ASSOCIATIONS BETWEEN 24-HOUR MOVEMENT BEHAVIOUR AND ANXIETY DISORDER: THE MEDIATING ROLE OF BASIC PSYCHOLOGICAL NEEDS

ZHOU XIAOGANG

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ZHOU XIAOGANG

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24-HMB	24-Hour Movement Behaviour
BMI	Body Mass Index
BPN	Basic Psychological Need
BPNF	Basic Psychological Need Satisfaction
BPNS	Basic Psychological Need Frustration
HBSC	Health Behaviour in School-aged Children
MVPA	Moderate-to-vigorous-intensity Physical Activity
PA	Physical Activity
PSQI	Pittsburgh Sleep Quality Index
SAS	Zung' Self-Rating Anxiety Scale
SB	Sedentary Behaviour
SEM	Structural Equation Modelling
WHO	World Health Organization

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PERKAITAN ANTARA TINGKAH LAKU PERGERAKAN 24 JAM DAN GANGGUAN KEBIMBANGAN DALAM KALANGAN REMAJA: PERANAN PENGANTARA KEPERLUAN PSIKOLOGI ASAS

ABSTRAK

Bukti yang meluas telah mendokumentasikan hasil kesihatan yang baik yang berkaitan dengan aktiviti fizikal (PA), tingkah laku sedentari (SB), dan tidur (SLP) yang terasing. Dalam beberapa tahun kebelakangan ini, paradigma pergerakan 24-jam (24-HMB)—yang menggabungkan PA, SB, dan SLP—mendapat perhatian global kerana potensinya untuk mengoptimumkan kesihatan holistik. Sebagai tindak balas, Kanada memperkenalkan Garis Panduan Pergerakan 24-Jam pertama untuk Kanak-Kanak dan Belia, mengesyorkan ≥ 60 minit MVPA, ≤ 2 jam SB berasaskan skrin, dan 8-10 jam SLP. Namun, perubahan gaya hidup moden menyebabkan penurunan PA, peningkatan SB, dan kekurangan SLP di kalangan remaja sekolah di China. Bersama trend ini, gangguan kecemasan (AD) muncul sebagai masalah kesihatan mental utama. Berdasarkan teori keperluan psikologi asas (BPN), kajian ini mengkaji kaitan antara 24-HMB dan AD di kalangan remaja Cina, dengan fokus pada peranan perantaraan BPN dan kesan moderasi jantina dan BMI. Sampel kluster berstrata sebanyak 1,390 remaja (purata umur = 14.45±1.24 tahun) dari tiga bandar di Wilayah Zhejiang dinilai menggunakan HBSC, SAS, dan Skala BPNSF. Data dianalisis menggunakan SPSS dan Mplus. Keputusan menunjukkan hanya 3.2% remaja mematuhi semua garis panduan 24-HMB, dengan pematuhan lebih tinggi di kalangan lelaki dan remaja luar bandar. Malangnya, 23.9% tidak memenuhi mana-mana garis panduan. AD tersebar di kalangan remaja, dengan 3.74% mengalami AD yang teruk. Kajian ini menunjukkan bahawa pematuhan kepada garis panduan SLP sahaja memberikan kesan perlindungan

terhadap AD (β = −.201, p = .011), manakala penggabungan SB untuk memenuhi gabungan SB+SLP meningkatkan kesan ini (β = −.491, p < .001). Pematuhan penuh kepada garis panduan 24-HMB (PA+SB+SLP) memberikan kesan perlindungan yang paling kukuh (β = −.856, p < .001). Penemuan ini menekankan bahawa seluruh hari itu penting, dengan menggalakkan gaya hidup yang seimbang—bergerak secukupnya, duduk kurang, dan tidur dengan baik. Kajian mendapati bahawa kepuasan BPN berkorelasi negatif dengan AD, sementara kekecewaan menunjukkan korelasi positif. BPN secara signifikan memediasi kaitan antara 24-HMB dan AD, dengan kepuasan BPN memediasi hubungan PA+SB dan PA+SLP dengan AD, manakala kekecewaan memediasi kesan SB+SLP dan PA+SB+SLP terhadap AD. Selain itu, jantina memoderasi kaitan antara 24-HMB dan AD, sementara BMI tidak menunjukkan kesan moderasi yang serupa. Penemuan ini mencadangkan langkah berfokuskan BPN mungkin berguna dalam menguruskan AD, dengan pertimbangan jantina meningkatkan keberkesanannya. Kajian ini adalah usaha perintis dalam menerapkan kerangka tingkah laku pergerakan bersepadu untuk mengkaji kaitan dan mekanisme antara 24-HMB dan AD di kalangan remaja Cina, bergerak melepasi tingkah laku terasing yang tradisional. Ia bukan sahaja menetapkan garis panduan tingkah laku pergerakan bersepadu berasaskan bukti yang disesuaikan untuk remaja Cina bagi mengurangkan gangguan kebimbangan, tetapi juga memperdalam pemahaman dengan mendedahkan kesan langsung dan tidak langsung tingkah laku pergerakan bersepadu terhadap gangguan kebimbangan remaja melalui keperluan psikologi asas, serta kesan pemoderasi jantina.

