

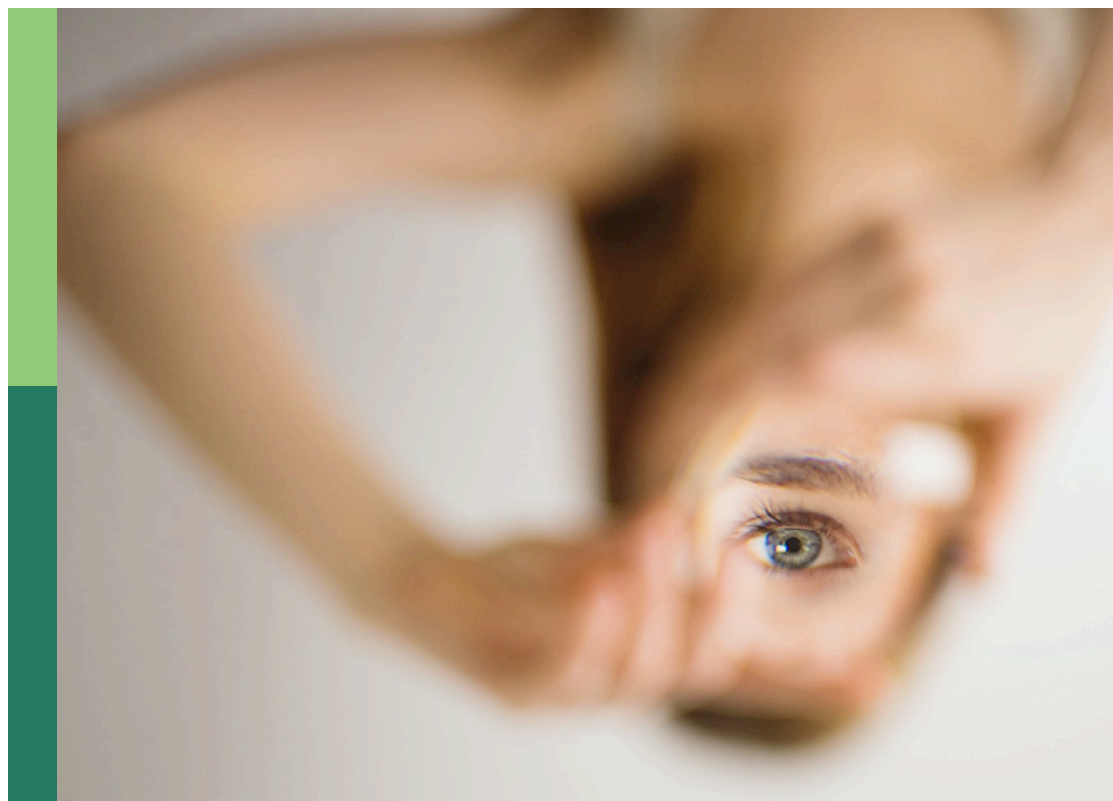
Motivations for physical activity, volume III

Edited by

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and Iuliia Pavlova

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Motivations for physical activity, volume III

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Editorial: Motivations for physical activity—Volume III

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Editorial on the Research Topic

Motivations for physical activity—Volume III

Introduction

The practice of regular physical activity is widely recognized as one of the main pillars of health throughout the life cycle. Despite the robust evidence supporting its benefits (e.g., in the prevention of chronic diseases, in the improvement of mental health, in the promotion of wellbeing and longevity) a significant part of the population still does not comply with the minimum recommendations for physical activity. This paradox between knowledge and action has motivated increasing attention from the international scientific community, seeking to understand the psychological and behavioral mechanisms that influence, facilitate or inhibit the regular practice of physical activity and sports participation.

It was in this context that this Research Topic was born, jointly hosted by the journals *Frontiers in Psychology* and *Frontiers in Sport and Active Living*, with the aim of aggregating scientific contributions that explore the psychological and behavioral dimensions of the practice of physical activity and involvement in sport, at different ages, cultures, contexts and modalities. The set of 20 articles gathered in this Research Topic constitutes a valuable repository of empirical data, theoretical reflections, and proposals for concrete intervention applicability. This editorial thus aims to present a critical synthesis of the main emerging themes, articulate individual contributions in an integrated narrative and highlight the implications for research, practice and public policy formulation. The methodological and geographical diversity of the studies presented allows us to observe more clearly the complexity of this phenomenon and the way in which different variables interact, reinforce, or limit the active involvement of people throughout the various stages of life. Contributions range from psychometric analyses to qualitative investigations, from clinical trials to systematic reviews, offering a comprehensive and interdisciplinary panorama.

Motivation, identity and self-regulation: structuring nuclei

Motivation continues to be one of the most studied axes in the field of physical activity, with approaches ranging from classical theories (e.g., self-determination, planned behavior) to more recent perspectives, focused on hope, grit or athletic identity.

Kovács analyses motivational profiles of more than a thousand young Hungarian athletes, highlighting the complexity of the interactions between sports orientation, persistence and personality traits. The study by Tokarska and Rogowska, used a person-centered approach to identify distinct motivational profiles in cyclists and runners. The authors revealed that different combinations of intrinsic and extrinsic motivation, as well as levels of self-efficacy, configure typologies that directly impact the behavior of athletes. This differentiated vision allows for the design of intervention strategies that are more adjusted to the reality of each practitioner. The contribution of Ronca et al. broadens this reflection suggesting that personality traits (such as extraversion or emotional stability) can influence not only the preference for certain intensities of physical exercise, but also the magnitude of stress reduction obtained after a training program. This work highlights the importance of individualizing activity proposals, considering psychological predispositions. In the sphere of self-regulation, Blythe et al. demonstrate that hope agency predicts the ability to achieve exercise goals in college students. Participants with higher levels of hope showed greater consistency and success in achieving the set physical goals, pointing to the relevance of positive, future-oriented motivational states. Finally, Zhou et al. present a meta-analysis that reveals a moderate and bidirectional association between exercise motivation and cardiorespiratory fitness in students, consolidating the evidence of the importance of motivation for physical development and vice versa.

Self-efficacy, confidence, and psychological wellbeing

The role of self-efficacy as a behavioral determinant is evidenced in several studies in this collection. The meta-analysis by Xie et al. demonstrates a consistent association between self-efficacy and physical activity in older adults, with a mutually reinforcing relationship. This virtuous cycle is especially relevant for the design of interventions aimed at active aging. The relevance of this construct also extends to other age groups, as evidenced by Kessler et al., who studied middle-aged and older adults with musculoskeletal pain. The work revealed that hope (understood as an emotional component related to self-efficacy) significantly predicts the levels of physical activity reported, even in the face of physical limitations. This finding reinforces the idea that positive psychological aspects can mitigate physical barriers and motivate active behavior. On the other hand, Na et al. contributed to the development and preliminary validation of a scale of parenting practices promoting physical activity for Chinese children between 3 and 6 years old. The application of this instrument revealed the significant influence of parenting

styles on children's self-efficacy beliefs regarding movement and structured play practice, highlighting the importance of facilitating contexts from early childhood. Still in the field of the relationship between exercise and mental health, Zhang et al. demonstrated that regular physical activity in Chinese university students significantly improves emotional management, and this effect is mediated by two factors: life satisfaction and perceived health. These results point to psychological mediation mechanisms with potential for interventions in academic environments. Still in the field of the relationship between exercise and mental health, the study by Ahsan et al. analyzed the effects of physical activity on mental toughness and quality of life in a gender-differentiated sample of young adults. The authors identified differences between men and women in physical activity levels, as well as in several domains of mental strength and quality of life. These results reinforce the importance of considering gender as a moderating variable, and point to the role of physical activity as a transversal promoter of psychological skills and global wellbeing.

Social factors, interpersonal relationships, and supportive climate

The influence of the social environment and interpersonal interactions is another theme that is strongly transversal to the articles included in this Research Topic. In fact, human behavior in the field of physical activity is profoundly influenced by the social environment. The quality of interpersonal relationships, leadership styles and the motivational climate play a decisive role in the way people start, maintain or abandon active practices. In performance sports, Liu et al. show that coaches' leadership behavior has direct and indirect positive effects (via coach-athlete relationship and psychological fatigue) on athletes' performance. This study reinforces the need for training in relational skills for training professionals. On the practitioners' side, Wineinger et al. explored effects of ego-centered motivational climates on master swimmers in the United States. The results indicate that excessively competitive environments, which promote social comparisons to the detriment of personal development, tend to compromise the perception of competence and long-term commitment. These data are particularly relevant in the context of senior sport, where wellbeing and active longevity should be priorities. Kim et al. show, in a study applied to the practice of Pilates, that subjective norms and perceived social value have greater weight than functional or emotional value in the intention to engage in practice. This evidence emphasizes the importance of perceived support and social influence in decision-making.

Culture, values, and patterns of sports consumption

The practice of physical activity is not dissociated from cultural contexts and dominant value systems. They are also anchored in cultural values, social habits, and symbolic forms of belonging, expression, and consumption. Chen et al. use

structural equation modeling to analyse the relationship between attitudes toward exercise and sports consumption patterns in Chinese urban residents. The results reveal that positive attitudes directly influence the practice, which, in turn, is associated with greater sports consumption; suggesting a circular model of behavioral and economic reinforcement. The article by Wambsganz et al. also contributes to this field, identifying intrapersonal factors (e.g., self-efficacy, intrinsic motivation, personality traits) that distinguish regular practitioners from inactive practitioners, in a sample of the German population. The study offers valuable clues for designing more effective behavioral campaigns.

