Matches are typically characterized by rapid exchanges, short reaction times, and constant cognitive decision-making under pressure. Klein-Soetebier et al. (2021) claimed that athletes must process visual and auditory cues, anticipate opponents' moves, and respond with technical accuracy—all within milliseconds. In such a fast-paced and unpredictable environment, success depends not only on physical conditioning but also on psychological preparedness. As a result, the concept of psychophysiological performance, which refers to the integrated relationship between physiological functioning and psychological states, has

emerged as a crucial area of focus in elite table tennis training and performance research (Kumar et al., 2022).

From a physiological standpoint, certain biomarkers are consistently used to assess an athlete's readiness and adaptability to the demands of the sport. Among the most important indicators are heart rate, VO_2 max (maximal oxygen uptake), oxygen saturation levels, and body mass index (BMI). These measures provide insight into an athlete's cardiovascular efficiency, aerobic capacity, and overall body composition (Deliceoğlu et al., 2024; Zamodics et al., 2025). For example, VO_2 max has been identified as a key determinant of endurance and stamina, particularly in matches involving prolonged rallies and high-intensity footwork (Ndlomo, 2022; Rodríguez-Fernández & Sánchez-Sánchez, 2025). Pradas et al. (2023) reported that elite table tennis players with superior VO_2 max values tend to maintain consistent performance throughout long matches, showing resilience against fatigue and better recovery between rallies. Similarly, resting heart rate and post-exercise recovery time are reliable indicators of cardiovascular health and conditioning (da Fonseca et al., 2024).

Oxygen saturation, on the other hand, reflects the athlete's ability to maintain adequate oxygen supply to the muscles during intense activity (Perrey, 2022). In high-stakes competitions where physical and mental stress peaks, efficient oxygen utilization becomes essential for maintaining precision and agility. Body mass index (BMI), although a more generalized measure, is used in conjunction with other data to monitor athletes' body composition. Huang et al. (2023) and Pradas et al., (202!) asserted that maintaining an optimal BMI is important in table tennis, where excessive weight may impede agility and quick foot movements, while extremely low body mass may affect endurance and strength. Therefore, a balanced physical

profile is necessary to ensure both explosiveness and stamina across varying match conditions.

While the physiological aspects are foundational, the psychological components often become the distinguishing factor in determining match outcomes, especially among athletes with similar physical capabilities (Kalisch et al., 2021). Goldstein (2025) explained that psychological readiness involves managing pre-match nerves, maintaining focus, sustaining motivation, and coping with high-pressure situations. Key constructs include anxiety, mental toughness, concentration, and arousal regulation (Julvanichpong et al., 2022; Pramesti et al., 2022). Research by Liting et al. (2020) highlights that athletes with strong mental toughness are better able to recover from setbacks, maintain strategic clarity under stress, and execute game plans effectively. Moreover, anxiety—particularly cognitive and somatic anxiety—has been shown to influence performance trajectories. Cognitive anxiety involves the mental worry or fear of failure, while somatic anxiety reflects physiological manifestations such as increased heart rate, muscle tension, or sweating (Barros et al., 2022). Athletes who can manage both are more likely to maintain consistency and confidence throughout their matches.

In elite table tennis, particularly in powerhouse nations like China, mental skills training is integrated into the athlete development pipeline. Techniques such as goal-setting, visualization, and attentional control drills are employed alongside physical training (Liu et al., 2024). This dual emphasis ensures athletes are equipped to handle both the physiological rigors and the psychological demands of competition. The Chinese approach often includes access to sports psychologists, regular psychological profiling, and structured cognitive conditioning programs (Zhang et al.,

2023). Such systems foster psychological resilience, allowing players to remain calm under pressure and adapt strategically during gameplay.

In contrast, countries like Malaysia are still developing a holistic framework that incorporates psychophysiological factors into athlete training. While physical conditioning is emphasized, psychological readiness is often underrepresented in state-level development programs. This gap is particularly critical given that many Malaysian athletes balance academic commitments with sports, which can amplify stress and disrupt performance. Moreover, limited access to mental health resources, performance psychologists, and individualized psychological interventions means that many athletes are left to navigate mental challenges on their own. The absence of structured psychological support may result in increased cognitive anxiety, decreased confidence, and reduced focus during crucial match moments.

Another significant issue is the lack of integrated assessment systems that combine physiological and psychological data to monitor athlete progress comprehensively (Spanakis et al., 2024). While some training centers may track VO_2 max or heart rate variability, few programs contextualize these metrics alongside indicators of mental toughness or anxiety. This disconnect hinders the ability to implement data-driven training plans that address the athlete as a whole. Without acknowledging the interplay between body and mind, developmental programs risk producing athletes who are physically prepared but psychologically unready for the complexities of competitive performance.

Therefore, the need for comparative research in psychophysiological performance between athletes from different sports systems is more pressing than ever (Podrigalo et al., 2023; Tsatsiashvili & Shonia, 2023). Despite the increasing

awareness of these factors in sports science, very few empirical studies have explored the intersection of physical and psychological metrics among table tennis players, particularly at the state level. This gap is especially evident in Southeast Asian contexts, where resources and infrastructure may not yet support the integration of sports psychology into regular training. To address this shortfall, this study seeks to provide a comprehensive comparison between Malaysian and Chinese state-level table tennis players, highlighting not only the differences in their physiological profiles but also the psychological dimensions that influence their performance.

By doing so, this research contributes to a more nuanced understanding of the interconnected nature of physical fitness and mental preparedness, encouraging the implementation of integrated training systems in both emerging and established sporting nations. It serves as a call to action for coaches, policymakers, and sports scientists to embrace a psychophysiological framework that views athletes as complex, multidimensional performers—capable of reaching their fullest potential only when body and mind are trained in harmony.

1.2.3 State-Level Table Tennis Development in China and Malaysia

The development of table tennis at the state level differs markedly between China and Malaysia, reflecting each nation's broader sports policy priorities, institutional capacities, and cultural attitudes toward athletic excellence. In China, the foundation of table tennis development lies in a centralized and well-funded sports ecosystem that begins talent identification at a very early age. Children as young as six or seven are scouted through school competitions, regional tournaments, or talent search

initiatives, and those demonstrating potential are funneled into specialized sports schools. These institutions serve not merely as training grounds but as comprehensive development centers that combine academic learning with intensive athletic instruction. The goal is not just to produce skilled players, but to develop elite athletes capable of competing at the national and international levels.

These Chinese sports schools and academies operate under the guidance of the General Administration of Sport of China, which establishes standards and ensures the integration of best practices in coaching, monitoring, and performance management (Chen & Chen, 2022). Athletes receive daily training from certified coaches who adhere to scientifically grounded periodization models. In addition, they benefit from multidisciplinary support teams that include sports psychologists, physiotherapists, strength and conditioning experts, nutritionists, and biomechanical analysts (Zhang, 2023). This holistic approach ensures that athletes are not only technically proficient but also physically robust and mentally prepared to face the pressures of high-stakes competitions.

A defining feature of China's state-level sports development is its data-driven philosophy. Athletes undergo regular performance assessments involving advanced technologies such as motion analysis, wearable biometric trackers, and video playback systems (Liu et al., 2023). These tools are used to fine-tune techniques, monitor physiological changes, and evaluate psychological responses to training stressors. Psychological conditioning is an integral part of the training process, and athletes routinely participate in sessions aimed at improving focus, reducing performance anxiety, and building resilience (Talha, 2023). As noted by Xu and Wang (2022), such programs contribute to the consistency and international

dominance of Chinese athletes in sports like table tennis, where mental and physical demands are deeply intertwined.

Malaysia, in contrast, adopts a more decentralized and multifaceted approach to athlete development, which reflects its multicultural society, varying resource availability across states, and differing institutional priorities (Meng et al., 2024). While Malaysia has made commendable strides in sports development, the infrastructure supporting state-level table tennis remains uneven. Athletes often balance academic responsibilities with sports commitments, which can disrupt the continuity and intensity of their training. Unlike China's centralized approach, training schedules in Malaysia can vary widely from one state to another, influenced by the availability of qualified coaches, access to facilities, and the level of support from local sports councils or schools.

Despite these challenges, the Malaysian government and the Table Tennis Association of Malaysia (TTAM) have implemented several initiatives aimed at improving the national sports landscape. Programs under the Ministry of Youth and Sports, such as National Sports Schools, Talent Identification Camps, and the Podium Program, aim to streamline talent development and prepare athletes for high-level competition (Sajadi et al., 2024). However, the reach and effectiveness of these programs at the grassroots and state levels remain limited. Many athletes continue to train in environments that lack dedicated psychological support, structured fitness monitoring, and individualized performance plans.

Another key difference lies in the integration of sports science and psychology. In Malaysia, most training programs focus heavily on technical and tactical development, often neglecting the psychological dimensions of performance (Wong

et al., 2024). While basic fitness routines and skill drills are common, mental skills training, stress management strategies, and visualization techniques are not uniformly practiced across states. In contrast, Chinese coaches routinely incorporate mental rehearsal, concentration drills, and controlled breathing techniques into daily training. These elements are seen not as supplementary, but as essential for developing well-rounded athletes.

This disparity in the application of psychophysiological optimization strategies creates a performance gap that becomes evident during international competitions. Malaysian athletes may demonstrate strong technical skills but struggle with mental consistency and recovery under pressure, especially in matches that require sustained focus and emotional regulation (Wong et al., 2024). Meanwhile, Chinese athletes benefit from repeated exposure to high-pressure simulations, peer competition, and structured psychological preparation, which enhances their ability to deliver consistent performance even under extreme stress.

Furthermore, the institutional culture surrounding sports in both countries plays a significant role in shaping athlete development. In China, sports is viewed as a path to national prestige, and athletes are encouraged to pursue excellence as a matter of national duty (Zhouxiang & Hong, 2021). There is substantial societal support for those involved in competitive sports, and athletes often enjoy privileges such as scholarships, stipends, and job placements upon retirement. In contrast, Malaysian society often places greater emphasis on academic achievement, and athletes may face pressure from families and schools to prioritize education over sports (Rahaman et al., 2024). This dual expectation can lead to conflicting commitments, which affect the consistency and psychological readiness of athletes.

The coaching culture also reflects this divide. Chinese coaches often operate within a hierarchical structure, where strict discipline and adherence to training protocols are emphasized (Chen & Chen, 2022). Feedback is immediate, and athletes are expected to respond quickly to corrective instructions. In Malaysia, coaching environments may range from highly structured to informal, depending on the coach's background and access to professional development (Abd Rahman et al., 2024; Yusliza et al., 2021). While some coaches promote athlete-centered approaches that foster creativity and autonomy, others may lack the training to implement scientifically grounded methods.