ASSOCIATIONS BETWEEN 24-HOUR MOVEMENT BEHAVIOUR AND ANXIETY DISORDER: THE MEDIATING ROLE OF BASIC PSYCHOLOGICAL NEEDS

ABSTRACT

Extensive evidence has consistently documented the favourable health outcomes associated with isolated physical activity (PA), sedentary behaviour (SB), and sleep (SLP). Over the past few years, the emerging paradigm of 24-hour movement behaviour (24-HMB)— which combines PA, SB, and SLP—, has garnered substantial global attention for its potential to optimize holistic health. In response to this momentum, Canada introduced the first 24-Hour Movement Guidelines for Children and Youth, recommending ≥ 60 minutes of MVPA, ≤ 2 hours of screen-based SB, and 8-10 hours of SLP. Yet, shifts in modern lifestyles have led to decreased PA, increased SB, and insufficient SLP among Chinese school-aged adolescents. Alongside these trends, anxiety disorder (AD) has emerged as one of the most prevalent mental health concerns in this population. Grounded in the basic psychological needs (BPN) theory, this study aims to examine the associations between 24-HMB and AD among Chinese adolescents, with a focus on the mediating role of basic psychological needs and the moderating effects of gender and BMI. A stratified cluster sample of 1,390 adolescents (mean age = 14.45±1.24 years) from three cities in Zhejiang Province was assessed using the HBSC, SAS, and BPNSF Scale. Data were analyzed with SPSS and Mplus. Results revealed that only 3.2% of adolescents fully adhered to all the 24-HMB guidelines, with higher compliance observed among males and rural adolescents. Alarmingly, 23.9% met none. AD was widespread among adolescents, with 3.74% experiencing severe AD. The study indicated that among all movement behaviour

patterns, adherence to SLP guideline alone yielded a modest protective effect against AD (β = −.201, p = .011), while integrating SB to meet the SB+SLP combination substantially amplified this effect (β = −.491, p < .001). Notably, the most robust protective effect was observed with full adherence to 24-HMB (PA+SB+SLP) guidelines (β = −.856, p < .001). These findings highlight that the whole day matters, fostering a well-balanced lifestyle—moving more, sitting less, and sleeping well. The study found that BPN satisfaction negatively correlated with AD, while frustration showed a positive correlation. Notably, BPNs significantly mediated the associations between 24-HMB and AD, with the satisfaction of these needs mediating the relationship between PA+SB and PA+SLP and AD, whereas frustration mediating the effect of SB+SLP and PA+SB+SLP on AD. Furthermore, gender moderated the associations between 24-HMB and AD, whereas BMI did not exhibit a similar effect. These findings suggest that BPN-focused measures might be beneficial in managing AD, while gender-specific considerations potentially enhance their efficacy. This study is a pioneering effort in applying the integrated movement behaviour framework to examine the associations and mechanisms between 24-HMB and AD among Chinese school-aged adolescents, moving beyond traditionally isolated behaviours. It not only establishes evidence-based integrated movement behaviour guidelines tailored to Chinese adolescents for mitigating AD, but also deepens understanding by revealing both direct and indirect effects of integrated movement behaviours on adolescent AD through BPNs, along with the moderating effects of gender.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Mental health is a vital and inseparable component of overall well-being, with growing recognition of the pivotal role that mental well-being plays in shaping our overall quality of life throughout the entire lifespan (WHO, 2018). Maintaining good mental health conditions can bring about a wide range of favourable impacts on various aspects of our lives from childhood to adulthood, including interpersonal relationships (Li et al., 2020), academic performance (Agnafors et al., 2021), and physical health (Ohrnberger et al., 2017). However, it is essential to be aware of adolescents' heightened vulnerability to mental health challenges. They are particularly vulnerable to enduring social isolation, discrimination, stigma, educational difficulties, risk-taking behaviours, physical ill-health, and human rights violations (WHO, 2021a). Alarmingly, estimates suggest that one out of every seven adolescents experience mental health disorders, making up 14% of the overall global disease burden in this age group all over the world (WHO, 2021a).

Among the various mental health issues, anxiety disorder (AD) stands out as one of the most commonly occurring conditions, often developing in the course of childhood and adolescence (Walter et al., 2020; Beesdo et al., 2009). Adolescence is a time of exploration and the formation of a sense of identity (Erik & Erikson, 1995), suffering from AD is likely to have a host of negative impacts on developmental outcomes, such as academic performance, impaired social relationships, peer relationships, family life, interpersonal difficulties, and victimization, suicide-related behaviours (Bitsko et al., 2018; Hill et al., 2011; Khalid-Khan et al., 2007).

The increasing prevalence of AD in modern society is associated with a variety of factors, requiring the identification of the factors that contribute to AD. Apart from the intricate involvement of biological, psychological, social, and environmental factors, lifestyle behaviours also play a noticeable role in shaping this trend to some extent. Notably, among the lifestyle factors, physical activity (PA) (Stubbs et al., 2017), sedentary behaviour (SB) (Cao et al., 2011), and sleep (SLP) (Ojio et al., 2016) have been identified as important elements responsible for the upsurge in AD.

Evidence suggests that behavioural exposures that make up a typical day play a vital role in shaping the overall health and well-being of adolescents. Among these, PA, SB, and SLP may both individually and collectively have an impact on adolescents' health and well-being. However, it is revealed that the combination of these behaviours together can yield even more substantial benefits for overall health. Scholarly discourse has increasingly emphasized the importance of adopting an integrative and comprehensive perspective on well-being, rather than examining various health determinants in isolation (Chaput et al., 2014; Tremblay et al., 2016). Specifically, it is proposed that integrating PA, SB, and SLP as an integrated entity may enhance the explanatory power for health outcomes when compared to examining each of these components separately (Rollo et al., 2020). From a comprehensive viewpoint, this indicates that adjusting these three daily behaviours collectively may yield greater health benefits compared to targeting each behaviour individually. The establishment of the Canadian 24-HMB Guidelines for Children and Youth exemplifies this paradigm shift, reflecting the growing emphasis on considering these behaviours together to promote overall well-being (Tremblay et al., 2016).