Technology, innovation, and emotional engagement

The incorporation of technology in the contexts of sports practice and physical activity has been profoundly transforming the way people engage with exercise. In addition to monitoring and personalization, the elements of immersion and emotional involvement have taken on an increasingly relevant role. For instance, the potential of technology as an enabler of active lifestyles is explored. In a pilot study Touloudi et al. compared a traditional exercise program with a virtual reality-based program in adults with obesity. The virtual reality intervention demonstrated greater effectiveness in improving body composition, activity levels, and exercise pleasure; key factors for sustained adherence. Emotionally and sensorily, Suwabe and Kawase reveal that music with high groove has positive effects on running speed and mood, especially among university women. These results show that immersive and pleasurable experiences can be catalysts for practice. The effectiveness of persuasive communication is addressed by Sun et al., who demonstrate that messages aligned with the recipient's regulatory style (promotion vs. prevention) are more effective in influencing the intention to exercise. This "regulatory fit" approach offers a promising avenue for more targeted and impactful campaigns.

Together, these studies underline that technological innovation and attention to emotional engagement are essential components for a contemporary approach to the promotion of physical activity. Technology should not be seen only as a measurement tool, but as a catalyst for positive, motivating and personalized experiences.

Life transitions and behavioral changes

The practice of physical activity does not occur in a linear way throughout life. Transition phases, such as early adulthood, parenting, aging, or professional and social changes, are critical moments with a strong impact on movement-related behaviors. The transition to parenthood represents one of the most significant changes in adult life and has a direct impact on health behaviors. Bekhuis and van Abswoude analyse longitudinal data and conclude that after the birth of their first child, women tend to temporarily reduce their sports participation, while men maintain stable patterns. These data suggest that policies to promote physical activity should be sensitive to gender and family dynamics. At

the opposite end of the life cycle, the study by González-Calvo et al. explored, through a qualitative approach with men between 65 and 76 years old, how physical practice contributes to the reconstruction of identity in aging. The authors identified that exercise promotes emotional wellbeing, challenges traditional norms of masculinity, and fosters meaningful social connections. Regular practice, especially in groups, emerges as a space of resistance to deficient narratives about aging, also evidencing the structural and socioeconomic barriers that limit access to physical activity for this age group. The research reinforces the importance of inclusive public policies and a positive and critical approach to active aging.

Integration, diversity, and future implications

The set of articles gathered here represents a diverse and methodologically rich sample of research that focuses on the interface between psychology, human behavior and physical activity. By addressing different age groups, geographies, modalities and methodologies, this collection contributes to a more holistic and applied understanding of the phenomenon. The practical implications, which are numerous, can be summarized as: (i) interventions must be multicomponent, integrating individual (e.g., motivation, self-efficacy), contextual (social and physical environment) and technological (digital supports, sensory stimuli) factors; (ii) pleasure and emotional involvement should be considered not as a consequence, but as a condition that promotes adherence; (iii) the design of public policies must take an ecological perspective, articulating health, urbanism, education and culture; (iv) research should evolve toward longitudinally sustained approaches, with continuous measurement of effects and adaptation to social transformations (e.g., digitalisation, demographic aging, inequalities of access).

Conclusion

This collection of twenty articles contributes significantly to the advancement of knowledge about the psychological and behavioral determinants of physical activity and sport. The studies presented here challenge traditional models, introduce innovative variables, validate approaches in different cultures and offer concrete clues for intervention. As editors, we express our sincere thanks to all the authors, reviewers, and contributors who made this publication possible. We believe that this Research Topic will not only be a reference for the scientific community, but also a catalyst for new ideas, programs and policies that are more effective in promoting active and healthy lifestyles.

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PM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

AR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. IP: Writing – original draft, Writing – review & editing.

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The relationship between urban residents' physical exercise attitudes and sports consumption demands: the mediating role of physical activity level

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Object: This study examines the differences and relationships among urban residents' physical exercise attitudes, physical activity levels, and sports consumption demands, focusing on how physical activity level mediates the relationship between exercise attitudes and consumption behaviors.

Method: A survey was conducted among residents in Chengdu using validated questionnaires to measure physical exercise attitudes, physical activity levels, and sports consumption demands. Data analysis included independent samples *t*-tests and one-way ANOVA to assess differences across demographic variables, as well as correlation analysis and structural equation modeling to examine the path relationships among key variables.

Results: Independent samples *t*-tests and ANOVA showed significant differences in sports consumption demands across age, education, and income groups ($p < 0.05$). Correlation analysis revealed significant positive relationships among physical exercise attitudes, physical activity levels, and sports consumption demands ($p < 0.01$). Structural equation modeling confirmed that physical activity levels partially mediated the relationship, with a direct effect size of 0.295 ($p < 0.001$) and an indirect effect size of 0.117 ($p < 0.001$), accounting for 28.4% of the total effect.

Conclusion: The study highlights that positive exercise attitudes significantly impact sports consumption demands directly and through the mediating role of physical activity levels. Enhancing physical activity can amplify the effects of exercise attitudes on consumption, providing insights for promoting sports participation and consumption in urban settings.

KEYWORDS

physical exercise attitudes, sports consumption demands, physical activity level, urban residents, Chengdu City

1 Introduction

In contemporary society, the sports industry has emerged as a pivotal force in driving high-quality economic development (Li et al., 2022), with sports consumption serving as a core component that is gradually evolving into a new aspiration to meet the growing needs of people for a better life (Koronios et al., 2020). In recognition of this, the government has promulgated a series of policy documents aimed at promoting mass sports participation and

consumption awareness, and fostering the high-quality development of the sports industry (Volf et al., 2022; Hughes et al., 2022). These policies not only provide a strong foundation for the vibrant growth of the sports industry (Hai, 2014), but also offer a solid policy basis for this study to explore the relationship between physical exercise attitudes and sports consumption demands.

However, the current situation of sports participation among Chinese residents is far from optimistic (Su et al., 2017; Gan and Jiang, 2022). The prevalence of sedentary lifestyles and other unhealthy behaviors has significantly hindered the growth of sports consumption demand (Dong and Liu, 2022; Dong et al., 2023). The inadequacy of sports participation has become one of the major constraints limiting the development of the sports industry (Li et al., 2023; Xing et al., 2020; Thibaut et al., 2020). Therefore, exploring the relationship between physical exercise attitudes and sports consumption demands holds significant importance in stimulating sports consumption and propelling the progress of the sports industry.

At the theoretical level, this study introduces the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM) to effectively link core variables such as physical exercise attitudes, physical activity level, and sports consumption demands. TPB emphasizes the crucial role of behavioral intention in predicting actual behavior (Armitage and Conner, 2001; Ajzen, 2011), with physical exercise attitudes and subjective norms being key factors influencing behavioral intention (La Barbera and Ajzen 2021; Rhodes et al., 2024; Phipps et al., 2021). Meanwhile, TAM approaches the issue from the perspective of consumer perception (Yau and Hsiao, 2022; Venkatesh et al., 2003), positing that perceived usefulness and perceived ease of use are significant determinants of consumer attitudes and behaviors (Rhodes et al., 2024; Ibrahim, 2013; Sanjida and Touhiduzzaman, 2022). These theories provide vital theoretical support and analytical frameworks for this study.

In summary, this study aims to investigate the relationship between physical exercise attitudes, physical activity level, and sports consumption demands. Through an in-depth examination of this topic, we aspire to offer insightful ideas and recommendations that can foster greater participation in sports activities, enhance sports consumption awareness, and promote the high-quality development of the sports industry.

2 Literature review and theoretical framework

2.1 Physical exercise attitude

In psychology, attitude refers to a stable psychological tendency held by an individual toward a specific object of inclination (person, idea, emotion, or event) (Fishbein and Ajzen, 1977), which implies the individual's subjective evaluation and the resulting specific behavioral tendency (Rhodes et al., 2024). An attitude consists of three dimensions: cognition, affect, and behavioral intention (Bock et al., 2005). Cognition refers to the meaningful commentary made by an individual about the attitudinal object, including knowledge, understanding, doubt, and approval (Elizabeth, 2000). Affect concerns the emotional experience an individual has toward the attitudinal object, such as liking or disliking (McAllister, 1995). Behavioral

intention indicates the individual's responsiveness and readiness to react toward the attitudinal object (Bock et al., 2005).

Regarding physical exercise attitude, scholars offer slightly varying interpretations. Some studies suggest that physical exercise attitude constitute a narrow component within the broader concept of sports attitude, referring specifically to an individual's motivation to engage in physical exercise (Wen-Qian and Jian-Ping, 2006; Cui-Jin et al., 2012; Song, 2019). This motivation is seen as a relatively stable cognitive manifestation that can be acquired through learning (Cui-Jin et al., 2012; Wei-Qiang, 2017). Others define physical exercise attitude as the emotional and behavioral responses exhibited by individuals across different contexts (Qi-Feng, 2017), representing a comprehensive manifestation of cognition, affect, and behavioral intention toward physical exercise (Mei et al., 2019; Lee et al., 2021). Such attitudes are believed to exert a positive influence on subsequent exercise behaviors (Wen-Qian and Jian-Ping, 2006; Wei-Qiang, 2017; Sindik et al., 2022). Furthermore, physical exercise attitude also encompass specific exercise content, determining the types and forms of exercise an individual chooses to participate in and ultimately affecting the effectiveness of their physical training (Xu and Yu, 2013).

Some scholars have further subdivided attitude toward physical exercise into eight dimensions: behavioral attitude, goal attitude, behavioral cognition, behavioral habit, behavioral intention, emotional experience, sense of behavioral control, and subjective norm (Jaarsma et al., 2014).

In this study, physical exercise attitude is defined as the individual's cognitive, affective, and behavioral intention specifically toward engaging in physical exercise. This definition focuses on attitudes that drive direct participation in physical activities, including motivation, emotional response, and readiness to engage in exercise. This study employs this dimensional framework—encompassing cognition, affect, and behavioral intention—to investigate how attitudes toward physical exercise influence sports consumption demand among urban residents.