These variations in systemic structure, coaching philosophy, and institutional support have significant implications for athlete development. They influence not only the physical capabilities of the athletes but also their mental resilience, motivation, and confidence levels. Malaysian players may benefit from greater flexibility and cultural diversity in their training experiences, but without the structural rigor and psychological infrastructure observed in China, they risk facing limitations when competing at higher levels.

Understanding the developmental pathways in both contexts is essential for identifying best practices and areas for improvement. China’s model offers lessons in consistency, scientific integration, and psychological conditioning, while Malaysia's context highlights the importance of balancing academic and athletic goals, cultural inclusivity, and flexible athlete management. A comparative analysis of these systems can serve as a valuable resource for policymakers, sports administrators, and coaches seeking to enhance talent identification and athlete development in Malaysia and beyond.

Ultimately, this study aims to uncover how these divergent systems impact the psychophysiological outcomes of state-level athletes in table tennis. By doing so, it will contribute to a deeper understanding of how training environments, institutional support, and cultural factors shape athletic performance. The goal is not to suggest that one model is superior, but to identify actionable insights that can inform the design of more holistic and effective development programs across diverse sporting contexts.

1.2.4 Cultural and Environmental Influences on Sports Psychology

The psychological development of athletes does not occur in a vacuum; it is heavily shaped by the broader cultural and environmental context in which athletes are raised and trained. Culture not only influences how individuals perceive success, failure, competition, and discipline but also molds the way they respond to pressure, setbacks, and emotional challenges (Prots et al. 2021). These influences are particularly salient in the realm of sports psychology, where mental resilience, focus, confidence, and emotional regulation are critical determinants of performance outcomes.

In collectivist societies such as China, cultural norms place a high value on conformity, perseverance, and loyalty to group objectives. These values are deeply embedded in the training and development of athletes. From a young age, Chinese athletes are socialized into a system that emphasizes obedience to authority, respect for coaches, and dedication to team and national goals (Zhu et al., 2024). Success in sport is viewed not only as an individual accomplishment but also as a contribution to national prestige (Zhouxiang & Hong, 2021). According to Liang and Yu (2022), this

orientation fosters a strong sense of duty, discipline, and sacrifice, which can reinforce mental toughness and the ability to endure demanding training schedules without complaint.

This cultural backdrop shapes Chinese athletes' responses to psychological stressors. The pressure to succeed is immense, but it is normalized within a societal context that celebrates endurance and achievement. Chinese training institutions often embed traditional Confucian values, which emphasize hierarchical respect and self-restraint, into their coaching practices (Snell et al., 2022). Athletes are expected to suppress individual emotions, comply with rigorous routines, and internalize the notion that excellence is achieved through repetition, suffering, and long-term commitment. Such values contribute to the development of psychological traits like delayed gratification, emotional control, and performance consistency under pressure, all of which are essential in high-level sports.

Malaysia, on the other hand, presents a pluralistic and multicultural society, where the interplay of Malay, Chinese, Indian, and indigenous traditions produces a more varied psychological environment (Awang et al., 2022). While values such as hard work and discipline are shared across communities, the emphasis on competitive sports varies across ethnic, regional, and socio-economic lines. In certain communities, sports may be viewed as a legitimate career path, while in others, it may be seen as secondary to academic achievement or economic stability (Durisic, 2022). This cultural diversity contributes to heterogeneous levels of support for athletes, influencing their self-perception, confidence, and resilience in different ways.

Malaysian athletes may also face competing demands between education and sport, which can lead to elevated cognitive anxiety and reduced focus during

training and competition. As noted by Azizan et al. (2021), the academic success of youth is often prioritized in Malaysian families, and the pursuit of sporting excellence may be seen as risky or uncertain. This dual expectation places psychological strain on young athletes, who may experience guilt for dedicating time to sport instead of academics, or feel pressure to excel in both domains simultaneously. Unlike in China, where elite athletes are often excused from formal academic obligations to focus entirely on sport, Malaysian athletes are frequently required to juggle multiple responsibilities, which can dilute the intensity and focus of their training.

The training environment itself is another key determinant of psychological development (Wang & Park, 2021). In China, the coach-athlete relationship is typically hierarchical, with coaches assuming authoritarian roles that command respect and obedience (Li & Li, 2021). This structure can enhance clarity of expectations, discipline, and immediate behavioral correction, all of which can strengthen psychological conditioning. Feedback is direct, and athletes are expected to respond promptly to instructions without resistance. Moreover, mental skills training—such as visualization, breathing exercises, emotional regulation drills, and pre-competition rituals—is often embedded into daily routines, further reinforcing mental resilience (Tang & Lim, 2025).

In contrast, coaching practices in Malaysia can vary significantly across states, schools, and training centers. While some Malaysian coaches adopt structured, evidence-based methods, others may rely on informal approaches shaped by personal experience rather than psychological science (Koh et al., 2024). The variability in coaching quality can result in inconsistent development of psychological skills, with some athletes benefiting from individualized mental support and others receiving little to none. Furthermore, the coach-athlete dynamic in Malaysia is often

less formal and more interpersonal, influenced by local cultural norms that emphasize approachability and mutual respect (Chen & Mok, 2024). While this can create a more nurturing environment, it may also limit the enforcement of strict psychological conditioning practices.

Parental involvement also differs markedly between the two countries. In China, parents often entrust the development of their children to sports institutions and play a more passive role, focusing instead on outcomes such as competition wins or university placements secured through sports quotas (Liu et al., 2024). In Malaysia, however, parents tend to be more directly involved in their children's athletic pursuits, offering emotional and logistical support but also voicing concerns about long-term career security. This involvement can be both a source of motivation and pressure, depending on the expectations set by the family.

Peer support systems also contribute to psychological outcomes. Chinese athletes often live and train with their teammates in residential sports academies, creating strong peer bonds that foster a sense of collective identity and shared goals (Ni et al., 2025). This cohesion reinforces emotional stability and a team-oriented mindset, buffering against individual stress. In Malaysia, athletes may train part-time or in decentralized facilities, which can limit opportunities for sustained peer interaction and diminish the formation of close athletic communities. As a result, athletes may experience greater social isolation, especially during periods of poor performance or injury.

Environmental factors such as facility availability, access to sports psychologists, and exposure to competitive events further shape psychophysiological development (Alasinrin et al., 2024). Chinese athletes benefit from state-of-the-art

facilities, structured competition calendars, and regular exposure to high-pressure scenarios, which help them develop coping mechanisms and adaptive responses. Malaysian athletes, particularly those outside urban centers, may face constraints in accessing similar resources, leading to uneven psychological preparedness and performance outcomes.

By incorporating cultural and environmental variables into the study of psychophysiological performance, this research acknowledges that athlete development is not merely a function of biological traits or technical training. Instead, it is a complex, socially embedded process influenced by norms, expectations, and institutional practices. A nuanced understanding of these influences allows for more culturally sensitive training interventions that take into account the psychosocial realities faced by athletes from different backgrounds.

Ultimately, this study highlights the importance of contextualizing sports psychology within broader sociocultural frameworks. It calls for the development of athlete-centered programs that integrate not only physical and technical training but also culturally responsive psychological support. In Malaysia, this might involve improving access to mental health resources in sports, training coaches in psychological literacy, and creating public awareness about the value of psychological resilience in athletic success. In China, ongoing efforts could be made to balance the benefits of strict discipline with the need for emotional autonomy and mental well-being.

By recognizing and responding to the cultural and environmental dimensions of athletic development, stakeholders can build more effective and equitable sports systems. These systems will not only produce technically skilled athletes but also

psychologically resilient individuals capable of thriving in the increasingly competitive and globalized world of table tennis.

1.3 Problem Statement

Athletic performance in high-speed, reaction-based sports like table tennis is the product of a dynamic interplay between physiological readiness and psychological resilience (Wang, 2023; Zhang et al., 2025). In such sports, where decisions must be made within fractions of a second and movements must be both explosive and controlled, neither physical conditioning nor mental focus can be viewed in isolation. Despite this reality, existing research continues to treat these domains separately, rarely integrating them in a comprehensive analytical framework (Çocuk et al, 2025; Ferrandez et al., 2021; Sharma, 2022; Sharma et al., 2024). This oversight is particularly apparent at the state-athlete level, where performance discrepancies between nations like Malaysia and China remain largely unexplained by conventional analyses. The absence of integrated psychophysiological profiling represents a critical gap that this study aims to address.

Table tennis is not merely a sport of reflexes but one that also requires sustained cognitive engagement, high-level decision-making, and tactical precision under duress (Zhang et al., 2023). Athletes must constantly monitor, anticipate, and react to opponents' movements while regulating their own bodily control and maintaining peak physical condition. This makes the sport uniquely dependent on both mental and physical faculties operating at optimal levels. Researchers such as Hertting et al. (2018) and Peng and Kim (2023) have underscored the importance of psychological traits like attentional control, emotional regulation, and performance

under pressure. However, the current body of literature lacks attempts to investigate these psychological elements alongside physiological indicators such as BMI, heart rate variability, oxygen saturation, and VO_2 max within a shared empirical framework.

This disjointed approach to analyzing performance is problematic because psychological and physiological factors often co-influence one another in real-time. An athlete with high aerobic capacity may still succumb to performance anxiety or mental fatigue under pressure. Similarly, athletes with superior mental toughness may find their performance constrained by poor cardiovascular conditioning or inadequate oxygen utilization. Several studies (Guo & Chang, 2024; Bastug & Sitki, 2018) have discussed the independent contributions of mental or physical variables to athletic success, but these studies typically lack the holistic lens required to explore how these variables interact. This results in a significant theoretical and practical blind spot, especially for developing countries like Malaysia where optimizing limited training resources is paramount.

Furthermore, the stark performance contrast between China and Malaysia in international table tennis competitions raises important questions about systemic and structural differences in athlete development. As of 2024, China ranks 1st in the world in table tennis according to the International Table Tennis Federation (ITTF), while Malaysia holds a much lower position, ranked 45th. This stark contrast in global performance rankings underscores the urgency of examining the systemic, physiological, and psychological differences that may contribute to such disparities. China, often regarded as a global leader in table tennis, has institutionalized a training ecosystem that integrates sport science, psychological conditioning, and early talent identification. Athletes are systematically monitored from a young age and receive consistent exposure to high-pressure environments that cultivate both

physical endurance and mental discipline. In contrast, Malaysian table tennis development remains more decentralized, with inconsistent training structures and limited access to psychological or physiological support services. These institutional disparities are well documented (Guo et al., 2020; Ibrahim et al., 2022) but have not yet been explored through a psychophysiological comparative framework.