Numerous studies have increasingly highlighted the role of psychological mechanisms in explaining the relationship between PA, SB and SLP and mental health

outcomes (Fraguela-Vale et al., 2020; Quartiroli & Maeda, 2014; Li et al., 2021; Li, 2023). In particular, the satisfaction of basic psychological needs—autonomy, competence, and relatedness—may serve as a key mediating factor in this relationship. Grounded in Basic Psychological Need Theory, these BPNs are fundamental to psychological functioning and emotional well-being (Vansteenkiste & Ryan, 2013). Understanding this mediating pathway could offer deeper insight into how integrated movement behaviours influence AD.

Chapter one serves as an introductory section, encompassing the background of the study, problem statement, research objectives, research questions, research hypotheses, research significance, conceptual framework, definitions of key terms, and a summary.

1.2 Background of the Study

Epidemiologic studies have highlighted AD as a significant public health concern worldwide (Polanczyk et al., 2015; Konnopka & König, 2019; Syed Fahad Javaid et al., 2023). It is among the top 10 causes of years lived with disability in every region of the World Health Organisation (WHO) and is the sixth highest contributor to non-fatal health loss globally (WHO, 2017). AD can sometimes lead to severe physical and mental impairment and disability (WHO, 2017). It is worth noting that the prevalence of AD remains high, affecting an estimated 267 million people of all ages worldwide, with a particularly concerning prevalence among adolescents (Vos et al., 2016). As indicated by statistics from the National Institutes of Health, approximately one-third of adolescents will experience AD, and these numbers have shown a steady increase (McCarthy, 2019). Thus, the far-reaching impact of AD on people and society as a whole should not be understated.

In China, there is a growing recognition of the pressing challenges surrounding the mental health of adolescents. Among these issues, AD stands out as a particularly prevalent and concerning issue. A recent meta-analysis comprising 252 studies conducted in mainland China reported a high prevalence rate of 26.3% for AD among Chinese adolescents from 2010 to 2020 (Yu et al., 2022). According to a recent epidemiological survey, only 14.28% of students reported normal AD levels, whereas 52.88% experienced mild, 22.70% moderate, and 10.14% excessive AD (Cai & Liu, 2023), highlighting the prevalence and varying degrees of AD among school-aged adolescents in China (Chen et al., 2023).

Yet, AD is often minimized or overlooked by parents and teachers, which may lead to their exacerbation over time (Liu & Zhang, 2024). In response to the urgency of this situation, many national authoritative departments have begun to prioritize mental health initiatives, including the Party Central Committee, the Central Leading Group for Education Work, the Party Group of the Ministry of Education, the Party Central Committee, and the State Council, the National Health Commission. Over the past few years, a series of national mental health education related policy policies and action plans have been issued to manage student mental health challenges, such as the "Healthy China Action - Child and Adolescent Mental Health Action Plan (2019-2022) (Centers for Disease Control and Prevention, 2019)", "Notice on Strengthening Student Mental Health Management Work", (Ministry of Education's General Office, 2021), "Guidelines for Life Safety and Health Education in Primary and Secondary School Curricula", (Ministry of Education of the People's Republic of China, 2021). In 2023, a series of policy documents, including the "Special Action Plan for Comprehensive Enhancement and Improvement of Student Mental Health in the New Era (2023-2025)", (Ministry of Education of the People's Republic of China and 17

Other Departments, 2023), was jointly released by the Ministry of Education and 17 additional departments. The focus is on implementing specialized actions to promote student mental health and facilitate their healthy growth.

Over the past two decades, more and more PA guidelines have been released to help adolescents improve their well-being all over the world, such as UK, China, USA, Canada, etc. (Zhang et al., 2017; Tremblay et al., 2011; Piercy et al., 2018; Twisk, 2001). However, the previous movement campaigns for adolescents have consistently concentrated too much on the positive effects of regular PA, especially for those associated with moderate-to-vigorous-intensity physical activity (MVPA). Indeed, it is generally acknowledged that engaging in PA on a regular basis is an efficient way to prevent a number of health risk factors (Janssen et al., 2010; Paterson et al., 2010; Warburton et al., 2006). Alarmingly, even for those adolescents who comply with the existing PA guideline of 60 minutes of MVPA daily, there remain 23 hours per day for other activities, such as schooling, sleeping, and discretionary time. It is found that PA (20%) constitutes just a minor fraction of the 24-hour cycle, even in active adolescents. In contrast, SB (~ 40%), and SLP (~ 40%) make up approximately 80% of the 24-hour period (Chaput et al., 2014). Accordingly, it is equally crucial to recognize the significant impact of SB and SLP, on our overall well-being. In the context of our daily lives, individuals often participate in a range of behaviours, and they may not consistently meet all the recommended guidelines for PA, SB, and SLP. Rather, on most occasions, individuals tend to exhibit diverse combinations of PA, SB, and SLP patterns. Independently, each behaviour can bring about positive health outcomes, but when combined, they can achieve even more favorable overall health benefits (Rollo et al., 2020). Therefore, combining PA, SB, and SLP is essential for promoting overall health and well-being.

In recent years, a new integrated movement behaviour paradigm known as the "24-Hour Movement Behaviour" (24-HMB) has emerged (Tremblay et al., 2016). The paradigm proposes the integration of PA, SB, and SLP throughout an entire day, emphasizing the importance of adopting a balanced lifestyle and considering various aspects of daily activities for optimal health and well-being, rather than focusing exclusively on PA (Chaput et al., 2014; Rosenberger et al., 2019). From a holistic perspective, the integration of three core components of 24-HMB—PA, SB, and SLP—yields eight distinct patterns: Only PA, Only SB, Only SLP, PA+SB, PA+SLP, SB+SLP, PA+SB+SLP, and None. By incorporating these healthy lifestyle behaviours into their daily routines, individuals can obtain optimal overall health outcomes.