2.2 Physical activity level

The term “Physical Activity Level” refers to the amount of physical activity engaged in by an individual (Xu, 2013). Physical activity level falls within the scope of sports behavior and is considered its primary manifestation (Piątkowska, 2012). To delve into the physical activity level, one must first clarify what is meant by “physical exercise,” also known as bodily exercise (Caspersen et al., 1985). It refers to physical activities aimed at improving health, enhancing physical fitness, regulating one's spirit, and enriching cultural life (Surkalim et al., 2024). Studies have shown that sports behavior entails the conscious adoption of sports methods and means to achieve sporting goals (Kuczkowska, 2021). Exercise behavior mainly occurs during leisure time, with health as the primary objective, and involves bodily activities of certain intensity, frequency, and duration (Wang, 2015). Some define it as leisure-time physical activity, which is a subset of physical activity (Li, 2012). Studies have shown that sports behavior is a conscious adoption of sports methods and means to achieve sports goals (Shenoi et al., 2022).

In this study, physical activity level is defined as the extent of involvement in sports-specific activities that are structured, planned, and undertaken with the goal of improving or maintaining physical

health, such as recreational exercise and fitness activities. This definition intentionally excludes physical activities related to daily routines, such as household chores, gardening, work, or transport. The measurement tool applied in this research (i.e., the Physical Activity Rating Scale) assesses the level of engagement in sporting activities, with a focus on intensity, frequency, and duration, to ensure that the assessment aligns specifically with sports-related physical activity rather than general daily movements.

2.3 Sports consumption demand

Consumption demand refers to the desire and willingness of consumers to acquire various consumption materials to fulfill their needs for survival, enjoyment, and development (Bronsard, 1981; Liu, 2000). Therefore, demand for sports consumption represents the degree of consumers' desire for various sports products (Chen et al., 2008).

Sports consumption demand can be understood as an inevitable reflection of the organism's demand for sports consumption when people have basically met their physiological and safety needs, in pursuit of health, entertainment, social interaction, respect, and other needs (Liu, 2000; Pang and Li, 2016). It is a product of social productive forces developing to a certain stage and an indispensable component of the consumption structure of modern people's lives (Liu et al., 2004). From the perspective of the objects of sports consumers' demand, it can be divided into two major categories: material consumption of sports and spiritual consumption of sports (Chen et al., 2008). Material consumption demand mainly refers to people's demand for various physical sports products (such as sportswear, fitness equipment, etc.) (Chen et al., 2008). Spiritual consumption demand mainly refers to people's demand for watching sports competitions, participating in sports activities, training, enjoying sports services, etc., to meet physiological and spiritual needs (Chen et al., 2008).

Some studies have pointed out the general laws of sports consumption behavior and believe that sports demand is the starting point for sports consumption behavior (Liu, 2000; Pang and Li, 2016; Shasha, 2023). At the same time, research indicates that sports consumption demand is built on individuals' basic physiological and safety needs, arising from the need for health, entertainment, social interaction, etc., and is an inevitable product of the continuous development of social productive forces (Weimar and Breuer, 2022; Guo and Chen, 2022).

Sports consumption demand encompasses a wealth of content, and its classification should be hierarchical, specifically including participation demand, tangible demand, information demand, and ornamental demand (Chen et al., 2008). The attributes it possesses transition continuously and hierarchically from material to spiritual (Chen et al., 2010).

In this study, sports consumption demand is defined as the multifaceted desire and willingness of individuals to engage in both material and spiritual aspects of sports. This encompasses not only the direct purchase of sports products and services but also the broader consumption of sports experiences, such as participating in or spectating sports activities, as well as engaging with sports-related content for entertainment and social interaction. This study aims to capture both active involvement (e.g., direct participation) and passive

engagement (e.g., spectating and consuming sports media), providing a comprehensive perspective on the ways urban residents interact with sports as consumers.

2.4 Physical exercise attitude and sports consumption demand

Investigations into the dynamics of physical exercise attitude and sports consumption demand reveal an evolving relationship tied to the various stages of exercise engagement (Xu, 2013). Initial studies chart a clear trajectory of rising sports consumption as individuals progress from contemplation (pre-intention stage) to active participation (action stage), with a noted dip during the habituation (maintenance stage) (Chen et al., 2012).

In the context of university students, a nuanced pattern emerges, illustrating an escalation in sports-related spending correlating with the advancement through exercise stages (Chen, 2020). Early stages see modest expenditure, under 100 yuan monthly, which notably increases to between 100 and 300 yuan as students reach the maintenance phase of their exercise routines (Jiao et al., 2018).

In addition, investigations in certain regions of China have shed light on how attitudes toward physical activity influence sports consumption behaviors. Findings suggest that students with a positive disposition toward regular physical exercise tend to have higher sports consumption, illustrating the significant connection between physical exercise attitudes and spending behaviors on sports (Cui-Jin et al., 2012; Wei-Qiang, 2017; Fan, 2012).

Further analysis extends to the adolescent demographic, dissecting sports consumption into three distinct needs: intrinsic (self-purpose), supportive (auxiliary), and functional (instrumental) consumption. The study found an important link between daily physical activity attitudes and these different consumption categories, underscoring a strong correlation even after adjusting for demographic effects (Chen, 2020; Yang et al., 2020). Positive attitudes toward extracurricular physical activity are clearly aligned with these identified sports consumption demand, highlighting the comprehensive interplay between physical exercise attitudes and sports consumption demand at different life stages and activities (Chen, 2020; Mao, 2003).

2.5 Physical exercise attitude and physical activity level

When exploring the relationship between physical exercise attitude and physical activity level, studies have found limitations in traditional planned behavior theory, as it ignores the potential impact of emotions, goal attitudes, and habits on exercise intentions and behaviors (Martínez-de-Quel et al., 2021). To address this gap, researchers have proposed a more comprehensive "Exercise-Behavior Nine-Factor Model" and designed a corresponding physical exercise attitude scale (Hagger and Hamilton, 2020), which has been widely used in China to assess the exercise attitudes of groups such as adolescents and college students.

Further empirical research has revealed a certain correlation between physical exercise attitude and physical activity levels. In a study targeting college students, researchers used the physical

exercise attitude scale and the physical activity rating scale, finding that apart from a significant negative correlation between subjective norms and exercise volume, the other seven dimensions of exercise attitude all showed a weak positive correlation with exercise volume (Zhou and Zhou, 2009). Another study on urban residents indicated that physical exercise attitude, subjective norms, and cognitive behavior control jointly influenced their physical activity levels (Frmel et al., 2020). Additional research has explored the predictive effect of physical exercise attitude on the exercise behavior activity levels of college students in specific regions (such as Heilongjiang Province), finding that physical exercise attitude had a good predictive effect on exercise intensity and frequency but a less satisfactory predictive effect on exercise duration (Liu and Li, 2011).

2.6 Physical activity level and sports consumption demand

The relationship between physical activity level and sports consumption demand has garnered attention through various studies, particularly focusing on university students in urban settings (Knaggs et al., 2022). Research conducted in metropolitan areas shows a clear positive correlation between the frequency and intensity of physical activities and the demand for sports-related products and services among students (Zhen-Long et al., 2009). This link underscores the direct impact that exercise behaviors have on sports consumption patterns.

Moreover, a study spanning a range of ages from schoolchildren to university students revealed that specific exercise routines significantly affect the diversity and type of sports consumption, pointing to varied preferences based on individual characteristics and interests (Chen, 2020).

However, despite these insights, there remains a gap in research specifically targeting the urban resident population (Fan, 2012; Wirnitzer et al., 2023). This gap presents an opportunity for further exploration, especially considering the changing socio-economic conditions, rising disposable incomes, and the growing proliferation of fitness initiatives (Fang et al., 2022). Addressing these factors in future studies could offer deeper understanding into consumer behaviors and demands within the ever-evolving sports market.

Although there are many researches on the pair-to-pair correlation between physical exercise attitude, physical activity level and sports consumption demand, no studies have been found on the relationship between the three. Based on this, this study includes physical exercise attitude, physical activity level and sports consumption demand at the same time, and discusses the relationship among the three.

According to the relevant studies reviewed in literature, there is a pin-wise correlation between the physical exercise attitude, physical activity level and sports consumption demand, but the relevant studies are also controversial, that is, the specific correlation between the three dimensions may not be significant. At the same time, the research on the physical exercise attitude, physical activity level and sports consumption demand is mostly concentrated on the study of college students, but the research is relatively scarce in the urban residents in our country. Therefore, this study takes Chengdu City as an example to explore the relationship among urban residents' physical exercise attitude,

physical activity level and sports consumption demand. Based on the results of the above literature review, the following hypotheses are proposed:

H1: There are significant differences in the sports consumption demand of Chengdu City residents with different demographic variables.

H2: There is a significant positive correlation between the physical exercise attitude, physical activity level, and sports consumption demand of residents in Chengdu City.

H3: The physical activity level of Chengdu residents mediates the relationship between physical exercise attitude and sports consumption demand.

2.7 Current study

In the context of the burgeoning sports industry and the evolving landscape of urban lifestyles, there's a pressing need to understand the dynamics between urban residents' physical exercise attitude, their actual engagement in physical activities, and the resultant sports consumption demands. Previous research has often explored these elements in isolation, examining either the relationship between physical exercise attitude and sports consumption demand or the impact of physical activity levels on consumption patterns. Yet, the interconnectedness of these factors and their collective influence on sports consumption demand remains underexplored, especially within urban Chinese settings such as Chengdu City.