The lack of country-specific integrated data on both physiological and psychological metrics creates a practical bottleneck in designing effective athlete development programs. Coaches and sports scientists often rely on generalized assessment tools that focus on basic fitness tests or subjective observations, without capturing how psychological readiness may buffer or exacerbate physiological responses during competition. For example, athletes experiencing high anxiety may have elevated heart rates that negatively impact precision and timing, yet such patterns remain undiagnosed in the absence of integrative data collection. Kumar et al. (2022) argue that without simultaneous monitoring of mental and physical indicators, performance evaluations remain superficial and fail to provide actionable insights.

This fragmented approach to profiling also undermines the personalization of training. While some athletes may require focused attention on their aerobic endurance or muscular strength, others may benefit more from psychological coaching to manage competitive stress or improve concentration. The failure to distinguish between these needs leads to one-size-fits-all programs that may overlook the root causes of underperformance. A holistic psychophysiological profile can help segment athletes into meaningful categories for tailored intervention, thereby optimizing training outcomes and reducing injury risks associated with mismatched regimens.

Moreover, the Malaysian context presents additional layers of complexity due to its multicultural and academically driven environment. Unlike China's centralized sports schooling model, Malaysian athletes often navigate the dual demands of academics and sports with less institutional support. This may result in heightened cognitive anxiety, inconsistent training schedules, and limited recovery time—all of which impact both physiological and psychological well-being. These contextual stressors have not been sufficiently explored in relation to measurable performance indicators, leading to speculative conclusions about athlete development challenges in Malaysia. Without empirical comparison to more structured systems like China's, Malaysian sports policy remains reactive rather than proactive in its design.

China's collectivist cultural values, hierarchical coaching models, and high-performance expectations further influence the development of psychological traits like emotional suppression, grit, and obedience to authority—all of which may affect how Chinese athletes cope with stress (Kun et al., 2023). On the other hand, Malaysia's more individualistic, community-oriented values might cultivate resilience in a different form but also introduce variability in athlete motivation and engagement. These environmental and cultural influences likely shape both the expression and development of psychophysiological traits, yet comparative data is almost entirely absent from the current body of literature. Without such insights, any conclusions about training efficacy or athlete readiness remain incomplete.

Additionally, while there is growing recognition globally of the importance of sports psychology, its implementation remains uneven (Nicholls, 2021). China has increasingly integrated mental skills training—including goal setting, visualization, and emotion regulation—into its state sports academies. In contrast, Malaysia still faces barriers in making psychological services accessible to young athletes,

especially at the state level (Rahaman et al., 2024; Wong et al., 2024). The uneven distribution of these resources not only exacerbates performance disparities but also leaves Malaysian coaches and athletes under-equipped to deal with the psychological demands of elite competition.

In light of these challenges, the absence of a comprehensive psychophysiological model is both a research gap and a practical problem. This study aims to respond to this gap by offering a comparative analysis of state-level table tennis players in Malaysia and China. By integrating data on BMI, heart rate, VO_2 max, and oxygen levels with psychological measures such as mental toughness, concentration, and anxiety, the study seeks to generate an evidence-based profile of performance drivers in each context. Such a model can inform individualized coaching plans, resource allocation decisions, and national sports development policies.

This research also holds theoretical significance. It challenges the traditional siloed approach to sports science by arguing for a more interdisciplinary framework that views physiological and psychological attributes as co-constitutive rather than separate. As proposed by Liting et al. (2020) and Pradas et al. (2023), the future of athlete performance optimization lies in moving beyond reductionist models and embracing integrated approaches that reflect the complex realities of competitive sport. This study contributes to that evolution by grounding its inquiry in both empirical data and contextual analysis.

In conclusion, the central issue this research addresses is the lack of integrated psychophysiological profiling among table tennis players from two nations with vastly different training environments. Without such comparative insight, efforts

to improve training effectiveness, enhance psychological readiness, and reduce the performance gap between China and Malaysia will remain hindered. The study not only fills a significant gap in the literature but also offers practical strategies for athlete development that are evidence-based, context-sensitive, and culturally informed.

1.4 Purpose of the Study

The primary purpose of this study is to conduct a comprehensive analysis of the psychophysiological profiles of state-level table tennis players in Malaysia and China. This investigation includes both psychological and physiological components, which are essential for understanding the holistic makeup of an elite athlete in a cognitively demanding and physically intense sport like table tennis. On the psychological side, the study focuses on core constructs such as mental toughness, anxiety levels, and concentration, while on the physiological side, it investigates body mass index (BMI), heart rate, oxygen saturation levels, and maximum oxygen uptake (Vo_2 max). These selected variables are strategically chosen for their relevance to athletic performance and for their interconnectivity in determining outcomes in high-stakes competition.

Table tennis is uniquely positioned as a sport where performance hinges on split-second decision-making, precision motor skills, and sustained cognitive alertness. Unlike many other endurance-based sports, the physical and psychological demands in table tennis occur in rapid bursts, often within rallies that last mere seconds. As such, physical endurance alone is insufficient to ensure success. Psychological attributes such as the ability to remain calm under pressure, maintain intense focus, and adapt strategies mid-game are equally critical. This study

aims to bridge the existing gap in the literature by offering an integrated perspective—one that accounts for the reciprocal influence of mind and body on performance outcomes.

Another key aim of this study is to systematically compare Malaysian and Chinese state-level players in terms of their psychophysiological profiles. China, with its long-standing dominance in the international table tennis arena, provides a valuable benchmark for comparison. Malaysian athletes, while showing steady improvement, have not yet achieved consistent success at the international level. This study, therefore, seeks to identify whether psychophysiological discrepancies exist between athletes from these two nations and, if so, how those differences may contribute to the performance gap. Such comparisons can provide empirical evidence to inform interventions and reforms in athlete preparation programs in Malaysia and similar developing sports contexts.

Additionally, this study is guided by the belief that athlete development should be informed by empirical data rather than assumptions or one-size-fits-all models. By generating measurable data across two contrasting populations, this research seeks to present a nuanced understanding of how various psychophysiological factors combine to influence performance. Rather than isolating one factor at a time, the purpose is to capture the dynamic interplay of variables—how anxiety may affect heart rate, how VO_2 max correlates with mental endurance, and how BMI might influence agility and decision-making under pressure. Such integrated profiling is rarely explored in current literature but is crucial for designing more effective and individualized training programs.

From a practical standpoint, the findings of this study will serve as a valuable resource for coaches, trainers, and sports scientists. In the Malaysian context, where sports science support structures are still evolving, the study can offer a template for athlete assessment and monitoring. By identifying which physiological and psychological markers are most predictive of performance, stakeholders can tailor their training methods, mental conditioning programs, and fitness regimens accordingly. In China, the results may further validate existing methodologies or uncover new opportunities to refine athlete development protocols, especially at the state level.

Beyond the practical implications, the study also aims to contribute to the academic discourse on psychophysiology in sports. While there is an abundance of research on individual psychological or physiological factors, studies that consider both in an integrated framework—particularly in racquet sports like table tennis—are still limited. This study addresses that gap by combining theoretical knowledge from sport psychology and exercise physiology to offer a more holistic understanding of athletic excellence. The results are expected to advance theoretical models of sports performance and may serve as a reference for future cross-cultural or cross-sport comparative studies.

The study also holds cultural and developmental significance. As highlighted in the background section, differences in national training systems, sociocultural values, and educational priorities can influence the development of psychological and physiological traits in athletes. By investigating how these external factors manifest in measurable performance outcomes, the study contributes to a culturally sensitive understanding of athlete development. It recognizes that mental toughness or cardiovascular fitness does not develop in isolation but is shaped by a broader

ecosystem involving coaching philosophy, family support, institutional structures, and societal expectations.

In summary, the purpose of this study is multifaceted. It aims to provide a data-driven, cross-national comparison of psychophysiological factors in table tennis; to generate practical insights for athlete development in Malaysia and China; to contribute to academic theory through an integrated research model; and to deepen the understanding of how cultural and training contexts shape athlete potential. Ultimately, this research aspires to not only fill a notable gap in the existing literature but also to inspire future innovations in the assessment, training, and support of elite athletes in racquet sports.

1.5 Objectives of the Study

The primary objective of this study is to assess and compare the psychophysiological profiles of table tennis players of Perak and Yinchuan. Specifically, the research aims to assess and analyze various factors, including BMI, heart rate, oxygen levels, and Vo2max (physiological aspects), as well as mental toughness, anxiety, and concentration (psychological aspects). The specific objectives of the study are as follows:

1. To determine the characteristics (age, gender, training time in one week, years of experience, types of event participated) among table tennis players in Perak and Yinchuan.

2. To compare the differences in characteristics (age, gender, training time in

one week, years of experience, types of event participated) between table tennis players in Perak and Yinchuan.

3. To assess the BMI levels of table tennis players in Perak and Yinchuan.

4. To evaluate the heart rate levels of table tennis players in Perak and Yinchuan.

5. To assess the oxygen levels of table tennis players in Perak and Yinchuan.

6. To evaluate the Vo2max levels of table tennis players in Perak and Yinchuan.

7. To assess the levels of mental toughness among table tennis players in Perak and Yinchuan.

8. To assess the levels of anxiety among table tennis players in Perak and Yinchuan.

9. To evaluate the levels of concentration among table tennis players in Perak and Yinchuan.

10. To examine the correlation among physiological levels (BMI, heart rate, oxygen, Vo2max) between Perak and Yinchuan table tennis players.

11. To examine the correlation among psychological levels (mental toughness, anxiety, and concentration) between Perak and Yinchuan table tennis players.

1.6 Research Questions

The study is guided by the following research questions:

1. What are the characteristics (age, gender, training time in one week, years of experience, types of event participated) among table tennis players in Perak and Yinchuan?

2. What are the differences in characteristics (age, gender, training time in one week, years of experience, types of event participated) between table tennis players in Perak and Yinchuan?

3. What are the BMI levels of Perak and Yinchuan table tennis players?

4. What are the heart rate levels of Perak and Yinchuan table tennis players?

5. What are the oxygen levels of Perak and Yinchuan table tennis players?

6. What are the Vo2max levels of Perak and Yinchuan table tennis players?

7. What are the levels of mental toughness among Perak and Yinchuan table tennis players?

8. What are the levels of anxiety among Perak and Yinchuan table tennis players?

9. What are the levels of concentration among Perak and Yinchuan table tennis players?

10. Is there a correlation in physiological levels (BMI, heart rate, oxygen, Vo2max) between Perak and Yinchuan table tennis players?

11. Is there a correlation in psychological levels (mental toughness, anxiety, and concentration) between Perak and Yinchuan table tennis players?