A growing body of evidence indicates a positive correlation between the 24-HMB guidelines and various aspects of physical, physiological, and cognitive health. For example, it has been revealed that adolescents who adhered to the 24-HMB guidelines often get better academic performance (Lien et al., 2020), reduced likelihood of suicidality (Sampasa-Kanyinga et al., 2020a) and obesity (Roman-Viñas et al., 2016), superior global cognition (Walsh et al., 2018), better mental health status (Sampasa-Kanyinga et al., 2020b). The “24-HMB” paradigm underscores the significance of comprehensively considering the combined impact of engaging in regular PA, reducing excessive SB, and ensuring sufficient restorative SLP across 24 hours on individual health. It offers valuable insights into promoting healthier lifestyles and achieving better overall health outcomes, leading to positive and sustainable impacts on individuals’ physical and mental well-being throughout their lives. Taking on this integrated perspective can effectively mitigate the risks associated with insufficient PA, prolonged screen-based SB, and inadequate SLP, thereby fostering optimal health in a balanced and holistic way.

In 2016, the first global 24-HMB guidelines for adolescents were released in Canada, providing recommendations on the amount of time allocated to all levels of PA (light, moderate, vigorous), SB, and SLP to optimize health benefits (CSEP, 2016). It is recommended that adolescents "Sweat, Step, Sleep and Sit", outlining that a healthy 24 hours for children and adolescents should include a minimum of 60 minutes of MVPA; a maximum of 2 hours of recreational screen-based SB, and 8 to10 hours of SLP (Tremblay et al., 2016). This terminology embodies a paradigm shift that transcends the focus on movement behaviours in isolation and embraces the notion that "the Whole Day Matters" (Rollo et al., 2020). Subsequently, the Australian Government Department of Health released the Australian 24-HMB guidelines for Children and Adolescents (Department of Health and Aged Care, 2019). Collectively, these guidelines integrate PA, SB, and SLP over 24 hours, which provide some comprehensive and scientific guidance on promoting overall health.

The positive health benefits of adhering to 24-HMB guidelines among adolescents have been well-documented in previous studies. It has been consistently shown that following 24-HMB guidelines is related to a wide variety of positive health outcomes, including reduced adiposity (Chen et al., 2021; Roman-Viñas et al., 2016), lower cardiometabolic risk (Katzmarzyk & Staiano, 2017), heightened global cognitive capacity (Walsh et al., 2018), decreased odds of suicidality (Sampasa-Kanyinga et al., 2020a), diminished risk of internalizing and externalizing behaviours (Sampasa-Kanyinga et al., 2020c), improved executive function (Zeng et al., 2022), higher academic achievement (Watson et al., 2021), and better life quality (Xiong et al., 2021), as opposed to those who fail to comply with the guidelines. Besides, it is found that adhering to the 24-HMB guidelines is linked to improved mental well-being in adolescents (Sampasa-Kanyinga et al., 2020b).

Some prior research has identified the independent protective benefits of enough PA, reduced screen-based SB, or proper SLP on AD in adolescents (McMahon et al., 2016; Bélair et al., 2018; Ojio et al., 2016). For example, a cross-sectional study involving 11,110 adolescents from 10 European countries revealed that engagement in PA was connected to decreased AD levels across both genders (McMahon et al., 2016). Another study observed that the odds of experiencing symptoms of AD were significantly more prevalent in sedentary adolescents in contrast to their non-sedentary counterparts (Bélair et al., 2018). An additional study from Japan revealed that among male adolescents, having a SLP duration of ≥ 8.5 hours on school nights might be linked to the minimized AD risk on average (Ojio et al., 2016). Furthermore, three cross-sectional research investigating the relationship between 24-HMB and AD, also support that that complying with all 24-HMB guidelines is tied to improved AD outcomes (Brown et al., 2021; Lu et al., 2021; Zhu et al., 2019). Collectively, these studies have shown crucial evidence of the associations between meeting PA, SB, and SLP guidelines and AD among adolescents, both in isolation and in combination.

The basic psychological needs (BPNs)—competence, autonomy, and relatedness—serve as key mediators, potentially shaping the associations between health-related behaviours and well-being. According to the BPN Theory, the needs for competence, autonomy, and relatedness are essential psychological resources that underpin health and well-being, and human behaviour can be better understood through the lens of the BPNs (Ryan & Deci, 2000a; Ryan & Deci, 2000b). Once these needs are satisfied, people experience growth and wellness. Conversely, when these needs are thwarted, a broad spectrum of suboptimal outcomes emerge, such as anxiety, sadness, hostility, and other psychological disorders. These emotions often arise as responses to perceived threats or hindrances to fulfilling one's needs (Ryan & Deci,

2000b). It is crucial to recognize that at an individual level, variations in need satisfaction and need frustration over time or situations are found to predict variations in optimal functioning and wellness versus ill-being (Ryan & Deci, 2017). This underscores the significance of considering both the fulfilment and thwarting of psychological needs for individuals' psychological functioning and promoting their optimal well-being.

Gender and Body Mass Index (BMI) act as important moderators and may modify the associations between health-related behaviours and well-being. Gender differences in movement behaviours, such as PA, SB, and SLP, may lead to varying mental health outcomes (Poitras et al., 2016; Carson et al., 2016; Chaput et al., 2016). Consequently, gender may moderate the relationship between 24-HMB and AD by shaping how movement behaviours impact mental health across different genders. Similarly, BMI functions as a significant health indicator, with higher BMI linked to an increased risk of AD, particularly among adolescents who exhibit lower compliance with 24-HMB (José Francisco López-Gil et al., 2023; Wang et al., 2019). BMI may moderate the effect of 24-HMB on AD by altering how 24-HMB influences AD. Together, gender and BMI are likely to shape the relationship between 24-HMB and AD in meaningful ways, making it essential to examine their moderating roles in this study.