The present research seeks to fill this gap by proposing an integrative model that examines the relationships among physical exercise attitudes, physical activity levels, and sports consumption demands within an urban context. Specifically, the study aims to:

- (1) Assess the direct relationship between urban residents' physical exercise attitudes and their sports consumption demands.
- (2) Explore the extent to which physical activity levels mediate the relationship between physical exercise attitudes and sports consumption demands.
- (3) Investigate the compounded effects of physical exercise attitudes and physical activity levels on the variety and intensity of sports consumption among urban residents.

This research makes several significant contributions to both theory and practice:

- (1) **Theoretical Expansion:** By integrating the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM), this study extends existing theoretical frameworks to the context of sports consumption. This novel approach allows for a comprehensive understanding of how attitudes toward physical exercise influence consumption behaviors through the mediating role of physical activity levels.
- (2) **Empirical Insights:** Offering empirical evidence from Chengdu City, the study enriches the body of knowledge on sports consumption behaviors in urban China. It provides nuanced insights into how exercise attitudes and engagement levels

influence sports consumption, addressing a significant gap in the current literature.

- (3) Policy and Marketing Implications: The findings are poised to inform policymakers and marketers about the underlying motivations of sports consumption. By understanding the role of exercise attitudes and activity levels, strategies can be devised to promote healthier lifestyles and boost sports consumption in urban settings.
- (4) Sociocultural Perspective: Given the unique sociocultural dynamics of urban Chinese populations, this research contributes to the global discourse on sports consumption by highlighting the influence of local environmental and societal factors.

3 Methods

3.1 Participants

This study utilized three questionnaires, comprising a total of 83 items alongside demographic data collection, resulting in approximately 90 survey items. Following the 1:10 ratio principle commonly applied in social science surveys (i.e., 10 times the number of questionnaire items), the minimum required sample size was set at 900 respondents. To account for potential invalid responses, a total of 1,500 residents were initially recruited.

The inclusion criteria ensured that all participants were adults aged 18 years or older. Participation was voluntary and anonymous, with informed consent obtained verbally from all respondents prior to the survey. Exclusion criteria for the data included: (1) substantial omissions in questionnaire responses; (2) random answering patterns (e.g., repetitive or illogical sequences such as “1” shape or “Z” shape patterns); and (3) height and weight values significantly deviating from normal ranges. For questionnaires with minor omissions or errors, missing values were handled through linear interpolation.

After excluding invalid questionnaires, a total of 1,227 valid responses were obtained. Among the 1,227 participants, the age distribution was as follows: 10.59% were aged 18–20, 36.92% were aged 21–30, 30.48% were aged 31–40, 17.11% were aged 41–50, and 4.89% were over 51 years old. The sample was balanced in terms of gender, with 50.04% male and 49.96% female participants. Educational backgrounds included 3.67% with junior high school education or below, 27.38% with high school/technical secondary/vocational/technical education, 26.89% with junior college degrees, 37.65% with bachelor's degrees, and 4.40% with graduate degrees. Monthly income levels were reported as 1.71% below 1,500 RMB, 22.74% between 1,501 and 2,000 RMB, and 75.55% above 2,001 RMB. Sports consumption levels were 62.51% below 100 RMB, 23.47% between 101 and 300 RMB, 10.35% between 301 and 500 RMB, and 3.67% above 501 RMB.

3.2 Measurement tools

3.2.1 Physical Exercise Attitude Scale

This study utilized the “Exercise Attitude Scale” developed by Mao (2003), to measure the physical exercise attitudes among urban residents of Chengdu City. The scale comprises 70 items across eight dimensions: behavioral attitude, goal attitude, behavioral cognition,

behavioral habit, behavioral intention, emotional experience, sense of behavioral control, and subjective norms. Each item is rated on a 5-point scale ranging from “strongly disagree” to “strongly agree,” with scores from 1 to 5, respectively. A higher score indicates a more positive attitude toward exercise.

Except for the subjective norms dimension, which has a Cronbach's α coefficient above 0.6, the remaining dimensions all have Cronbach's α coefficients above 0.8, demonstrating good reliability. Factor loadings for the survey questions related to this construct (Physical exercise attitude) ranged from 0.656 to 0.823. The scale's construct reliability (CR), which is higher than the evaluation cutoff limit of 0.60, was scored at 0.882. The AVE score of the scale was 0.637, over the assessment requirement of 0.50. This implies that the construct validity and discrimination of the scale are excellent. The scale's goodness of fit test findings was as follows: the following GFI, AGFI, NFI, IFI, CFI, and RMSEA values indicate that the scale has a satisfactory goodness of fit: 0.971, 0.966, 0.901, 0.977, and 0.041.

3.2.2 Physical Activity Level Scale

This study adopted the revised “Physical Activity Rating Scale (PARS-3)” by Liang (1994), to investigate the physical activity levels among urban residents of Chengdu City. The scale assesses the volume of physical activity among college students from three aspects: intensity of physical exercise, duration, and frequency, each divided into five levels. The intensity and duration of physical exercise are rated from 1 to 5, while the frequency of physical exercise is rated from 0 to 4. The test–retest reliability of this questionnaire is 0.82, indicating relatively high reliability. The formula for calculating physical activity level is: Physical Activity Level = Intensity of Physical Exercise $\times$ Duration of Physical Exercise $\times$ Frequency of Physical Exercise. The evaluation criteria for Physical Activity Levels are: ≤ 19 points for low volume, 20–42 points for moderate volume, and ≥ 43 points for high volume.

3.2.3 Sports Consumption Demand Scale

This study employed the “Sports Consumption Demand Scale” developed by Chen et al. (2010), to survey the sports consumption demands of urban residents in Chengdu City. Using a Likert 5-point scale, the scale evaluates sports consumption demands through 10 items across four dimensions: participation demand, tangible demand, information demand, and ornamental demand.

All four dimensions of the scale have Cronbach's α coefficients exceeding 0.7, showing good internal consistency reliability. Every survey question had a factor loading that varied from 0.649 to 0.823. The scale's construct reliability (CR) rating was 0.857, above the evaluation cutoff point of 0.60. The AVE value of the scale was 0.586, over the 0.50 evaluation threshold. This implies that the discrimination and construct validity of the scale are quite strong. The following outcomes of the scale's goodness of fit test were obtained: For the scale, the following values of GFI, AGFI, NFI, IFI, CFI, and RMSEA suggest a sufficient goodness of fit: 0.987, 0.975, 0.976, 0.989, and 0.023.

3.3 Procedures

The research employed a stratified cluster sampling method, randomly selecting Wuhou District, Qingyang District, Jinjiang District, Chenghua District, and Jinniu District from among the 12 districts and counties of Chengdu City for the survey, with 300

questionnaires distributed in each urban district. The distribution of questionnaires aimed to ensure a balanced representation of participants' ages and genders as much as possible. All questionnaires were completed on-site and collected immediately.

Data processing and statistical analysis were conducted using SPSS 25.0, Stata 12.0, and Amos 23.0. Parametric tests (independent samples *t*-test and one-way ANOVA) were applied for comparing demographic variables. The relationships among Physical Exercise Attitude, Physical Activity Level, and Sports Consumption Demand were explored using Pearson correlation. Additionally, the study examined the mediating role of Physical Activity Level between Physical Exercise Attitude and Sports Consumption Demand. Model fit was evaluated using CMIN/DF, RMSEA, NFI, RFI, IFI, TLI, and CFI indicators, with acceptable fit criteria set according to standard thresholds. The significance level for all statistical tests was set at $\alpha = 0.05$ (Hayes, 2017).

4 Results

4.1 Common method bias and multicollinearity test

To mitigate potential common method bias, this study employed anonymous questionnaires and varied scoring techniques. Common method bias was assessed using the Harman single-factor test (Zhou and Long, 2004). An unrotated factor analysis revealed 13 factors with eigenvalues exceeding 1, and the first factor accounted for 29.19% of the total variance, which falls below the critical threshold of 40%. Additionally, the Variance Inflation Factor (VIF) for each scale was found to be less than 5, indicating no issues of multicollinearity (Hair et al., 1998).

4.2 Differences in sports consumption demand and demographic variables

The survey results showed that the overall score for Sports Consumption Demand was 38.21 ± 7.79 . Independent samples *t*-tests and one-way ANOVA analyses were conducted to examine differences across various demographic variables. Significant differences in Sports Consumption Demand were observed across different age groups, with residents aged 21–30 (39.19 ± 6.60) and 31–40 (38.87 ± 7.49) exhibiting higher demand compared to other age groups. Differences were also noted among residents with different educational levels, where those with a junior college education showed the highest demand (39.44 ± 7.89). Furthermore, significant differences in demand were found based on monthly consumption levels and monthly sports spending. Interestingly, residents with higher monthly sports spending demonstrated lower sports consumption demand. However, no significant difference was observed between male and female residents.

These findings provide insights into how sports consumption demand varies with demographic characteristics, supporting Hypothesis 1. Detailed results are presented in Table 1.

4.3 Analysis of the relationship between physical exercise attitude, physical activity level, and sports consumption demand

Through Pearson correlation analysis, the relationships among physical exercise attitude, physical activity level, and sports consumption demand were explored (Table 2). The study found significant positive correlations between each pair of these three variables, supporting Hypothesis 2 of this research.

TABLE 1 Differences in sports consumption demand across demographic variables.