1.7 Theoretical Framework

Understanding athlete performance, particularly in a psychophysiological context, requires a multi-layered theoretical foundation that acknowledges the complexities of human motivation, social environment, and biological feedback systems. The theoretical foundation of this study is built upon three key frameworks: Self-Determination Theory (SDT) by Deci and Ryan (1985), Social-Cultural Theory by Vygotsky (1978), and Psychophysiological Specificity proposed by Goldstein and Ungerleider (1989). Each of these theories contributes a distinct dimension to the analysis of athlete behavior, performance, and development, forming a holistic scaffold for profiling table tennis players in Malaysia and China.

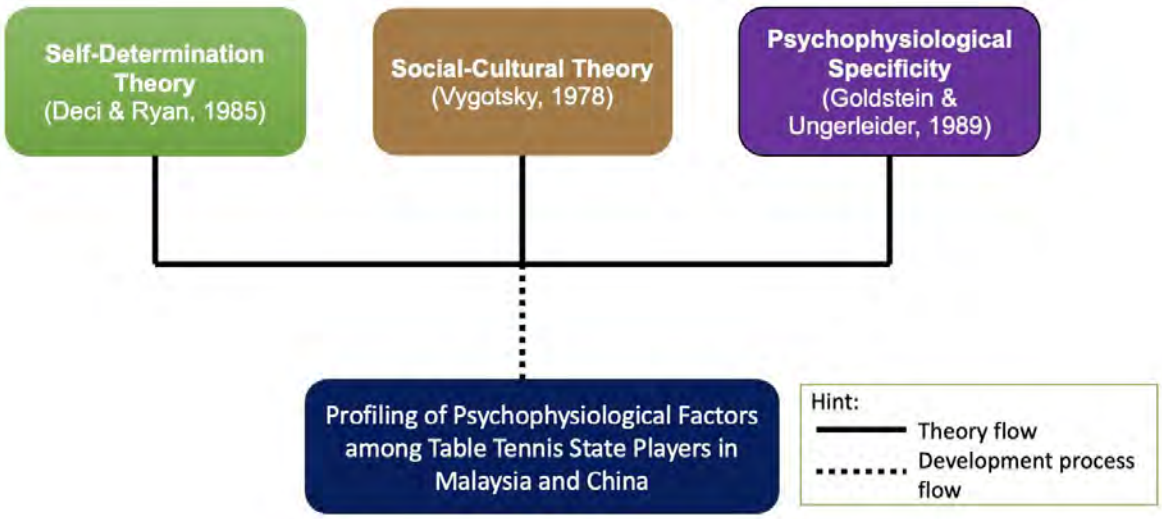
Self-Determination Theory (SDT) primarily addresses the internal motivational forces that drive athletic engagement and persistence. It offers valuable insight into how the fulfillment of basic psychological needs—autonomy, competence, and relatedness—can enhance or inhibit an athlete's internal drive to train and compete. Social-Cultural Theory, on the other hand, shifts the focus from the individual to the

cultural and societal structures that shape learning and development, emphasizing how socio-cultural conditioning and institutional contexts influence an athlete's trajectory. Finally, Psychophysiological Specificity theory provides the biological lens, detailing how distinct psychological states result in specific physiological responses, thus offering a mechanism for integrating mental and physical performance markers.

These theories are not treated in isolation but interactively, as depicted in Figure 1.1, to capture the interconnectedness of motivational climate, socio-cultural influence, and physiological expression in shaping athletic performance. This integrative framework allows the study to analyze the interplay between internal motivation, external training environments, and measurable physiological indicators, thereby facilitating a comprehensive and context-sensitive understanding of athlete development.

Figure 1.1

Theoretical framework of the study



1.7.1 Self-Determination Theory

Self-Determination Theory (SDT), conceptualized by Deci and Ryan (1985), is a prominent framework in motivational psychology that has been extensively applied to the field of sports science and athlete development. The theory posits that human motivation is driven by three fundamental psychological needs: autonomy, competence, and relatedness. These needs are considered innate, essential for psychological growth, and applicable across all cultural and situational contexts, although their manifestation may vary depending on the social environment. When these needs are fulfilled, individuals tend to exhibit intrinsic motivation, marked by self-determined engagement in activities due to personal interest and enjoyment rather than external rewards or pressures.

In sports settings, the relevance of SDT becomes especially apparent, as athletes continuously negotiate between internal desires and external demands. Autonomy refers to an athlete's perception of volitional control over their actions, such as making decisions about training routines or match strategies. Competence reflects an athlete's belief in their ability to effectively execute required skills and succeed in performance tasks. Relatedness, meanwhile, denotes the sense of belonging and connection with significant others, including teammates, coaches, and supporters. When these three needs are consistently supported by the training environment, athletes are more likely to display enhanced emotional well-being, motivation to improve, and persistence in the face of setbacks (Ryan & Deci, 2000).

SDT has been widely validated in empirical sports research, with multiple studies demonstrating its predictive value in understanding athlete engagement, burnout, mental toughness, and long-term performance consistency. For example,

Bhavsar et al. (2020) found that athletes whose coaches supported autonomy, provided positive feedback to enhance competence, and fostered team cohesion through shared goals had significantly lower anxiety levels and better concentration during competition. These findings reinforce the notion that psychological need satisfaction is a cornerstone of athletic excellence, particularly in high-pressure sports like table tennis, where both mental focus and physical agility are essential.

In the context of this comparative study, SDT provides a critical theoretical lens to examine motivational differences between Malaysian and Chinese state-level table tennis players. The Chinese sports training system is characterized by early specialization, centralized coaching, and rigorous training regimens, often underpinned by external rewards such as scholarships, national recognition, or professional contracts. This environment, while structured, may at times constrain autonomy and internal motivation. Athletes may be driven by controlled forms of motivation—such as the desire to meet coach expectations or achieve status—rather than by intrinsic enjoyment. In contrast, Malaysian athletes may operate in less centralized systems, where training environments, coaching quality, and motivational climates vary across regions. This variability can either support or undermine the fulfillment of the three psychological needs, leading to greater individual differences in motivation and performance consistency.

Moreover, the concept of "autonomous motivation"—where athletes engage in sports for internal satisfaction and a sense of personal achievement—has been shown to be more sustainable over time compared to "controlled motivation", which is driven by fear of failure or external pressure. In this regard, Malaysian players who perceive higher autonomy may exhibit greater resilience and creativity, whereas Chinese players exposed to highly structured and controlled training may excel in

discipline and consistency, but face higher risk of burnout or motivational decline if intrinsic interest is not nurtured. This dichotomy provides a compelling basis for cross-cultural investigation into how motivation affects psychophysiological states, such as heart rate, oxygen consumption, anxiety, and concentration.

Additionally, SDT offers practical implications for coaching and training interventions. Coaches who understand the principles of SDT can intentionally foster environments that support autonomy by allowing athletes to participate in decision-making, such as setting personal goals or choosing training strategies. They can nurture competence by designing developmentally appropriate skill challenges, providing constructive feedback, and recognizing improvement. Relatedness can be promoted by emphasizing team spirit, mutual respect, and a positive coach-athlete relationship. These environmental conditions not only influence psychological outcomes like confidence and focus, but also have physiological effects—such as reduced cortisol secretion, lower pre-match heart rate, and faster cardiovascular recovery (Lourenço et al., 2022).

Furthermore, SDT plays a vital role in linking psychological need satisfaction with behavioral regulation and emotional control, which are crucial for psychophysiological performance. Athletes who feel autonomous and competent are more likely to self-regulate their arousal levels, adopt adaptive coping strategies, and exhibit greater control over stress-induced physiological reactions. This is particularly important in table tennis, where rapid decision-making, mental agility, and sustained concentration are necessary to outperform opponents during prolonged rallies and unpredictable gameplay. By incorporating SDT, this study seeks to connect the dots between motivational orientation and physiological markers such as resting heart rate,

VO_2 max, and post-match oxygen saturation, offering a nuanced understanding of athlete readiness and resilience.

The value of SDT also extends to policy formulation and sports development programs. Understanding the motivational needs of athletes in different cultural and organizational contexts can guide policymakers and sports associations in designing athlete-centered programs. For instance, in Malaysia, efforts could be made to improve coach training, enhance athlete feedback mechanisms, and create a more inclusive and motivational climate across state-level training centers. Meanwhile, Chinese sports institutions could explore ways to integrate more autonomy-supportive practices within their otherwise rigid frameworks, helping to balance extrinsic rewards with intrinsic drive.

In conclusion, Self-Determination Theory serves as a cornerstone of the theoretical framework in this study, offering deep insight into how internal motivation—shaped by autonomy, competence, and relatedness—impacts both psychological states and physiological responses. By applying SDT to the comparative analysis of Malaysian and Chinese table tennis players, this study aims to uncover how motivational climates contribute to performance variability, stress regulation, and long-term athlete development. This comprehensive perspective not only enriches the academic discourse but also holds meaningful implications for coaches, athletes, sports psychologists, and policymakers seeking to cultivate motivated, healthy, and high-performing athletes.

1.7.2 Social-Cultural Theory

Social-Cultural Theory, developed by Lev Vygotsky (1978), is a foundational framework in the field of developmental psychology that emphasizes the central role of social interaction, cultural tools, and community norms in shaping an individual's cognitive, emotional, and behavioral development. Unlike theories that prioritize internal or biological processes, Social-Cultural Theory asserts that learning and development are inseparable from the cultural and social contexts in which individuals are embedded. It posits that knowledge is co-constructed through dialogue, mentorship, and shared cultural practices, all of which profoundly influence how individuals think, feel, and act—including in high-performance sports.

One of the central concepts of Vygotsky's theory is the Zone of Proximal Development (ZPD), which refers to the range of tasks an individual can perform with guidance but not yet independently. In sports, this can be likened to how athletes improve their techniques, tactical decisions, or mental strategies with the help of more knowledgeable others—typically coaches, senior athletes, or sports psychologists. The ZPD highlights the importance of scaffolded learning, where the support provided gradually fades as the athlete gains competence. This concept underscores why social guidance and structured feedback are essential for athletic growth, especially in skill-dense and mentally demanding sports like table tennis.

In the realm of sports science, Social-Cultural Theory provides a valuable framework for understanding how cultural norms, societal expectations, and institutional structures shape the development of athletes. In China, for example, table tennis is not merely a recreational activity; it is a culturally significant sport imbued with national identity, political symbolism, and collective pride. Young

athletes are often enrolled in state-sponsored sports schools from an early age, where rigorous physical training is supplemented by a strong emphasis on discipline, obedience, and emotional resilience. The social narrative surrounding table tennis in China equates athletic success with patriotism and societal contribution, thereby reinforcing a performance-driven mindset that may influence both psychological development and physiological readiness.