Therefore, this research will integrate PA, SB, and SLP within a unified framework to examine the associations between 24-HMB and AD among Chinese adolescents, with a specific focus on the mediating role of BPNs and the moderating effects of gender and BMI.

1.3 Problem Statement

Anxiety disorders (ADs) have emerged as a significant mental health challenge, affecting over 267 million individuals worldwide (Vos et al., 2016), with particularly high vulnerability reported in China (Guo et al., 2016). Notably, epidemiological data revealed that approximately 25% of Chinese adolescents exhibit anxiety-related issues, highlighting the critical need for focused attention on this vulnerable population (Chai et al., 2021). Despite the widespread prevalence of AD, much research attention remains concentrated on pharmacological and cognitive-behavioural therapy approaches (Chambless & Gillis, 1993; Ravindran & Stein, 2010; Garakani et al., 2020; Nicoară et al., 2023), often overlooking lifestyle-related behavioural contributors— especially modifiable and cost-effective daily movement behaviours (i.e., PA, SB, and SLP), which may contribute to the mitigation of these anxiety-related conditions.

The increasing prevalence of modern lifestyles—marked by reduced PA, increased screen-based SB, and SLP disturbance, has profoundly reshaped adolescents' daily behavioural patterns. Growing numbers of adolescents are allocating less time to PA, immersing themselves in screen-based SB, and falling short of achieving the basal level of SLP—behavioural patterns that significantly impact their overall health and well-being (Cao et al., 2011; Qi et al., 2020). In response, the emerging paradigm of 24-HMB, which emphasizes balancing PA, SB, and SLP to achieve optimal health benefits, offers a promising holistic framework for understanding and mitigating mental health outcomes such as AD (Tremblay et al., 2016; Rollo et al., 2020). Within the 24-HMB framework, the three core components of 24-HMB—PA, SB, and SLP—can be integrated into eight distinct movement

behaviour patterns: Only PA, Only SB, Only SLP, PA+SB, PA+SLP, SB+SLP, PA+SB+SLP, and None.

Empirical evidence has shown that each movement behaviour —PA, SB, and SLP—is independently linked to AD. For instance, previous studies have highlighted that regular PA has been linked to lower AD levels (Stubbs et al., 2017), whereas excessive screen-based SB (Cao et al., 2011) and insufficient SLP have been correlated with higher anxiety risks (Short et al., 2020; Roberts & Duong, 2017). Nonetheless, research on 24-HMB within the Chinese context remains in its infancy (Qi & Wang, 2021), with limited attention paid to adolescents' compliance, especially in the aftermath of the pandemic. To date, most existing studies have examined PA, SB, or SLP in isolation, without holistically examining how distinct combinations of these behaviours (i.e., integrated patterns such as PA+SLP, SB+SLP, PA+SB+SLP, etc.) relate to AD within a unified framework. In particular, little is known about which specific movement behaviour patterns yield the greatest protective benefit against AD among Chinese adolescents.

Grounded in the Basic Psychological Need Theory, the three basic psychological needs (BPNs)—autonomy, competence, and relatedness—are increasingly recognized as key psychological mechanisms through which health-related behaviours influence mental well-being. Empirical studies have shown that engagement in PA, SB, or SLP can individually foster the satisfaction of these needs (Fraguela-Vale et al., 2020; Quartiroli & Maeda, 2014; Li et al., 2021; Li, 2023). The satisfaction of BPNs, in turn, has been associated with lower levels of mental health problems, particularly AD (Wu et al., 2018; Erden & Aliyev, 2022; Costa et al., 2022). Despite this, the mediating role of BPNs in the associations between 24-HMB and AD

remains underexplored, especially among Chinese school-aged adolescents. Furthermore, gender and BMI may further moderate these associations by shaping behavioural engagement patterns (e.g., PA and SLP) and psychological sensitivity (McLean et al., 2011; DeJesus et al., 2016). However, these moderating effects have been largely neglected within a unified framework, hindering a comprehensive understanding of individual differences in this behavioural–psychological–mental health pathway.

Therefore, this study seeks to examine how 24-HMB is associated with AD among Chinese school-aged adolescents, with BPNs as a mediator, and gender and BMI as moderators.

1.4 Research Objectives

The primary aim of this study is to examine the associations between 24-HMB and AD, with BPNs as a mediator and gender and BMI as moderators. Specifically, the research objectives of this study are outlined as follows.

RO1. To determine the overall compliance with 24-HMB guidelines across various behaviour patterns (Only PA, Only SB, Only SLP, PA + SB, PA + SLP, SB + SLP, PA+SB+SLP, or None) among Chinese school-aged adolescents.

RO2. To investigate the prevalence of AD among Chinese school-aged adolescents.

RO3. To examine the associations between 24-HMB and AD among Chinese school-aged adolescents.

RO4. To examine the potential mediating role of BPNs towards the associations between 24-HMB and AD among Chinese school-aged adolescents.

RO5. To examine the moderating effects of gender and BMI in the associations between BPNs and AD among Chinese school-aged adolescents.

1.5 Research Questions

The research questions addressed in this study are outlined as follows.

RQ1. What is the overall compliance with 24-HMB guidelines among Chinese school-aged adolescents?

RQ2. What is the prevalence of AD among Chinese school-aged adolescents?

RQ3. What are the associations between 24-HMB and AD among Chinese school-aged adolescents?

RQ4. Do BPNs have a significant mediating effect on the associations between 24-HMB and AD among Chinese school-aged adolescents?

RQ5. Do gender and BMI moderate the associations between 24-HMB and AD among Chinese school-aged adolescents?

1.6 Research Hypotheses

The research hypotheses of this study are outlined as follows.