Demographic variable	Group	Mean $\pm$ SD	Statistical test result
Age	18–20	36.28 ± 8.37	$F = 13.081, p < 0.01$
	21–30	39.19 ± 6.60	
	31–40	38.87 ± 7.49	
	41–50	38.00 ± 8.38	
	>51	32.34 ± 9.87	
Education level	High school or below	36.64 ± 8.19	$F = 9.208, p < 0.05$
	Junior college	39.44 ± 7.89	
	Bachelor's degree	38.48 ± 6.83	
	Graduate degree	35.89 ± 8.54	
Monthly consumption	<1,500 RMB	34.84 ± 7.38	$F = 4.663, p < 0.05$
	1,501–2000 RMB	37.48 ± 8.32	
	>2001 RMB	38.54 ± 7.54	
Monthly sports spending	<100 RMB	38.97 ± 7.26	$F = 9.134, p < 0.05$
	101–300 RMB	37.53 ± 8.06	
	301–500 RMB	36.69 ± 8.35	
	>501 RMB	34.11 ± 8.21	
Gender	Male	38.3388 ± 7.48152	$t = 0.557, p > 0.05$
	Female	38.1109 ± 8.07304	

TABLE 2 Correlation analysis of physical exercise attitude, physical activity level, and sports consumption demand (*r*).

Variables	Physical exercise attitude	Physical activity level	Sports consumption demand
Physical exercise attitude	1		
Physical activity level	0.374**	1	
Sports consumption demand	0.348**	0.364**	1

Significant * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 3 Fitting indices.

Index	Value
CMIN/DF	2.724
NFI	0.988
RFI	0.985
IFI	0.991
TLI	0.989
CFI	0.991
RMSEA	0.047

TABLE 4 Direct estimations.

Paths	Relationships	Standardized estimates	SE	C.R.	<i>P</i>
1	Physical exercise attitude → Physical activity level	0.409	0.066	8.455	<0.001
2	Physical exercise attitude → Sports consumption demand	0.295	0.068	5.618	<0.001
3	Physical activity level → Physical exercise attitude	0.287	0.049	5.537	<0.001

4.4 Fitting model

The study conducted a path analysis with residents' physical exercise attitude as the independent variable, residents' sports consumption demand as the dependent variable, and the physical activity level as the mediating variable. The results of the model fit tests showed that CMIN/DF = 2.724, RMSEA = 0.047, with NFI, RFI, IFI, TLI, and CFI values being 0.988, 0.985, 0.991, 0.989, and 0.991, respectively, indicating an overall good fit of the model (Table 3).

4.5 Structural model

Maximum likelihood estimation was used to calculate the coefficients for each path, and the results (Table 4) showed that the coefficients for Paths 1, 2, and 3 were statistically significant ($p < 0.001$), indicating that the pathway from physical exercise attitude to residents' sports consumption demand through the physical activity level is valid.

4.6 Mediation analysis

To ascertain the mediating influence of physical activity level on the relationship between physical exercise attitude and sports consumption

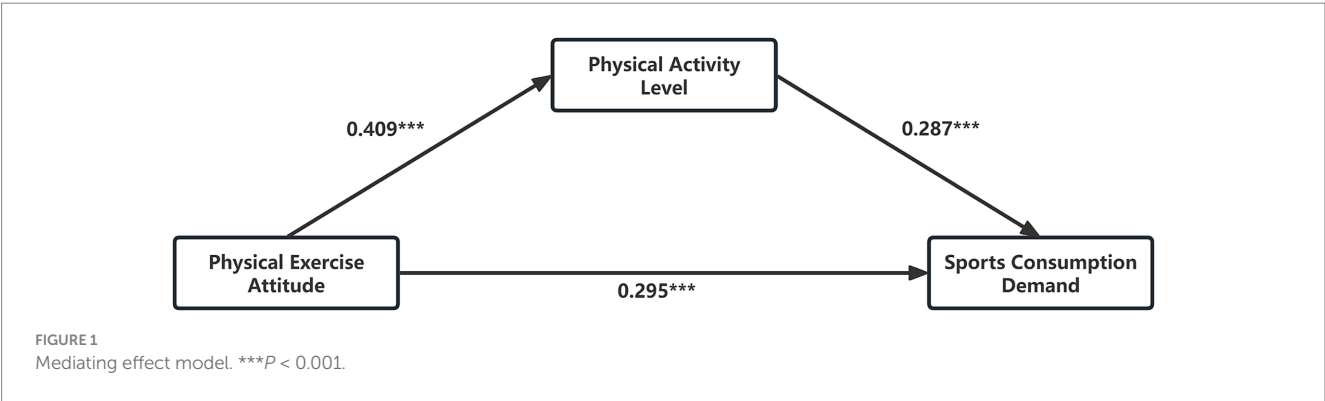
demand, the present investigation utilized the Bootstrap approach within the AMOS software. The analysis executed 5,000 bootstrap samples applying both the Bias-corrected and Percentile methods.

Table 5 presents the mediation analysis examining the total, direct, and indirect effects of physical exercise attitude on sports consumption demand, with physical activity level serving as the mediator. The total effect was significant with an effect size of 0.412 (Boot SE = 0.044, $p < 0.001$), and 95% confidence intervals ranging from 0.319 to 0.495 in the bias-corrected CI and 0.321 to 0.496 in the percentile CI, accounting for the combined direct and indirect pathways. The direct effect of physical exercise attitude on sports consumption demand, not mediated by physical activity level, was also significant, with an effect size of 0.295 (Boot SE = 0.051, $p < 0.001$), and identical lower and upper bounds for both bias-corrected and percentile 95% CIs (0.193–0.390), constituting 71.60% of the total effect. The indirect effect through the mediator—physical activity level—had an effect size of 0.117 (Boot SE = 0.023, $p < 0.001$), with confidence intervals that did not include zero (bias-corrected CI: 0.077–0.170; percentile CI: 0.075–0.167), representing 28.40% of the total effect. These findings suggest that physical activity level is a significant mediator in the relationship between physical exercise attitude and sports consumption demand.

The model proposed in Figure 1 is thus supported as a partial mediation model, characterized by significant direct and indirect pathways that confirm the hypotheses 3 set forth in the study. The mediation role of physical activity level is statistically significant, and

TABLE 5 Analysis of total effect, direct effect, and indirect effect.

	Effect	Boot SE	P	Bias-corrected 95% CI		Percentile 95% CI		Effect ratio (%)
				Lower	Upper	Lower	Upper	
Total effect	0.412	0.044	<0.001	0.319	0.495	0.321	0.496	
Direct effect	0.295	0.051	<0.001	0.193	0.390	0.193	0.390	71.60
Indirect effect of physical activity level	0.117	0.023	<0.001	0.077	0.170	0.075	0.167	28.40



the model demonstrates substantial indirect effects, validating the study’s theoretical framework.

5 Discussion

The findings from this study’s survey, presenting a score of 38.21 ± 7.79 for sports consumption demand, provide empirical support for Hypothesis H1, which posits significant differences in sports consumption demand among Chengdu City residents based on various demographic variables. Independent samples *t*-tests and one-way ANOVA reinforced this hypothesis by revealing statistically significant differences across age groups, educational levels, and income brackets.

Age, as an influential demographic factor, displayed a marked variance in sports consumption demand ($F = 13.081$, $p < 0.01$), revealing that younger age cohorts, specifically those aged 21–30 and 31–40, had higher consumption demand. This finding correlates with the lifestyle and energy expenditure patterns of these age groups, often associated with heightened physical activity and thus a greater engagement in sports-related consumption (Pang and Li, 2016; Liu and Zhong, 2023). The reduced demand observed in the 41–50 age bracket and notably lower demand for those over 51 may reflect shifts in lifestyle, priorities, or physical capabilities that accompany aging (Xu and Yu, 2013; Liu, 2000), a trend well-documented in consumer behavior research. These age-related variations suggest that targeted marketing strategies could be particularly effective if tailored to the unique demands and lifestyle shifts of different age groups. For instance, younger individuals may respond to marketing that emphasizes social and dynamic aspects of sports, while older groups may benefit from promotions highlighting health maintenance and wellness.

Education level is another demographic determinant of consumption patterns, with this study demonstrating a significant

effect on sports consumption demand ($F = 9.208$, $p < 0.05$). Residents with junior college education exhibited the highest demand, perhaps indicative of a more pronounced awareness or value placed on health and fitness, which could be attributed to educational curricula that emphasize these aspects (McGee and Adriana, 2014; Hua, 2022). Interestingly, those with graduate degrees showed the lowest demand, potentially due to time constraints or other commitments often associated with higher educational pursuits (McGee and Adriana, 2014; Kiani and Keivan, 2021). This education-based finding has implications for public health policies and educational programs. Promoting the benefits of sports participation within educational institutions, especially at advanced education levels, may encourage a culture of lifelong sports engagement, potentially offsetting the decreased demand observed among highly educated groups.

Monthly consumption levels also significantly differentiated sports consumption demand ($F = 4.663$, $p < 0.05$), underscoring the role of disposable income in the propensity to spend on sports. Residents with higher overall consumption levels likely have greater financial flexibility to allocate funds toward sports, affirming findings from economic theories on consumer spending (Xiaojuan and Yilu, 2020). In contrast, when isolating monthly sports consumption levels, a surprising inverse pattern emerged ($F = 9.134$, $p < 0.05$), where higher outlay on sports did not correspond to greater demand. This may suggest a saturation point in sports consumption or the presence of other factors such as time limitations or perceived value from spending that influences demand (Koronios et al., 2020; Hughes et al., 2022; Tang, 2023). These income-related insights highlight the importance of adaptive pricing strategies and product offerings tailored to different income brackets, which can help maximize engagement across varying economic backgrounds.

The absence of a significant gender difference ($t = 0.557$, $p > 0.05$) in sports consumption demand within Chengdu’s urban population may reflect a cultural context where sports engagement and related

expenditures are becoming more gender-neutral, reflecting broader global trends toward gender equality in sports (Kateshumbwa, 2012; Uyar et al., 2022). This finding regarding gender neutrality in sports consumption is valuable for informing gender-inclusive marketing strategies and health initiatives that cater to both men and women without bias, reinforcing efforts toward equal access and engagement in sports activities.