This cultural embedding of table tennis in China contributes to intense psychological pressure but also fosters deep intrinsic meaning for athletes. Social-Cultural Theory helps illuminate how such cultural meanings are internalized, influencing mental toughness, competitive anxiety, and the ability to regulate emotions under stress. The hierarchical and collectivist nature of Chinese society also shapes the coach-athlete relationship, where authority is rarely questioned, and performance expectations are high. This can result in heightened focus and compliance but may also inhibit autonomy or creative expression—factors which can have both psychological and physiological repercussions.

In contrast, Malaysia presents a far more heterogeneous and pluralistic socio-cultural context. The country's multi-ethnic composition and diverse education systems mean that athletes often emerge from vastly different environments in terms of value systems, access to resources, and societal support for sports participation. For some communities, sporting excellence is highly valued; for others, academic achievement may be prioritized. This variability introduces both challenges and opportunities. On one hand, the absence of a unifying national narrative around table tennis may reduce systemic pressure on athletes, allowing for greater autonomy and personal meaning-making. On the other hand, inconsistent training environments and

varying degrees of institutional support may hinder long-term athlete development and reduce access to psychological resources.

Social-Cultural Theory also emphasizes the importance of mediation through cultural tools, such as language, symbols, traditions, and rituals. In sports, this includes coaching language, training routines, performance rituals, and team norms that convey implicit messages about effort, success, and failure. For instance, in Chinese sports academies, the daily structure of training is often rigid, with clearly defined routines that reinforce discipline, repetition, and endurance. In Malaysian settings, however, the variability in training institutions—ranging from school-based clubs to semi-formal state programs—means that the cultural tools of sports performance are less standardized, potentially influencing how athletes internalize expectations and develop mental discipline.

Importantly, Social-Cultural Theory allows for a relational view of athlete development, where performance is not simply the outcome of internal capabilities but is also shaped by social relationships, shared values, and environmental reinforcements. This perspective is especially useful for analyzing team dynamics, motivational climates, and emotional support systems. In collectivist cultures like China, athletes are socialized to value group success over individual achievement, which may foster a strong sense of purpose and resilience but could also create performance anxiety due to fear of letting down the team or nation. In Malaysia, where social norms are more individualistic in some regions and communal in others, the motivational climate may vary greatly across athlete populations, contributing to diverse expressions of psychological states such as confidence, stress regulation, and competitive drive.

Another important element of Vygotsky's theory is the role of more knowledgeable others in facilitating development. In elite sports, this refers to coaches, trainers, mentors, and senior teammates who model behaviors, provide feedback, and offer emotional support. In China, where coaching is often highly institutionalized and backed by national sports policy, athletes benefit from consistent technical guidance and structured psychological conditioning. In Malaysia, the availability and quality of such mentorship may depend on the region, funding, or institutional backing. Consequently, access to high-quality social mediation varies, potentially affecting the trajectory of skill acquisition, confidence building, and mental resilience.

Social-Cultural Theory, therefore, provides a robust foundation for cross-cultural comparisons in athlete development. It allows researchers to explore how macro-level cultural narratives and micro-level social interactions influence psychophysiological outcomes. For instance, cultural interpretations of success and failure—such as whether losing is seen as a personal shortcoming or a learning opportunity—may affect how athletes experience anxiety or recover from defeat. These experiences, in turn, impact physiological markers such as heart rate variability, cortisol release, and VO_2 max efficiency, thereby demonstrating the deep entanglement of social context and biological functioning.

In the present study, Social-Cultural Theory complements the Self-Determination Theory by offering a contextual and externally anchored perspective on athlete motivation and performance. While SDT focuses on internal psychological needs, Social-Cultural Theory emphasizes how these needs are shaped, supported, or suppressed by external social systems. Together, they provide a holistic lens to examine how cultural values, social structures, and interpersonal dynamics

contribute to the integrated psychophysiological profile of Malaysian and Chinese table tennis players.

Finally, integrating Social-Cultural Theory into this research also serves practical coaching and policy functions. By understanding how cultural norms and social relationships influence athletes' mental and physical readiness, coaches can design training environments that are not only technically effective but also culturally sensitive and psychologically supportive. Sports policymakers can use these insights to tailor national development programs, ensuring that interventions are grounded in both scientific evidence and socio-cultural realities.

1.7.3 Psychophysiological Specificity

The theory of Psychophysiological Specificity, advanced by Goldstein and Ungerleider (1989), underscores the fundamental concept that discrete psychological states are consistently linked to distinct physiological responses. Unlike generalized stress theories that treat physiological arousal as a uniform response to all mental stimuli, this theory proposes a precise mapping between specific mental states and corresponding bodily reactions. In essence, the theory posits that emotional, cognitive, and motivational processes—such as anxiety, focus, fear, or resilience—manifest through unique physiological patterns that are measurable and observable. This principle offers a powerful explanatory mechanism for the embodied nature of mental experiences, especially in high-stakes and high-performance environments such as competitive sports.

In the context of sports performance, the implications of Psychophysiological Specificity are both profound and practical. Athletes are continually navigating dynamic and emotionally charged environments where rapid decision-making, strategic execution, and sustained physical output are essential. These situations provoke not only cognitive processing and emotional regulation but also immediate physiological responses, such as increased heart rate variability, elevated cortisol levels, changes in oxygen consumption, and shifts in muscle tension or motor coordination. For example, a table tennis player preparing for a championship match may experience anticipatory anxiety, which can lead to elevated heart rate, shallow breathing, and muscle stiffness—conditions that may impair fine motor control and decision-making. Conversely, an athlete who is highly focused and mentally prepared may demonstrate lower resting heart rates, smoother oxygen utilization, and more efficient cardiovascular functioning.

This study applies the lens of Psychophysiological Specificity to integrate psychological constructs—such as anxiety, mental toughness, and concentration—with physiological metrics, including Body Mass Index (BMI), VO_2 max, heart rate (resting and post-exercise), and oxygen saturation levels. Rather than examining these variables in silos, the study investigates how specific psychological states are reflected in distinct physiological configurations, providing a holistic profile of each athlete. This approach is crucial in understanding not just what an athlete experiences mentally or physically, but how these experiences are interlinked, and how they collectively influence performance outcomes.

Importantly, Psychophysiological Specificity supports the multivariate and systems-based approach of this research. In high-performance sports like table tennis—where success depends on precision, timing, and agility—the interaction

between mind and body must be seamless. Athletes who are able to maintain psychological equilibrium (e.g., low cognitive anxiety, high self-confidence) often exhibit more stable physiological regulation (e.g., low variability in heart rate and efficient VO_2 max response). Conversely, players under mental duress may display erratic physiological reactions, such as excessive lactic acid buildup or delayed oxygen recovery, even if their technical skills remain intact. By mapping these co-occurrences, the study identifies psychophysiological signatures of both optimal and suboptimal performance.

Moreover, the theory facilitates a granular understanding of individual differences among athletes. While two players may show similar technical proficiency, their underlying psychophysiological profiles may differ substantially. One may rely on high arousal levels to energize performance, while another may perform best in a calm, low-arousal state. These differences necessitate personalized training and intervention strategies, rather than a one-size-fits-all approach. The use of psychophysiological assessment tools—such as biofeedback, heart rate monitors, and oxygen analyzers—enables coaches and sports scientists to observe real-time changes in athletes' states and adapt training intensity, duration, and psychological preparation accordingly.

Another critical advantage of Psychophysiological Specificity is its ability to incorporate the biopsychosocial model of athlete development, which recognizes that performance is shaped by biological (genetics, fitness), psychological (motivation, resilience), and social (coaching, culture) factors. For example, a mentally resilient athlete may still struggle with physiological recovery if training intensity is poorly managed, while a physically fit athlete may underperform due to unmanaged anxiety or lack of emotional regulation. The integration of these domains through

Psychophysiological Specificity offers a comprehensive diagnostic framework that can guide both short-term interventions and long-term developmental planning.

Incorporating cultural and environmental contexts further enriches the application of this theory. Athletes from different countries or cultural backgrounds may express or regulate psychological states differently, leading to variations in physiological manifestations. For instance, Chinese table tennis players—trained in highly disciplined and collectivist environments—may exhibit reduced outward emotional expression but increased internal somatic symptoms, such as elevated heart rate and muscle stiffness under pressure. In contrast, Malaysian players—exposed to more diverse and less centralized training settings—may display greater variability in both psychological and physiological responses. Psychophysiological Specificity accommodates these nuances by recognizing that the mind-body connection is both universal and culturally modulated.

Practically, the insights from this theory support the development of targeted coaching interventions. For instance, if an athlete is found to have elevated post-match heart rates alongside high anxiety scores, techniques such as progressive muscle relaxation, diaphragmatic breathing, or mindfulness-based stress reduction can be introduced. For athletes with strong mental composure but poor endurance, emphasis can be placed on aerobic conditioning or nutrition. By aligning mental profiles with physical realities, interventions become more precise, effective, and personalized, leading to enhanced performance sustainability.

In research methodology, this theory also offers a rigorous basis for data triangulation. Quantitative measures like heart rate, VO_2 max, and oxygen saturation can be cross-analyzed with psychological inventories such as the Competitive State

Anxiety Inventory (CSAI-2) or Mental Toughness Questionnaire (MTQ48), ensuring both validity and reliability in understanding the athlete's holistic profile. Such integration allows for predictive modeling, whereby specific psychological trends can forecast physiological performance patterns, or vice versa. This can inform not only athlete development but also injury prevention, fatigue management, and performance longevity.

Finally, in the theoretical architecture of this study, Psychophysiological Specificity serves as the bridge between Self-Determination Theory and Social-Cultural Theory. While SDT explains why athletes are motivated and Social-Cultural Theory explains how context shapes psychological states, Psychophysiological Specificity shows how these states are embodied. It converts abstract psychological motivations and socio-cultural influences into physiologically observable outcomes, enabling researchers and practitioners to see the invisible processes that underlie elite sports performance.