Ho1. Merely a minor proportion of Chinese school-aged adolescents will meet all three recommendations within 24-HMB guidelines.

Ho2. A substantial proportion of Chinese school-aged adolescents will exhibit AD at different levels.

Ho3. Adolescents who meet all three 24-HMB guidelines (PA+SB+SLP) will demonstrate significantly lower levels of AD compared to other movement behaviour patterns.

Ho4. The BPNs will significantly mediate the associations between 24-HMB and AD among Chinese school-aged adolescents, with optimal 24-HMB patterns enhancing satisfaction and reducing the frustration of BPNs, which in turn predict lower levels of AD.

Ho5. Gender and BMI will significantly moderate the associations between 24-HMB and AD among Chinese school-aged adolescents, with the protective effect of optimal 24-HMB patterns on AD being stronger for male adolescents and weaker among those with higher BMI levels.

1.7 Significance of the Study

The significance of this study holds both theoretical and practical significance.

1.7.1 Theoretical Significance

The 24-HMB (PA, SB, and SLP) represents an innovative paradigm that not only integrates PA but also SB and SLP, by considering the holistic health benefits of all these behaviours within a unified framework, this paradigm addresses the limitations of traditionally focusing on single movement behaviour (such as only PA).

It expands the research perspective from isolated PA to encompass the entire 24-hour period, recognizing the interplay and overall impact of PA, SB, and SLP. This paradigm offers fresh insights into promoting health and mental well-being by highlighting the comprehensive effects of these behaviours throughout the whole day.

Movement behaviours are increasingly recognized as critical in mitigating AD within the context of public health. This study contributes to a better understanding of how integrated movement behaviours are associated with mental health outcomes, particularly AD, among Chinese school-aged adolescents, thereby establishing a theoretical foundation for formulating pertinent guidelines or policies tailored specifically to Chinese adolescents and for implementing interventions based on 24-HMB. Moreover, the findings of this study provide valuable insights for the development of targeted strategies to reduce the risk of AD among adolescents.

1.7.2 Practical Significance

This study offers empirical evidence regarding the compliance rates of 24-HMB guidelines and the associations between 24-HMB and AD among Chinese adolescents.

The findings of this study may extend to broader implications for the development of public health strategies aimed at mitigating AD and improving the overall psychological well-being of Chinese adolescents. In particular, health campaigns focused on 24-HMB could help policymakers and practitioners reduce the burden of AD and related mental health concerns in this population.

The identification of the most protective movement behaviour patterns for AD will help to formulate appropriate measures for early prevention and intervention

programs for adolescents. This study can provide practical guidance to parents and educators regarding healthy daily practices for adolescents. Additionally, it can offer valuable insights for educational authorities, school leaders, and curriculum developers in formulating strategies that promote balanced 24-HMB.

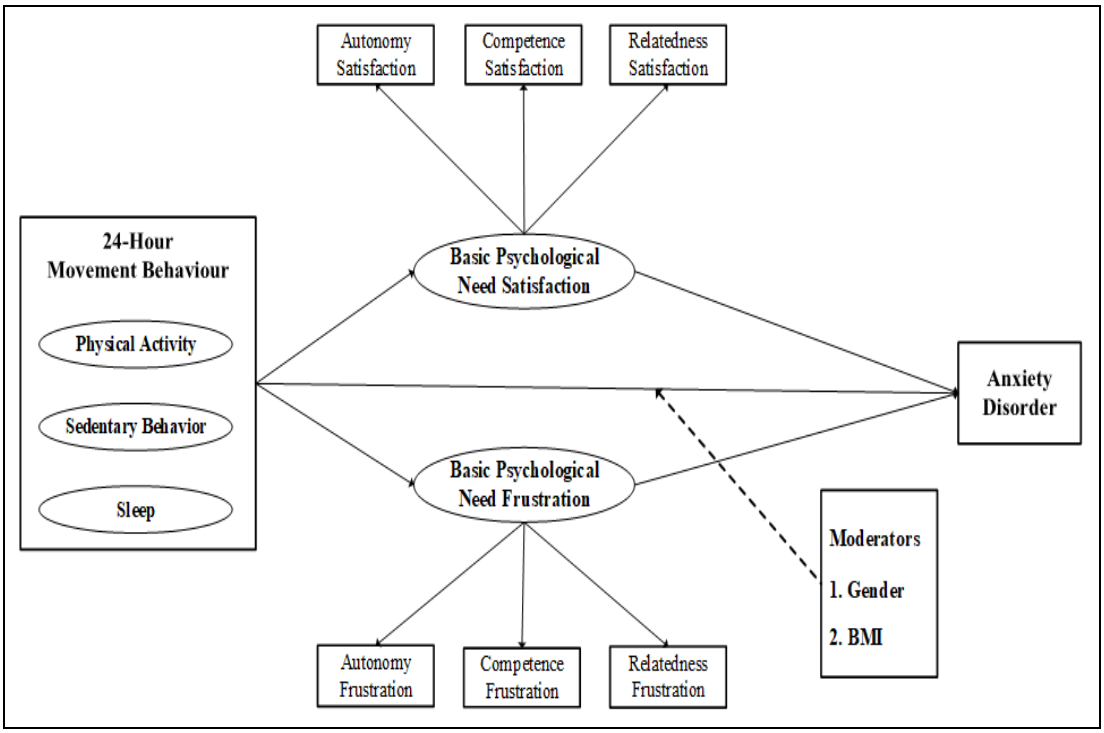
1.8 Conceptual Framework

The primary goal of this study is to examine the associations between 24-HMB and AD among Chinese school-aged adolescents, with a specific focus on the mediating role of BPNs and the moderating role of gender and BMI.