These demographic insights bolster the understanding of sports consumption behaviors and are instrumental for strategizing in sports marketing and policymaking. The findings contribute to a nuanced portrayal of sports consumer demographics, where age, education, and income levels play crucial roles in shaping demand, offering a vantage point for future research and industry application.

The intricate interplay between physical exercise attitude, physical activity level, and sports consumption demand has been a subject of considerable interest in the domain of sports economics and psychology. The present study advances this scholarly dialog by providing empirical evidence of significant positive correlations between these variables, hence supporting Hypothesis 2.

The positive correlation between physical exercise attitude and physical activity level (0.374^{**} , $p < 0.01$) aligns with the theoretical propositions of the Theory of Planned Behavior (Ajzen, 1991), which suggests that a positive attitude toward an activity is likely to result in increased participation. This correlation echoes the findings of previous research, which assert that attitudes toward exercise significantly predict the likelihood of engaging in physical activity (Armitage and Conner, 2001; Ajzen, 2011).

Furthermore, the relationship between physical exercise attitude and sports consumption demand (0.348^{**} , $p < 0.01$) reinforces the concept that favorable perceptions and beliefs about exercise are closely linked to consumer spending on sports-related goods and services. This nexus can be traced to consumer behavior theory (Hansen, 1972), where attitudes have been identified as key predictors of consumption intentions (Glenn, 2021).

The positive correlation observed between physical activity level and sports consumption demand (0.364^{**} , $p < 0.01$) offers empirical substantiation to the idea that individuals who are more active are also more likely to spend on sports. This is in line with findings from Zhen-Long et al. (2009), who identified that active engagement in physical activities tends to result in higher expenditure on sports commodities and services, likely due to the increased usage and, consequently, the need for sports-related products.

It is imperative to note that these correlations contribute to a more nuanced understanding of consumer behaviors within the sports market. For instance, while it is evident that attitudes and activity levels are positively correlated with sports consumption, there remains a complexity in these relationships that warrants further investigation. For example, the exact motivational drivers and the role of subjective norms in shaping these attitudes and behaviors may offer additional insights (Sanjida and Touhiduzzaman, 2022; Bock et al., 2005).

The mediation analysis undertaken in this study lends substantial support to the behavioral economics of sports consumption, dovetailing with the principles of the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM) to dissect the interplay between attitude, behavior, and economic outcomes (La Barbera and Ajzen 2021; Rhodes et al., 2024; Yau and Hsiao, 2022). Applying a Bootstrap methodology with AMOS software and conducting 5,000 bootstrap samples, this study substantiates the

proposed mediating role of physical activity level among Chengdu's urban dwellers.

The direct effect size of 0.295, accounting for 71.60% of the total effect, and the indirect effect size of 0.117, representing 28.40%, delineate the complexity of the relationship between attitude and consumption. This aligns with the theory within the framework of the Theory of Planned Behavior, which asserts that attitude significantly impacts an individual's intentions and subsequent behaviors, including consumption practices (La Barbera and Ajzen 2021; Rhodes et al., 2024).

Notably, the indirect effect confirms that physical activity level is not merely a byproduct of positive attitudes toward exercise but a substantive mediator that can influence consumption demand. This finding echoes the research who posits that the interplay between attitudes, physical activity, and consumption is essential in understanding how lifestyle choices translate into economic actions (Bock et al., 2005; Cui-Jin et al., 2012).

The mediating role of physical activity level has profound implications for sports marketers and policymakers. The statistically significant mediation effect implies that interventions designed to improve physical activity levels could have a ripple effect on increasing sports consumption demand. This is consistent with findings from Chen et al. (2008), who argue that engagement in physical activities can lead to a higher propensity to consume sports goods and services.

Furthermore, the study's results contribute to the ongoing discourse initiated by Kung et al. (2023) on the impact of sports participation on economic outcomes. By confirming a partial mediation effect, the study underscores the notion that while attitudes toward exercise have a direct impact on consumption, the actual engagement in physical activities is a vital catalyst for realizing this economic potential (Dong and Liu, 2022; Ashdownfranks et al., 2014).

In conclusion, the study advances our understanding by integrating the roles of attitudes and behaviors, thus offering a more nuanced explanation for sports consumption patterns. The evidence suggests that promoting physical exercise not only fosters a healthier populace but can also stimulate economic activity within the sports sector. This dual benefit is particularly pertinent for urban settings like Chengdu, where rapid lifestyle changes present both challenges and opportunities for sports-related businesses and public health initiatives.

6 Conclusion

The conclusion of this research underscores that demographic variables significantly differentiate sports consumption demand among urban residents, revealing age and education as influential factors. The analysis confirms a robust, positive relationship between physical exercise attitude and sports consumption demand, mediated by the residents' physical activity level. This mediation indicates that while attitudes toward exercise influence consumption directly, the translation of these attitudes into actual behavior further amplifies consumption. The findings align with the principles of the Theory of Planned Behavior and the Technology Acceptance Model, which suggest that both intent and behavior significantly shape economic actions. With implications for sports marketers and policymakers, this study highlights the potential of leveraging physical activity to boost sports-related economic activity, emphasizing a strategy that can contribute to both public health and urban economic vitality.

7 Limitations and future studies

While this study provides significant insights into the factors influencing sports consumption demand among urban residents, it is not without its limitations. Firstly, the study is geographically restricted to Chengdu, which may limit the generalizability of the findings to other urban or rural settings. Future research could extend this study to diverse geographical locations to verify the applicability of the results across different cultural and economic contexts.

Secondly, the cross-sectional design of this research limits the ability to establish causality between physical exercise attitude, physical activity level, and sports consumption demand. Longitudinal studies are recommended to better understand the dynamics of these relationships over time and to discern any potential causal links.

Additionally, while the mediation model provided valuable insights, the indirect effects identified suggest that other mediating variables might also play significant roles. Future studies could explore additional mediators such as psychological well-being or social influences that could further elucidate the pathway from physical exercise attitudes to sports consumption.

Moreover, significant variances in sports consumption related to age, educational level, overall monthly consumption, and specific sports-related spending highlight potential areas for incorporating moderating variables in future models. This approach could offer a more nuanced analysis of how different segments of the population engage with sports consumption under varying conditions.

Another limitation is the reliance on self-reported data, which can be susceptible to biases such as social desirability or recall biases. Incorporating objective measures of physical activity and consumption, perhaps through tracking devices or financial transaction data, could enhance the accuracy of the findings.

Finally, considering the rapid evolution of digital and mobile health technologies, future research could investigate how these advancements affect physical activity levels and sports consumption habits. This could provide deeper insights into the technological aspects of sports engagement and offer new avenues for promoting physical activity and sports consumption.

Addressing these limitations in future studies will not only strengthen the existing research framework but also expand our understanding of the complex interplay between lifestyle behaviors and economic activities in the sports sector.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1500150/full#supplementary-material>

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Reasons to move—a cross-sectional study to identify factors promoting regular exercise

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Regular physical activity can prevent various physical and mental illnesses or improve their prognosis. However, only about half of the German population meets the WHO recommendations for physical activity. The aim of this study was to identify factors that influence engagement in regular exercise and could help increase physical activity levels in the general population. To this end, we conducted a cross-sectional study using questionnaire instruments and self-designed items. The research cohort comprised a sample of online-acquired data from 1,119 mentally healthy individuals. Higher regular exercise was associated with higher both intrinsic and extrinsic motivation, self-efficacy, resilience, internal locus of control, and risk-taking behaviour, as well as higher scores in the personality traits conscientiousness, extraversion, and agreeableness. Higher regular exercise was also linked to lower external locus of control. Whether participants exercised was also related to external circumstances, such as their financial situation, whether family members frequently exercised during childhood or the availability of sports facilities. Furthermore, participants' preferred exercise environment was found to be different from reality. Despite expressing a preference for outdoor and group exercise, most participants reported exercising alone and indoors. People who exercised regularly during childhood stated higher levels of intrinsic as well as extrinsic motivation and resilience. Based on our findings, we suggest that additional low-threshold, low-cost opportunities for physical exercise should be provided in public spaces that lack exercise facilities, as well as in childcare settings with a particular focus on disadvantaged social groups.

KEYWORDS

physical exercise, motivation, personality traits, self-efficacy, cross-sectional study, online survey, general population

1 Introduction

Approximately 10% of all deaths in Europe are due to physical inactivity (1). This makes it one of the top 5 causes of death as it contributes to the development of cardiovascular, metabolic and musculoskeletal diseases (1). Physical inactivity also has a detrimental financial impact on health care systems worldwide, with an estimated cost of \$ 47.6 billion per year between 2020 and 2030 (\$502 billion in total over the decade) (2).

Abbreviations

ASKU, general self-efficacy short scale; BFI-10, big five inventory 10; BMI, body-mass-index; BRS, brief resilience scale; EMI-2, exercise motivation inventory 2; GPAQ, global physical activity questionnaire; IE-4, internal-external control belief scale; SSA, self-efficacy for sporting activity; R1 score, brief scale for risk taking.

Therefore, the World Health Organization (WHO) recommends that adults engage in at least 150 min of moderate physical activity or 75 min of vigorous physical activity per week (3).

Regular physical activity has a wide range of benefits for both physical and mental health: On the one hand, it reduces the risk for myocardial infarction, cardiovascular disease in general, diabetes, and colorectal cancer (4, 5). On the other hand, it can be a preventative measure for common mental health conditions such as depression and anxiety and also has a beneficial effect on these conditions (6). Overall, mortality rates are reduced by up to 30% in people who engage in at least some physical activity compared to people who do not move at all (7, 8). However, according to national surveys, only 45%–51% of the adult population in Germany met these recommendations in 2019/2020 (9) and only 32% of the adult population in the European Union (10). Therefore, it is a desirable objective to increase the level of physical activity in the population, and hence reduce the morbidity and mortality.