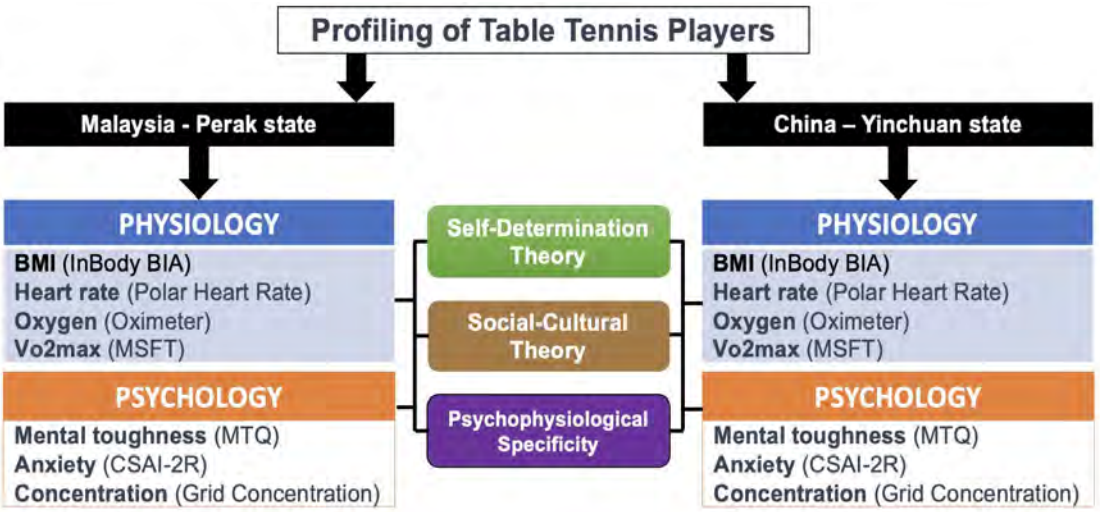
In conclusion, the integration of psychophysiological specificity into this study reinforces the commitment to multi-dimensional, evidence-based, and context-sensitive research. By exploring how psychological and physiological variables interact in real-time performance settings, the study not only enriches theoretical understanding but also provides actionable insights for athlete profiling, training optimization, and cross-cultural sports science innovation.

1.8 Conceptual Framework

A conceptual framework is a foundational component of any rigorous research design. It functions as a visual and theoretical scaffold that systematically outlines the key constructs, variables, and interrelationships under investigation. In essence, it is a blueprint for inquiry, guiding the researcher in the formulation of hypotheses, the selection of instruments, and the interpretation of data. As noted by Mousa and Othman (2020), a well-structured conceptual framework not only anchors the study within existing theoretical paradigms but also illuminates the mechanisms through which empirical data can be interpreted and applied. Within the context of this study, the conceptual framework (Figure 1.2) synthesizes theoretical constructs and empirical indicators to profile the psychophysiological characteristics of elite table tennis players in Perak, Malaysia, and Yinchuan, China.

Figure 1.2

Conceptual framework



At the heart of this framework lies the profiling of state-level table tennis players, an approach that captures the dual dimensions of physiological and psychological performance factors. The physiological domain includes core metrics known to affect endurance, stamina, cardiovascular health, and respiratory efficiency—namely, Body Mass Index (BMI), heart rate (resting and post-exercise), oxygen saturation (SpO_2), and VO_2 max, which is evaluated using the Multistage Fitness Test (MSFT). These physiological measures are obtained using validated tools such as the InBody BIA analyzer, Polar heart rate monitors, and oximeters. Collectively, these instruments allow for precise tracking of physical readiness, fatigue response, and metabolic efficiency in high-intensity sports like table tennis.

On the psychological front, the framework focuses on three critical cognitive-emotional constructs: mental toughness, competitive anxiety, and concentration ability. These are measured using well-established psychological instruments: the Mental Toughness Questionnaire (MTQ), the Competitive State Anxiety Inventory-2 Revised (CSAI-2R), and a Concentration Grid Test. These tools provide insight into athletes' inner states, including their resilience under pressure, emotional regulation, and attentional control. Given the rapid pace and strategic complexity of table tennis, where matches often hinge on split-second decisions and composure under duress, psychological readiness is just as vital as physical conditioning.

The framework adopts a comparative design to assess two culturally and geographically distinct athlete cohorts—those from Malaysia (Perak state) and China (Yinchuan state). These two groups were selected not only for their regional representation but also for their contrasting training infrastructures, cultural conditioning, and access to resources. The use of identical instruments across both populations ensures standardization, allowing for robust and meaningful cross-

cultural comparisons. This comparative design strengthens both the internal and external validity of the study and enables the detection of nuanced patterns in psychophysiological development influenced by socio-cultural and institutional factors.

Centrally positioned within the framework are the three core theories that inform and structure the study: Self-Determination Theory (SDT) by Deci and Ryan (1985), Social-Cultural Theory by Vygotsky (1978), and Psychophysiological Specificity by Goldstein and Ungerleider (1989). These theories are not merely abstract references; they serve as analytical lenses through which each empirical measure is interpreted. SDT contributes an understanding of intrinsic versus extrinsic motivation and how the satisfaction of psychological needs—autonomy, competence, and relatedness—shapes performance. This framework suggests that athletes with higher self-determination are more likely to commit to training, endure setbacks, and excel under pressure.

Social-Cultural Theory introduces a critical contextual dimension. Athletes are not developed in a vacuum—they are embedded in social, educational, and cultural systems that shape their beliefs, behaviors, and expectations. Chinese athletes, for example, operate within a centralized sports development model that emphasizes discipline, national pride, and collectivist values. Malaysian athletes, on the other hand, navigate a more pluralistic system with varying levels of institutional support and cultural attitudes toward sports. These differences are likely to impact how athletes process competitive stress, respond to coaching, and internalize success or failure.

The third theory, Psychophysiological Specificity, bridges the gap between psychology and physiology. It posits that specific mental states correspond with

identifiable physiological responses—a principle especially relevant in high-performance sports. Anxiety, for instance, may manifest as elevated heart rate and decreased VO_2 max efficiency, while focused attention may correlate with stable cardiovascular output and improved respiratory performance. By integrating this theory, the study explores bidirectional relationships—how psychological states influence bodily function, and vice versa. This allows for a holistic profiling approach, where neither domain is viewed in isolation.

The conceptual framework also proposes several interdependent pathways between variables. For example, it is hypothesized that mental toughness may serve as a moderator in the relationship between physiological fatigue and performance outcomes. Similarly, anxiety might act as a mediator between VO_2 max levels and cognitive concentration, affecting the athlete's ability to stay focused during extended rallies or critical match points. These interactions reflect the complexity of real-world athletic performance, where success is rarely attributable to a single variable but rather emerges from the synergy of multiple interacting factors.

From a practical perspective, the conceptual framework supports the development of targeted interventions and training programs. For example, if Malaysian players exhibit high cardiovascular potential but show lower psychological resilience, coaches might prioritize mental conditioning, including stress management and visualization exercises. If Chinese players demonstrate strong psychological composure but lower VO_2 max scores, emphasis may shift to aerobic training and recovery enhancement. By identifying each player’s unique psychophysiological profile, training regimens can be customized, increasing their effectiveness and reducing the risk of overtraining or burnout.

Moreover, the framework offers the potential for culturally responsive coaching strategies. By understanding how national identity, educational expectations, and training culture influence performance, stakeholders can adapt methods to resonate with athletes' lived experiences. This is particularly important in multicultural societies like Malaysia, where a one-size-fits-all coaching model may not be effective across ethnic or socio-economic groups.

In conclusion, this conceptual framework synthesizes theoretical depth with empirical clarity. It provides a multidimensional, comparative, and contextually grounded model for understanding the psychophysiological characteristics of elite table tennis players. It aligns closely with the study's overarching aim: to not only compare athletes across two national systems but also to uncover the mechanisms that drive excellence in sport. By integrating physiological data with psychological constructs underpinned by well-established theories, the framework paves the way for innovative, data-driven approaches to athlete profiling, development, and intervention across cultures and contexts.

1.9 Definition of Terms

The following terms represent the core concepts and variables frequently used in this study. Some are widely recognized in the field of physical education and sports science, while others are operationally defined for the purposes of this specific research. These definitions help ensure clarity, precision, and consistency throughout the study.

1.9.1 Psychophysiological Factors

According to Bertollo et al. (2021), psychophysiological factors refer to the dynamic interplay between an individual's psychological states and physiological responses, underscoring the bidirectional relationship between mental and physical domains. In sports science, this term embodies the holistic view that optimal athletic performance cannot be fully understood without considering both cognitive-emotional processes and biological markers. Psychophysiological factors are integral in evaluating how the body and mind collectively respond to the demands of competitive environments.

In this study, the physiological aspects refer to objective, measurable bodily functions such as Body Mass Index (BMI), heart rate, oxygen saturation, and Vo_2 max. These physiological indices provide insight into physical readiness, stamina, and the ability to recover under pressure. The psychological dimension, on the other hand, involves constructs like mental toughness, competitive anxiety, and concentration, which significantly affect decision-making, resilience, and composure during gameplay. By analyzing these psychological traits in tandem with physiological data, the study aims to uncover patterns that define the comprehensive psychophysiological profile of elite table tennis players in Malaysia and China.

Furthermore, psychophysiological analysis allows for a more integrated approach to athlete assessment and development. Rather than isolating physical fitness from psychological preparedness, this study adopts a multi-dimensional lens to identify how the interaction of these variables predicts and influences competitive performance. Understanding psychophysiological dynamics is essential for coaches and sports scientists aiming to create personalized training and mental conditioning programs.

1.9.2 Table Tennis State Players

As defined by Pradas et al. (2021), table tennis state players are elite-level athletes who represent a specific regional or state team in organized competitive table tennis tournaments. These players typically occupy a tier above local or recreational participants and are often seen as part of the talent pool for national or international selection. Their selection reflects a high degree of skill, dedication, training experience, and competitive consistency, distinguishing them as advanced performers within their respective regions.

In this study, table tennis state players refer specifically to athletes from Perak state in Malaysia and Yinchuan state in China, who have qualified to represent their state in official competitions. These athletes are selected through rigorous trials, training camps, and performance evaluations. Their inclusion in the study is significant because they embody structured training exposure and competitive experience, offering meaningful insights into the psychophysiological demands of high-level table tennis.

By comparing athletes from these two regions, the study can examine how different training environments, cultural contexts, and support systems influence the psychophysiological profiles of state-level players. It also highlights how geographic and institutional disparities may contribute to differences in performance readiness and development trajectories.

1.9.3 Profiling

Warburton et al. (2020) define profiling as a systematic process of identifying, measuring, and interpreting a set of variables to describe the characteristics of individuals or groups. In sports, profiling is essential to understand the strengths, weaknesses, and potential of athletes, enabling targeted interventions for performance enhancement. It involves the use of standardized tools and protocols to gather quantitative and qualitative data relevant to physical and psychological capacities.

In this study, profiling entails the detailed assessment of selected physiological (BMI, heart rate, oxygen levels, VO_2 max) and psychological (mental toughness, anxiety, concentration) indicators among elite table tennis players in Malaysia and China. Through profiling, the study aims to develop a comprehensive athlete database that reflects real-world variations across multiple domains. The process involves precise data collection tools—such as the InBody BIA, Polar Heart Rate Monitor, and validated psychological questionnaires—to ensure scientific rigor.

The ultimate purpose of profiling in this context is to identify patterns and correlations between variables, which can then be used to inform coaching strategies, athlete selection, and sports development policies. By capturing a snapshot of both internal and external factors influencing player performance, profiling supports evidence-based decision-making in high-performance sport.