This study is grounded in the Basic Psychological Need Theory, which postulates that the fulfilment of three BPNs—autonomy, competence, and relatedness—is essential for psychological well-being (Ryan & Deci, 2000a). According to the Basic Psychological Need Theory, when these needs are satisfied, individuals experience enhanced well-being, whereas frustration with autonomy, competence, or relatedness can lead to feelings of alienation, failure, or helplessness (Vansteenkiste et al., 2020). Notably, the three BPNs encompass both positive (satisfaction) and negative (frustration) dimensions, with the frustration of these needs being more detrimental than mere non-fulfilment (Vansteenkiste et al., 2020; Ryan & Deci, 2000b). While the satisfaction of these needs promotes mental well-being, their frustration is strongly associated with mental disorders such as AD (Vansteenkiste et al., 2020). The proposed conceptual framework is visually represented in Figure 1.1.

Figure 1.1

Conceptual Framework



The independent variable is 24-HMB, consisting of three components: Physical Activity (PA), Sedentary Behaviour (SB), and Sleep (SLP). These elements are examined both individually and in combination to assess their impact on AD. Together, these three movement behaviours can form eight distinct movement behaviour patterns based on the presence or absence of each behavious (e.g., Only PA, Only SB, Only SLP, PA + SB, PA + SLP, SB + SLP, PA+SB+SLP, or None). The mediating variable is BPNs, which includes autonomy, competence, and relatedness. This study will assess both the satisfaction and frustration of these needs to explore their mediating role in the relationship between 24-HMB and AD. AD is the dependent variable, and its relationship with various patterns of 24-HMB will be examined. The moderating variables are gender and BMI, which will be assessed to explore whether they moderate the relationship between 24-HMB and AD.

In this conceptual framework, 24-HMB is proposed as the independent variable influencing the dependent variable (AD), both directly and indirectly via the mediating role of BPNs. This framework is supported by substantial empirical evidence. 24-HMB, including PA, SB, and SLP has been shown to directly influence AD level. Multiple studies have consistently supported this direct relationship. For instance, extensive studies have confirmed the beneficial effect of regular PA on reducing AD (Stubbs et al., 2017; Dale et al., 2019; Schuch et al., 2019). Similarly, limited SB has been linked to lower AD levels (Allen et al., 2019; Cao et al., 2011; Edwards & Loprinzi, 2016; Rebar et al., 2014; Teychenne et al., 2015; Bélair et al., 2018), while proper SLP duration is associated with reduced AD (Ojio et al., 2016; Mullin et al., 2016; Short et al., 2020; Roberts & Duong, 2017). Moreover, specific combinations of these movement behaviours also have notable associations with AD. For example, the combination of PA and SB has been found to influence AD (Cao et al., 2011; Hrafnkelsdottir, 2018; Liu et al., 2019), as well as PA and SLP (Xiang et al., 2021; Kim, 2020). Additionally, the combination of SB and SLP has been linked to AD (Zhang et al., 2021; Sampasa-Kanyinga et al., 2020b). Moreover, adherence to all 24-HMB, involving balanced PA, limited SB, and proper SLP, has been associated with reduced AD levels (Feng et al., 2021; Lu et al., 2021; Bu et al., 2021; Zhu et al., 2019).

In addition to the direct effects, BPNs are proposed to mediate the relationship between 24-HMB and AD. A significant body of research supports this mediation. Engaging in PA has been shown to enhance BPNs, which in turn may reduce AD (Li et al., 2021; Fraguela-Vale et al., 2020; Springer et al., 2013; Kazak, 2018). Similarly, limited SB is associated with increased BPNs (Quartiroli & Maeda, 2014; Li et al., 2021), and also proper SLP contributes to the enhancement of BPN (Campbell et al., 2015; Li, 2023; Tavernier et al., 2019; Quartiroli & Maeda, 2014; Li et al., 2021).

Furthermore, BPNs themselves have been found to play a critical role in mitigating AD (Wu et al., 2018; Erden & Aliyev, 2022; Costa et al., 2022; Maralani et al., 2016). Besides, gender and BMI are proposed as moderating variables in the relationship between 24-HMB and AD, which is supported by evidence from several studies (Tian et al., 2022; Brodersen et al., 2005; Ohannessian, 2009; Ohannessian, 2018; Wu et al., 2018; Mundy et al., 2017; Knell et al., 2019).

Overall, this framework elucidates the dual-pathway mechanism through which 24-HMB (PA, SB, SLP) influence AD - both directly and indirectly via BPNs (satisfaction and frustration), with gender and BMI serving as key moderators.

1.9 Operational Definition of Terms

The key terminologies and definitions, particularly focusing on the key definition relevant to this study, are systematically outlined below.

1.9.1 24-Hour Movement Behaviour

24-hour movement behaviour refers to the holistic integration of all movement behaviour occurring throughout a 24-hour period, including PA, SB, and SLP (Tremblay, 2016; CSEP, 2016). The integration of these components can yield eight distinct behaviour patterns: Only PA, Only SB, Only SLP, PA + SB, PA + SLP, SB + SLP, PA+SB+SLP, or None.

1.9.1(a) Physical Activity

Physical activity is defined as any bodily movement of the body generated by skeletal muscles that leads to the expenditure of energy (Caspersen et al., 1985). According to the 24-HMB guidelines, adolescents are encouraged to engage in several

hours of various light-intensity PA and accumulate at least an hour of MVPA daily, including aerobic activities, vigorous-intensity PA, as well as additional strengthening activities, for a minimum of three days each week (Tremblay et al., 2016). While PA encompasses a range of intensities, this study specifically focuses on MVPA—a subset of PA that has been associated with significant health benefits (Bull et al., 2020).