Whether people ultimately avoid physical activity, engage in regular exercise, or even achieve peak performance as competitive athletes is largely attributed to the presence or absence of motivation in everyday life (11). Motivation can be described as the drive to achieve a goal that is perceived as valuable (12). Thus, if persons evaluate the target state of exercise positively, for example by recalling feelings of reward and stress relief, they are more likely to exercise to achieve said state. However, if the target state is evaluated negatively (e.g., due to sore muscles after training) the action is more likely to be avoided and, consequently, the individual may cease to exercise (11).

The self-determination theory proposes that an individual's basic needs include competence (self-efficacy), social relatedness, and autonomy (13). It further includes six so-called mini-theories that explain different aspects of motivation or personality functioning. These mini-theories suggest that the fulfilment of these basic needs has a positive influence on motivation, which in turn has a positive effect on physical activity. The mini-theories also differentiate between intrinsic and extrinsic motivation (13). Intrinsic motivation is present when an action is driven by a person's own will. In other words, when the means (action) and the ends (goal of action) are thematically congruent (14). Intrinsic motives may include both the performance of an activity (e.g., kinesthetic experiences) and the achievement of a result dependent on the activity (e.g., a new personal best) (14). In contrast, extrinsic motivation is present when an action is performed due to the anticipation of an aftereffect (e.g., money or recognition) (14). Meaning, the action is the result of an external influence (15, 16). Both intrinsic and extrinsic motives may coexist in any person (14). Previous studies conducted indicate a positive association between levels of intrinsic motivation and high physical activity (17, 18).

However, other factors such as personality traits and self-efficacy also seem to impact physical activity (19, 20). Furthermore, motivation for physical activity has been found to be influenced by various factors, such as a supportive environment or self-efficacy (11, 14). There is also some evidence to suggest that different personality traits may be linked to exercise behaviours (19) and also may impact motivation (21).

Nevertheless, the current knowledge of the factors promoting and/or hindering physical activity is still scarce and incomplete.

There is a paucity of studies that have examined various factors such as motivation, personality traits, and in particular childhood sport history in the same group of subjects in a large-scale study population. Thus the aim of this study is to identify the principal factors that promote regular exercise.

To do this, we investigated the relationship between personality traits and intrinsic as well as extrinsic motives with the type and quantity of physical exercise engaged in. Higher intrinsic and extrinsic motivation was hypothesised to be associated with more frequent exercise. In line with self-determination theory, we also asked about self-efficacy, which corresponds to the basic need for competence; locus of control, which corresponds to the basic need for autonomy; and preference and actual setting for group exercise, which provides at least some insight into the fulfilment of the basic need for social relatedness.

Furthermore, this study explored associations between exercise behaviour during childhood and adolescence and the type as well as the amount of current physical activity. The hypothesis was that regular physical exercise and family support during childhood would be positively associated with regular physical exercise as an adult.

Additionally, this study evaluated facilitators and barriers to regular exercise and examined the impact of the resilience of study participants and their (sport-related) self-efficacy on the presence of physical exercise. It was anticipated that individuals with higher resilience and self-efficacy would be more likely to engage in physical exercise.

These findings can provide insights into how to improve conditions for regularly engaging in physical exercise and how to tailor interventions addressing related and relevant characteristics of respective participants.

2 Methods

2.1 Study design, population, and data extraction

Our study was approved by the local ethics committee of the Faculty of Medicine at the LMU Munich (registration number: 22-0625 KB) and complied with the Declaration of Helsinki.

This cross-sectional study was conducted in Germany using an anonymous questionnaire that could be completed online from any internet-enabled device via the online survey tool "SoSciSurvey" (22).

Inclusion criteria comprised being at least 18 years of age and prior informed consent regarding data collection. People with different levels of physical activity were surveyed, including professional athletes. There was no prior selection. Participants were recruited in a variety of ways, including emails to sports clubs and sport associations, clinics, students, and staff at the LMU Hospital Munich, social media (e.g., facebook groups for leisure swimmers), as well as well visibly placed flyers or posters on campus and in medical facilities. They had the chance to win one of 20 vouchers worth 20€ each. The recruitment period was between August 1st 2022 and December 18th 2022.

Upon completion of the survey, we categorised study participants into two groups according to whether they reported ever having been diagnosed with a mental illness or not. Separately, we identified a group of professional athletes who were members of a cadre with at least four training sessions per week and who participated in competitions such as world championships and Olympic Games. In this analysis, we focus on the sample of individuals who did not report a history of mental illness and were not professional athletes, i.e., the mentally healthy sample as detailed below.

2.2 Questionnaire

The questionnaire included standardised items on socio-demographic history and self-constructed items on physical and mental medical history and on detailed exercise history, both at present and during childhood. Data on body height and body weight were collected in order to calculate the body mass index (BMI). To further assess respondents' current weekly average of engaging in physical activity, the questionnaire also contained the Global Physical Activity Questionnaire (GPAQ) (23). Furthermore, the questionnaire inquired about barriers and facilitators for the implementation of physical exercise.

In addition, the following standardized instruments were implemented: The "Sport- und Bewegungsbezogene Selbstkonkordanz-Skala" (SSK scale) (24) surveyed different motives for exercising and the "SSA scale" (25) measured "self-efficacy for sporting activity". To investigate the different motives of intrinsic and extrinsic motivation as important factors for physical activity according to the self-determination theory (13), we applied the "Exercise Motivations Inventory" (EMI-2; used in an abbreviated form) (26).

The Big Five Inventory 10 (BFI-10) (27) was used to survey the five dimensions of personality traits (extraversion, conscientiousness, agreeableness, neuroticism and openness). The Internal-External Control Belief Scale (IE-4) (28) was used to assess internal and external loci of control (the extent to which someone believes that the occurrence of an event is dependent on or independent of their own behaviour), and the General Self-Efficacy Short Scale (ASKU) (29) was used to assess general self-efficacy. Furthermore, the Brief Resilience Scale (BRS) (30) and the Brief Scale for Risk Taking (R1) (31) assessed resilience and risk affinity, while the Sport-Related Support Scale (32) evaluated support from friends and family. Reliability and validity information for the psychometric instruments used can be found in the [Supplementary S1](#).

The questionnaire contained up to 190 questions and took about 20 min to complete. Depending on the information provided by the study participants, certain questions were automatically hidden or shown, providing further information on previous items (the full translated questionnaire can be found in [Supplementary Table S2](#)).

2.3 Statistical analyses

The descriptive preliminary analysis was carried out using Microsoft Excel version 16.73 (33). At first, we categorized the

mentally healthy sample into an exercising and a non-exercising group. Said classification was based on the notion of whether respondents currently exercised regularly (at least once each week). This classification did not consider occupational activities or distances travelled by foot or by bicycle that were not undertaken for the purpose of physical exercise. Similarly, we classified participants depending on whether they engaged in regular exercise during childhood or not, irrespective of physical education classes in school.

IBM SPSS version 29.0.0.0 (34) was used for further analysis and to characterise our sample by frequencies, means, medians and standard deviations. It was also used to calculate the participants' body-mass-index (BMI) as ratio of body weight in kilograms to height squared in meters.

To compare two different groups - for example, those who exercise and those who do not - we used independent *t*-tests for metric data, Cohen's *d* to measure the effect size of significant results and the Welch method to correct for unequal variances. Mann-Whitney *U*-tests and Chi-Square-tests were used for non-metric data. We also used binary logistic regression to examine the influence of a personality trait on the likelihood of regular exercise or to examine the influence of social support on the likelihood of regular exercise. Pearson correlations were performed for metric data and Spearman correlations for non-metric data. A distinct quantity of responses (*n*) was available for each question, which can be identified by the degrees of freedom (df).

3 Results

3.1 Demographic characteristics

1,746 people gave their informed consent and started to participate in the survey, of whom 1,577 responded to at least the sociodemographic and somatic history questions and were therefore included in our analysis. 1,376 participants completed the entire questionnaire. This publication focuses on the 1,119 individuals without a known history of mental illness, here referred to as the mentally healthy sample. The remaining 458 participants were either professional athletes or reported having been diagnosed with a mental illness.

The mean age in our mentally healthy sample was 38.3 ± 15.5 years, 66.5% (*n* = 744) were female and 33.5% (*n* = 375) male. Most respondents had the highest German school degree: 68.0% (*n* = 761). Financial worries were reported by 7.1% (*n* = 80) of the mentally healthy sample. A detailed characterisation of participants can be found in [Supplementary Table S3](#).

3.2 Determining factors of exercise behaviour

Overall, 73.1% (*n* = 754) of the mentally healthy sample reported to engage in regular exercise at the time of the study, 70.2% of the female participants and 78.6% of the male

participants. Most exercised one to three times a week (58.3%), 29.3% exercised 4–5 times and 12.4% exercised six times or more. For details on the participants' levels of physical activity as assessed with the GPAQ (23) see Table 1. In our exercising group, 92.7% met the WHO recommendations of taking part in at least 150 min of physical activity each week, 89.9% through leisure activities alone. In comparison, in our non-exercising group, only 51.8% met the WHO recommendations. Overall, the WHO recommendations were met by 81.8% of our mentally healthy sample. See Table 1 for more information about the participants' daily physical activity levels. Those who exercised regularly reported a slightly lower Body-Mass-Index (BMI) than our non-exercising group (23.31 vs. 24.55 kg/m²; $p < 0.001$, $t(393) = 3.94$, MD = 1.24, Cohen's $d = 3.92$, 95% CI [0.18, 0.46]).