1.9.4 BMI (Body Mass Index)

Body Mass Index (BMI) is a widely used anthropometric measure that evaluates body weight in relation to height and provides an estimate of overall body composition (Popovic et al., 2020). It is calculated by dividing a person's weight in kilograms by the square of their height in meters. While BMI does not distinguish between muscle and fat mass, it remains a quick and accessible screening tool for assessing nutritional status and body condition in athletic populations.

In this study, BMI was measured using the InBody Bioelectrical Impedance Analysis (BIA) system, which allows for more detailed body composition analysis beyond the traditional BMI formula. The BIA method estimates fat mass, lean muscle mass, and hydration status, making it more applicable for athletes. For table tennis players, optimal BMI ranges may reflect functional body types suited for speed, agility, and endurance. Deviations from optimal ranges could suggest areas needing nutritional or physical conditioning adjustments.

BMI serves as an important physiological variable in profiling, as it can influence movement efficiency, endurance capacity, and even mental confidence. Excessive body fat may hinder agility and stamina, while underweight athletes may face issues with strength and energy balance. Thus, analyzing BMI alongside other physiological and psychological indicators supports a holistic evaluation of athlete preparedness.

1.9.5 Heart Rate

Heart rate refers to the number of heart beats per minute and is one of the most basic and reliable indicators of cardiovascular function and aerobic endurance (Stepanyan & Lalayan, 2023). In sports science, heart rate data provides insight into an athlete's physical exertion, recovery rate, and cardiovascular efficiency under various levels of intensity. Elevated or irregular heart rate patterns may signal fatigue, stress, or insufficient conditioning.

In this study, heart rate was monitored using the Polar Heart Rate Monitoring System, a validated tool known for its real-time tracking capabilities and high accuracy. The continuous monitoring of heart rate during training or performance simulations helps evaluate how athletes respond physiologically to competitive stressors. This is especially important in table tennis, where matches demand bursts of speed, concentration, and endurance.

Heart rate data, when combined with psychological variables such as anxiety or mental toughness, can uncover psychophysiological correlations that reflect stress reactivity or recovery efficiency. Athletes with better cardiovascular control may experience enhanced focus and emotional regulation, contributing positively to competitive performance.

1.9.6 Oxygen Level

Oxygen level, often expressed as oxygen saturation (SpO_2), measures the percentage of oxygen-carrying haemoglobin in the blood (Nitzan et al., 2020). It

reflects how effectively the respiratory and cardiovascular systems deliver oxygen to working muscles and organs. In athletes, maintaining high oxygen saturation levels is essential for aerobic energy production, particularly in fast-paced sports like table tennis where endurance and quick recovery are critical.

In this study, oxygen levels were assessed using a finger pulse oximeter, a non-invasive device that provides real-time data on SpO_2 . The ability of athletes to maintain optimal oxygen levels during and after training may indicate superior aerobic conditioning and respiratory efficiency, both of which are essential for sustaining peak performance in high-intensity matches.

Oxygen levels also contribute to the psychophysiological profile by linking respiration to mental clarity and emotional control. Inadequate oxygenation may lead to early fatigue, impaired judgment, and reduced cognitive function, all of which are detrimental in precision sports. By examining this variable alongside psychological metrics, the study seeks to reveal how respiratory efficiency supports both physical and mental performance.

1.9.7 VO2max

VO_2 max, or maximal oxygen uptake, quantifies the maximum volume of oxygen the body can utilize during intense exercise (Lee & Zhang, 2021). It is widely regarded as the gold standard for assessing cardiovascular fitness and aerobic endurance. Athletes with high VO_2 max levels typically demonstrate superior physical capacity, faster recovery, and higher energy sustainability during prolonged or intense activities.

In this study, VO_2 max was estimated using the Multistage Fitness Test (MSFT), also known as the beep test. This field test is a practical and standardized method to assess aerobic capacity by requiring participants to run back and forth at increasing speeds over a set distance. The stage reached is then used to estimate VO_2 max. This method is especially suitable for profiling athletes in sports like table tennis, where dynamic and repeated movements demand strong aerobic systems.

Assessing VO_2 max contributes to a deeper understanding of performance readiness and complements other physiological data such as heart rate and BMI. It also interacts with psychological traits—such as motivation and resilience—as athletes with better cardiovascular fitness may also demonstrate higher self-confidence and stress tolerance.

1.9.8 Mental Toughness

Mental toughness is a psychological construct that describes an individual's capacity to maintain focus, determination, and composure under competitive pressure (Bédard Thom et al., 2021). It encompasses traits such as perseverance, confidence, emotional regulation, and the ability to rebound from setbacks. In the world of competitive sports, mental toughness is regarded as a crucial determinant of long-term success, particularly in sports that require quick decision-making and strategic thinking under duress.

In this study, mental toughness was measured using the Mental Toughness Questionnaire (MTQ), which provides a standardized framework for evaluating athletes' self-perception of their psychological resilience. The instrument assesses

key domains such as confidence, control, challenge, and commitment. For table tennis players—who must sustain attention, tolerate frustration, and recover from unforced errors—mental toughness plays a defining role in differentiating elite from average performers.

Analysing mental toughness in relation to physiological indicators such as heart rate or VO_2 max allows for an integrated understanding of how psychological resilience interacts with physical performance. For example, a mentally tough athlete may demonstrate stable cardiovascular responses even in high-pressure situations, reflecting efficient psychophysiological regulation.

1.9.9 Anxiety

Anxiety is defined as a psychological and physiological response to perceived threats or challenges, often characterized by worry, tension, and elevated arousal (Kaur et al., 2020). In a sports context, anxiety can manifest in both cognitive forms (e.g., fear of failure, negative thoughts) and somatic forms (e.g., increased heart rate, muscle tension). While a moderate level of anxiety can be motivating, excessive anxiety tends to impair performance by disrupting focus and coordination.

In this study, anxiety was assessed using the Competitive State Anxiety Inventory-2 Revised (CSAI-2R), a validated tool that evaluates cognitive and somatic anxiety as well as self-confidence. This multidimensional approach helps identify how athletes interpret and cope with stress during performance situations. For table tennis players, the ability to manage competitive anxiety can mean the difference between maintaining strategic control and succumbing to performance breakdown.

By examining anxiety levels in conjunction with physiological data—such as heart rate and oxygen saturation—the study aims to explore psychophysiological synchrony in athletes under stress. Athletes with better anxiety regulation are expected to exhibit more stable physiological responses, contributing to more consistent and effective performance.

1.9.10 Concentration

Concentration refers to the cognitive ability to direct and sustain attention on a relevant task while filtering out distractions (Reigal et al., 2020). It is a key performance factor in sports, particularly in precision-based activities such as table tennis, where the margin for error is minimal. Effective concentration enables athletes to anticipate opponents' moves, maintain strategic focus, and adapt quickly to changing situations.

In this study, concentration was measured using the Grid Concentration Task, a tool designed to assess selective attention, sustained focus, and mental endurance. This task requires athletes to identify sequential numbers on a grid within a limited time, simulating the attentional demands of a fast-paced match. It provides a quantifiable and practical measure of an athlete's mental sharpness.

Understanding concentration as part of the psychological profile allows researchers to examine how cognitive focus interacts with physiological states, such as fatigue or oxygen deprivation. For instance, an athlete's ability to maintain concentration under physical stress may be a predictor of superior performance consistency. Therefore, assessing concentration alongside mental toughness and

anxiety provides a well-rounded view of the psychological competencies required in elite table tennis.

1.10 Limitations of the Study

While this study has made significant contributions to the profiling of psychophysiological characteristics among state-level table tennis players in Malaysia and China, it is essential to acknowledge its limitations. These limitations are not indicative of shortcomings but rather serve as reflections of the study's methodological scope, logistical constraints, and contextual boundaries. Recognizing these limitations allows for a clearer interpretation of the findings and provides a roadmap for refining future investigations in this field.

One of the primary limitations of this study lies in its cross-sectional research design, which restricts data collection to a single time point. This approach, while practical and time-efficient, does not capture the temporal dynamics of psychophysiological variables. Athlete development is a progressive and often nonlinear process influenced by training cycles, competition exposure, maturation, and psychological adaptation. By limiting observations to one point in time, the study cannot account for fluctuations in psychological readiness or physiological adaptation that may occur over days, weeks, or seasons. A longitudinal design, where athletes are tracked over extended periods, would offer richer insights into how training, competition, recovery, and psychosocial influences evolve and interact in shaping performance outcomes.

Another notable limitation pertains to the geographic and demographic scope of the sample. The study focuses exclusively on two states—Perak in Malaysia and Yinchuan in China—which, while relevant for comparative purposes, do not encompass the full diversity of training systems, socio-cultural environments, or resource availability present across both countries. In China, for example, differences between economically developed regions like Beijing or Shanghai and less industrialized provinces could result in variations in athlete conditioning, coaching styles, and access to sports science support. Similarly, in Malaysia, athletes from more urbanized areas such as Kuala Lumpur may experience different developmental trajectories than those from rural regions. These regional disparities limit the external validity of the study, as the results cannot be generalized to all table tennis players across Malaysia and China.

A third limitation involves the use of self-report instruments for assessing psychological constructs such as mental toughness, anxiety, and concentration. Instruments like the MTQ, CSAI-2R, and the Grid Concentration Task, although validated and widely used in sports psychology, are inherently subjective. Participants' responses may be influenced by social desirability bias, lack of self-awareness, or cultural norms that discourage open expression of emotion or vulnerability. In collectivist societies such as China, where humility and group conformity are highly valued, athletes may underreport levels of stress or overstate mental resilience. These potential biases highlight the need to triangulate data sources—combining self-reports with objective physiological or behavioural indicators—to enhance the reliability and validity of psychological assessments.

The exclusive focus on the sport of table tennis constitutes another constraint. While the study provides in-depth insight into the psychophysiological demands of

this particular sport, the findings may not be transferable to other athletic disciplines with different physical, tactical, or psychological requirements. For example, endurance-based sports like marathon running, contact sports like rugby, or team sports like basketball all present distinct challenges that may shape athlete profiles differently. Table tennis, with its emphasis on reaction speed, fine motor control, and sustained cognitive focus, demands a unique psychophysiological balance that may not generalize to sports requiring high-impact strength or long-duration stamina. Future research that includes multi-sport comparisons could broaden the applicability of these findings across athletic domains.