MVPA is operationally defined in this research as any bodily movement that involves a moderate to high level of intensity over a specified period, typically within the last seven days. MVPA was assessed using the Health Behaviour in School-aged Children (HBSC) survey (Liu et al., 2010).

1.9.1(b) Sedentary Behaviour

Sedentary behaviour is typically defined by minimal physical movement and low energy expenditure (≤ 1.5 METs, Metabolic Equivalent Units) (Pate et al., 2008). It is typically associated with time spent engaging in screen-based activities using electronic devices such as TV, computers, and phones, while in a seated position (Mansoubi et al., 2015).

In this research, SB is operationally defined as engaging in activities that require minimal energy expenditure, typically for recreational screen-based activities. According to the 24-HMB guidelines, it is advised that adolescents restrict their screen-based sedentary time to a maximum of 2 hours each day (Tremblay et al., 2016). SB was measured by the HBSC questionnaire (Liu et al., 2010).

1.9.1(c) Sleep

Sleep is a naturally occurring condition of mind and body that is characterized by changes in consciousness, decreased sensory activity, reduced muscle activity, and the inhibition of nearly all voluntary muscles during fast eye movement (Ferrieri et al., 2008). According to the 24-HMB guidelines, adolescents are encouraged to have an uninterrupted SLP of 8 to 10 hours per night, maintaining consistent bedtimes and wake-up times (Tremblay et al., 2016).

In this research, SLP is primarily concerned with its duration, which is defined operationally as the total hours of sleep recorded each night. SLP was assessed using the HBSC questionnaire (Liu et al., 2010).

1.9.2 Anxiety Disorder

Anxiety disorder is defined as a neurosis characterized by excessive and persistent worry, often leading to panic and commonly accompanied by somatic experiences (Zung, 1971).

In this research, AD is described as a neurosis characterized by sustained, excessive worry, commonly leading to panic. The measurement of AD is conducted through the Zung' Self-Rating Anxiety Scale (Zung, 1971).

1.9.3 Basic Psychological Needs

The mediating variable is the basic psychological need, which is defined as a psychological nutrient that is crucial for individuals' adaptation, integrity, and growth of persons (Ryan, 1995), and the three fundamental psychological needs are those for autonomy, competence, relatedness (Ryan & Deci, 2017).

In this research, Basic Psychological Needs refer to the degree of autonomy, competence, and relatedness, crucial for personal adjustment and development, as assessed using the Basic Psychological Need Satisfaction and Frustration Scale (Ryan & Deci, 2017).

1.9.3(a) Autonomy Satisfaction

Autonomy satisfaction is the state of autonomously determining, fully willing, and volitionally carrying out an activity (Chen et al., 2015). It reflects the extent to which individuals feel a sense of choice and personal endorsement in their actions, rather than feeling pressured or controlled by external forces.

In the context of this study, autonomy satisfaction is operationalized as the degree to which adolescents experience a sense of self-determination in their daily activities, particularly in relation to their engagement with 24-HMB and its impact on their AD.

1.9.3(b) Competence Satisfaction

Competence satisfaction refers to feeling effective and capable of achieving desired outcomes (Chen et al., 2015). It reflects the extent to which individuals perceive themselves as skilled and competent in their actions, leading to a sense of mastery and accomplishment.

In the context of this study, competence satisfaction is operationalized as the degree to which adolescents perceive their ability to successfully engage in and manage 24-HMB, and its subsequent impact on their AD.

1.9.3(c) Relatedness Satisfaction

Relatedness satisfaction refers to the experience of intimacy and genuine connection with others (Chen et al., 2015). It reflects the extent to which individuals experience a sense of belonging and meaningful relationships in their social environment.

In the context of this study, relatedness satisfaction is operationalized as the degree to which adolescents feel socially connected and supported in their engagement with 24-HMB, and how this sense of connection influences their AD.

1.9.3(d) Autonomy Frustration

Autonomy frustration refers to feeling controlled through externally enforced or self-imposed pressures (Chen et al., 2015). It reflects the extent to which individuals perceive a lack of choice and personal endorsement in their activities.

In the context of this study, autonomy frustration is operationalized as the degree to which adolescents experience external pressures or constraints in their engagement with 24-HMB, and how this frustration impacts their AD.

1.9.3(e) Competence Frustration

Competence frustration refers to feelings of failure and doubts about one's efficacy (Chen et al., 2015). It reflects the extent to which individuals perceive themselves as lacking the skills or capabilities to succeed in their actions.

In the context of this study, competence frustration is operationalized as the degree to which adolescents feel incapable of effectively managing their 24-HMB, and how this sense of inadequacy influences their AD.

1.9.3(f) Relatedness Frustration

Relatedness frustration refers to the experience of relational exclusion and loneliness (Chen et al., 2015). It reflects the extent to which individuals perceive a lack of meaningful relationships or a sense of isolation in their social environment.

In the context of this study, relatedness frustration is operationalized as the degree to which adolescents experience social isolation or lack of support in their engagement with 24-HMB, and how this frustration impacts their AD.

1.9.4 Gender and BMI

In this study, the moderator variables encompass gender and BMI.

1.9.4(a) Gender

Gender refers to the characteristics of women, men, females, and males that are socially constructed (WHO, 2019). In the context of this study, gender is examined as a potential moderator in the relationship between 24-HMB and AD. Gender information of adolescents can be accessed through the background section of the questionnaire. Respondents are provided with options to specify their gender identity, allowing them to select either 'male' or 'female' as their response.

1.9.4(b) BMI

The BMI is a straightforward measure of weight for height, calculated by dividing an individual's weight in kilogrammes by the square of their height in metres (kg/m^2) (WHO, 2021b). In the context of this study, BMI is examined as a potential moderator in the relationship between 24-HMB and AD. BMI is determined by dividing an individual's weight in kilogrammes by the square of their height in meters