Sample size and demographic homogeneity also pose challenges. While the inclusion of athletes from two distinct regions adds value, the overall sample remains relatively small and composed solely of state-level players. This restricts the ability to examine subgroup differences by age, gender, years of experience, or socioeconomic status. These variables can significantly influence both psychological disposition and physiological capacity. For instance, adolescent athletes may still be developing their executive functioning and emotional regulation, while older athletes may possess greater tactical awareness but face physiological limitations. Similarly, athletes from lower socioeconomic backgrounds may have limited access to nutritional support or advanced coaching, which could affect training outcomes. Including a broader demographic spectrum in future studies would yield more nuanced conclusions and foster the development of targeted, equity-based interventions.

Language and cross-cultural instrument adaptation further represent limitations. Although translated and previously validated versions of psychological instruments were employed, linguistic nuances and cultural connotations may still

affect how participants interpret specific items. Concepts such as “mental toughness,” “self-confidence,” or “competitive anxiety” may not carry the same implications across languages and cultures. What is considered an expression of toughness in China may be perceived differently in Malaysia, leading to construct validity concerns. To mitigate this, future studies should conduct localized pilot testing, cognitive interviews, and psychometric revalidation of instruments in the target cultural settings to ensure conceptual clarity and measurement consistency.

Another area that could enhance the depth of analysis is the integration of objective performance data such as match outcomes, win-loss ratios, national or international rankings, and progression metrics. These external performance indicators would provide real-world validation of psychophysiological variables and allow researchers to draw stronger inferences about causality or predictive value. For example, if high VO_2 max and low anxiety levels correlate strongly with win rates, this relationship could inform athlete scouting and training decisions. Including performance analytics alongside physiological and psychological data would support the development of a comprehensive athlete evaluation model.

In addition to the individual-level variables assessed in this study, the social environment—including coaching behavior, team culture, parental involvement, and peer dynamics—plays a substantial role in shaping athlete outcomes. The absence of qualitative data from coaches, trainers, or athletes themselves limits the study’s ability to contextualize findings within the broader ecosystem of athlete development. For instance, a supportive coach-athlete relationship may buffer the effects of anxiety, while a high-pressure training environment might exacerbate physiological stress responses. Future research should include interviews, focus groups, or ethnographic

observations to capture the interpersonal dynamics that influence psychophysiological development.

Lastly, the study assumes a relatively linear relationship between psychological and physiological variables. However, emerging research suggests that these relationships are often nonlinear and context-dependent, influenced by factors such as sleep quality, hormonal fluctuations, dietary intake, and even environmental stressors (e.g., heat, crowd pressure, travel fatigue). These variables, although outside the current study's scope, could moderate or confound the observed relationships. Future research employing multilevel modeling or systems-based approaches could help disentangle these complex interdependencies and enhance the explanatory power of psychophysiological models.

1.11 Significance of the Study

The significance of this study lies in its multidimensional contributions to the field of sports science, particularly in understanding and enhancing performance among state-level table tennis players in Malaysia and China. The integration of physiological and psychological profiling not only addresses a critical gap in the literature but also provides a solid foundation for evidence-based practices in coaching, athlete development, and performance optimization. This research advances both theoretical understanding and practical application, making it highly relevant to sports scholars, coaches, athletes, and institutions.

One of the primary contributions of this study is the creation of comprehensive psychophysiological profiles of table tennis players from two distinct

regions—Perak, Malaysia, and Yinchuan, China. These profiles combine objective physiological data (e.g., BMI, heart rate, oxygen saturation, VO_2 max) with psychological constructs (e.g., mental toughness, anxiety, concentration), offering a more holistic view of athletic performance. While earlier studies such as those by Chow et al. (2017) and Li et al. (2019) addressed cultural and psychological factors in sports, this research uniquely integrates dual-dimensional profiling within a comparative cross-cultural framework, thus extending its applicability across diverse performance environments.

This study is also significant in contributing to the understanding of the performance gap between Malaysian and Chinese athletes. China's consistent success in table tennis at the international level stands in contrast to Malaysia's developing competitive presence. By exploring the psychophysiological factors underlying this disparity, the study offers valuable insights into how different training regimes, coaching philosophies, and cultural influences contribute to varying performance outcomes. These findings are expected to inform national sports development agendas and assist in formulating targeted strategies for closing the performance gap in Malaysia and other developing sports nations.

Furthermore, the study holds substantial practical value for coaches and sports practitioners. The findings provide concrete, data-driven insights that can inform the design of more effective and individualized training interventions. For example, identifying specific psychological traits that correlate with better physiological responses allows coaches to customize mental conditioning programs to enhance focus, resilience, and stress management. Similarly, understanding how physical conditioning influences psychological readiness can guide recovery protocols, periodization plans, and skill development drills. This holistic approach

empowers coaches to maximize athlete potential through scientifically grounded strategies.

In addition to its immediate applications in coaching and training, this study also contributes to educational and institutional development. Sports science programs in universities and colleges can utilize the findings to enhance curricula and promote interdisciplinary approaches to athlete development. For instance, the integration of psychological and physiological profiling tools in training modules can help future coaches and trainers appreciate the interconnected nature of performance variables. Moreover, institutions involved in talent identification and youth development can apply the profiling framework to design selection criteria that go beyond basic technical skills.

The significance of this study also extends to policy formulation and national sports planning. As sports become more data-driven and research-informed, governments and national sports bodies require empirical evidence to justify funding allocations, talent development pathways, and international benchmarking. By highlighting region-specific strengths and weaknesses, the study offers a framework for evaluating athlete readiness and program effectiveness. This is particularly important in emerging sports systems, such as Malaysia's, where strategic decisions are vital to optimizing limited resources and achieving long-term sporting success.

From a theoretical standpoint, the research enriches existing literature by applying Self-Determination Theory, Social-Cultural Theory, and Psychophysiological Specificity in a single, unified model. This theoretical integration allows for a more comprehensive understanding of how motivation, cultural context, and mind-body interactions influence sports performance. It provides a conceptual foundation for

future studies exploring similar phenomena across other sports, age groups, or competitive levels. The research also opens pathways for testing new hypotheses about cross-cultural athletic development and psychophysiological adaptation in high-performance contexts.

Finally, the broader implications of this study extend to athletes, clubs, and sports organizations seeking to enhance competitive readiness and long-term development. For athletes, understanding their own psychophysiological profiles fosters greater self-awareness and engagement in their training journey. For clubs and training centers, access to detailed profiling data supports talent nurturing and injury prevention. For sports organizations, the study offers a replicable model for evidence-based athlete evaluation and performance planning. In summary, this study contributes not only to academic discourse but also to real-world practices that shape the future of table tennis and athlete excellence in both Malaysia and China.

1.12 Research Gaps

Although substantial research had been conducted on sports performance, psychological traits, and physiological assessments in athletes, notable gaps remained in the context of psychophysiological profiling among state-level table tennis players, particularly those from Perak, Malaysia, and Yinchuan, China. Most existing studies either generalized findings across sports or focused solely on isolated variables, lacking cultural specificity or comparative depth. This study aimed to bridge these gaps through a focused, data-driven, and culturally contextualized investigation.

The first significant research gap concerned the absence of comparative psychophysiological studies between athletes from Perak and Yinchuan. While previous studies had examined physical and mental factors in Chinese or Southeast Asian athletes independently, there was limited literature that juxtaposed players from these two specific regions. These states differed not only geographically but also in their training philosophies, socioeconomic contexts, institutional support systems, and cultural attitudes toward sports participation. By directly comparing athletes from these contrasting environments, the study identified meaningful differences and similarities in physiological attributes—such as BMI, heart rate, VO_2 max, and oxygen saturation—as well as psychological traits including anxiety, mental toughness, and concentration.

Secondly, there was a scarcity of empirical research exploring the cultural underpinnings of psychophysiological responses in table tennis players. Sports performance was understood not only as a function of training and innate ability but also as an outcome of deeply ingrained cultural norms, beliefs, and practices. Cultural values shaped motivation, stress perception, coping mechanisms, and athlete-coach dynamics—all of which impacted both psychological states and physiological responses. This study examined how Malaysian and Chinese cultural norms, such as collectivism, discipline, societal pressure, and athlete identity, influenced athletes' mental states and bodily responses during training and competition.

In addition, most previous studies in the field tended to investigate either physiological or psychological factors in isolation, leading to fragmented interpretations of athlete performance. The lack of integrated studies examining the simultaneous impact of mental and physical factors created an incomplete picture of

athlete readiness and performance potential. This study addressed that by applying a psychophysiological model—an approach that acknowledged the interdependence of body and mind—to evaluate how variables such as heart rate and anxiety, or mental toughness and oxygen saturation, co-existed and influenced each other during high-stakes sports performance.

Moreover, a research gap existed in terms of contextualized assessment tools for athlete profiling. Many existing instruments had been developed in Western contexts, raising concerns about cross-cultural validity when applied to Asian populations. Although the instruments used in this study were validated, few previous studies had explored how athletes from different cultural and linguistic backgrounds interpreted and responded to tools like the Mental Toughness Questionnaire (MTQ) or the Competitive State Anxiety Inventory (CSAI-2R). This study enriched quantitative data with qualitative insights derived from interviews and background information to account for the socio-cultural context of each athlete group.

Another overlooked area in existing literature was the relationship between profiling results and actionable interventions. While athlete assessments were often conducted, they rarely translated into targeted or region-specific training changes. This study helped bridge that gap by connecting profiling data with practical coaching implications. By identifying distinct psychophysiological trends within each group, the study proposed performance enhancement strategies tailored to local contexts. This practical focus was essential for coaches, trainers, and sports policymakers working to improve the developmental pathways of athletes in different cultural environments.

To address the above gaps, the study employed a quantitative approach using standardized physiological assessments—BMI via InBody BIA, heart rate via

Polar monitors, oxygen levels via oximeter, and VO_2 max via the MSFT test—alongside psychological assessments using validated scales. Additionally, semi-structured interviews and background data collection were conducted to gain a deeper understanding of the athletes' cultural, educational, and training environments. This combination of quantitative and qualitative methods enhanced both the reliability and relevance of the study's findings.

Ultimately, by addressing these research gaps, the study made significant contributions to the field of sports science, psychophysiology, and cross-cultural athlete development. It not only generated a first-of-its-kind comparative psychophysiological dataset between Perak and Yinchuan players, but also advanced the understanding of how training environments and cultural settings shaped athletic experiences. Furthermore, the study informed the development of culturally responsive training frameworks and provided a replicable model for future research in other sports and contexts, reinforcing the importance of culture-specific perspectives in sports science.

1.13 Summary

In conclusion, Chapter 1 has established the foundation for the comparative analysis of psychophysiological factors among state-level table tennis players in Malaysia and China. Through an exploration of the significance of table tennis in both countries, the identification of gaps in existing literature, and the establishment of the theoretical framework, this chapter offers a comprehensive basis for the subsequent empirical investigation.