The mean age in the exercising group was 39.01 years (SD = 15.99) and 37.34 years (SD = 14.33) in the non-exercising group. There was no significant correlation between age and exercise behaviour nor did exercise behaviour differ based on

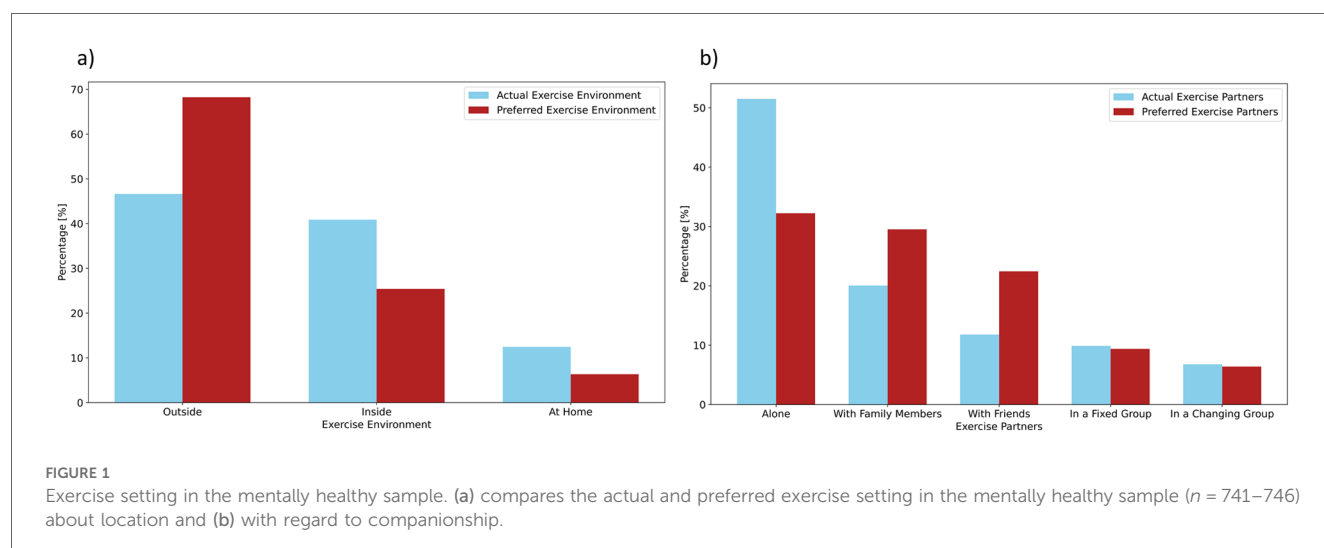
participants' income. However, we found a significant difference between the two groups regarding the subjectively reported variable "health status" ($U = 84,260.5$, $Z = -4.79$, $p < 0.001$) as well as for the variable "highest educational attainment" ($U = 97,292.5$, $Z = -2.00$, $p = 0.045$). Both variables showed higher values in the exercising group.

As illustrated in Figure 1, most of the mentally healthy sample (68.3%) reported a preference for exercising outdoors, whereas only 46.6% actually do so. Similarly, indoor, and at-home sports are practised much more frequently than theoretically preferred. There are also clear differences between preferred and actual levels of companionship. Although more than half of the mentally healthy sample (51.5%, $n = 383$) reported mostly exercising alone, the majority actually expressed a preference to exercise with friends [32.2% ($n = 239$)] or in a group [28.8% ($n = 214$)], whereas only 29.6% ($n = 220$) favoured exercising alone. Overall and noteworthy, discrepancies between preferred and actual settings were significant.

TABLE 1 Daily physical activity levels as assessed by the GPAQ.

	Descriptive statistics - mean (SD)			t-test: comparison between exercising sample and non-exercising sample					
	Total mentally healthy sample ($n = 1,119$)	Exercising sample ($n = 754$)	Non-exercising sample ($n = 278$)	p	df	T	MD	Cohen's d	95% CI
Daily moderate leisure activity in minutes	19.1 (25.8)	23.7 (27.5)	12.1 (20.4)	<0.001	665	-7.33	-11.58	25.81	[-0.59, -0.31]
Daily intensive leisure activity in minutes	22.1 (34.0)	30.7 (37.6)	4.8 (12.4)	<0.001	1,021	-16.61	-25.90	32.80	[-0.93, -0.65]
Daily moderate work activity in minutes	19.2 (51.9)	19.6 (51.7)	22.5 (57.0)	0.224					
Daily intensive work activity in minutes	7.8 (43.1)	5.8 (27.8)	8.1 (43.8)	0.207					
Daily total activity in minutes	68.2 (97.3)	79.9 (92.8)	47.5 (99.0)	<0.001	1,030	-4.88	-32.35	94.53	[-0.48, -0.20]
Daily transport activities in minutes	23.9 (29.6)	25.8 (29.1)	25.2 (32.6)	0.415					
Daily sitting in minutes	457.3 (649.6)	492.1 (724.7)	510.9 (454.6)	0.344					

Table 1 presents descriptive statistics for the GPAQ for the total mentally healthy sample, the exercising sample and the non-exercising sample and a comparison of means using an independent t -test between the exercising and non-exercising group. GPAQ, Global physical activity questionnaire (23), SD, standard deviation.



3.2.1 Personality traits in the mentally healthy sample

We further investigated whether the personality traits extraversion, conscientiousness, agreeableness, neuroticism, and openness as evaluated with the BFI-10 (27) were associated with the participants' exercise behaviour as well as preferred setting and kind of exercise.

Independent *t*-tests and binary logistic regressions showed that the personality trait conscientiousness ($p < 0.001$, $t(998) = -7.55$, MD = -0.42, Cohen's $d = 0.78$, 95% CI [-0.68, -0.40]) (OR = 0.95), as well as the traits extraversion ($p = 0.022$, $t(998) = -2.29$, MD = 0.17, Cohen's $d = 1.01$, 95% CI [-0.30, -0.02]) (OR = 0.17), and agreeableness ($p = 0.022$, $t(997) = -2.30$, MD = -0.131, Cohen's $d = 0.802$, 95% CI [-0.30, -0.02]) (OR = 0.22) were significantly related to whether or not a participant engaged in regular exercise (see Figure 2 for violin plots). Namely, participants who exhibited a stronger expression of these traits were more likely to engage in regular exercise. However, there was no significant association between the personality traits neuroticism or openness and exercise behaviour. Within the group of regular exercisers, higher levels of conscientiousness correlated positively with exercise frequency ($r = 0.16$, $p < 0.001$, $n = 729$) (see Figure 3 for violin plots).

In terms of exercise setting, people who exercised with others rather than alone had higher levels of agreeableness ($p = 0.046$, $t(723) = -2.00$, MD = -0.12, Cohen's $d = 0.78$, 95% CI [-0.29, -0.002]). No notable distinctions in other personality traits were observed between those groups.

We also found no discernible correlations between personality traits and the preferred kind of sports.

In conclusion, we observed that regular exercise was most closely linked to the personality traits extraversion, conscientiousness, and agreeableness. Conscientiousness was also significantly related to the frequency of exercise and agreeableness to the setting of exercise.

3.2.2 Self-efficacy, locus of control, resilience and risk taking

We also evaluated if engaging in regular exercise was associated with increased levels of self-efficacy, an internal locus of control, and resilience scores. Our results showed that the exercise group had significantly higher ratings in both general self-efficacy (ASKU score) ($p = 0.002$, $t(995) = -3.09$, MD = -0.13, Cohen's $d = 0.59$, 95% CI [-0.36, -0.08]) and sport-related self-efficacy (SSA score) ($p < 0.001$, $t(402) = -15.37$, MD = -1.41, Cohen's $d = 1.17$, 95% CI [-1.35, -1.05]), a rather internal locus of control (IE-4 score) ($p < 0.001$, $t(996) = -4.24$, MD = -0.193, Cohen's $d = 0.64$, 95% CI [-0.44, -0.16]) as well as higher scores in resilience ratings (BRS score) ($p < 0.001$, $t(993) = -4.54$, MD = -0.223, Cohen's $d = 0.69$, 95% CI [-0.46, -0.18]) when compared to the non-exercising group. In addition, the exercise group reported higher scores for risk taking (R1 score) ($p < 0.001$, $t(428) = -3.64$, MD = -0.25, Cohen's $d = 0.91$, 95% CI [-0.42, -0.14]). By contrast, an external locus of control was more pronounced in the non-exercising group (IE-4 score) ($p < 0.001$, $t(447) = 3.70$, MD = 0.21, Cohen's $d = 0.76$, 95% CI [0.13, 0.41]). The corresponding violin plots are shown in Figure 4.

3.2.3 Intrinsic and extrinsic motivation

As hypothesised, we found an association between intrinsic and extrinsic motivation as assessed by the EMI-2 (26) and exercise behaviour in the mentally healthy sample. Both intrinsic and extrinsic motivation were significantly related ($p < 0.001$) to whether a person engages in physical exercise or not (intrinsic: $t(351) = -13.93$, MD = -1.10, Cohen's $d = 0.93$, 95% CI [-1.34, -1.04]; extrinsic: $t(410) = -7.20$, MD = -0.46, Cohen's $d = 0.82$, 95% CI [-0.70, -0.42]). On average, motives related to intrinsic motivation were upwards of 20% more pronounced in the exercising than in the non-exercising group (on a scale of 0–5) (*t*-tests with $p < 0.001$): enjoyment ($t(391) = -16.61$, MD = -1.73, Cohen's $d = 1.30$, 95% CI [-1.48, -1.18]), challenge ($t(998) =$

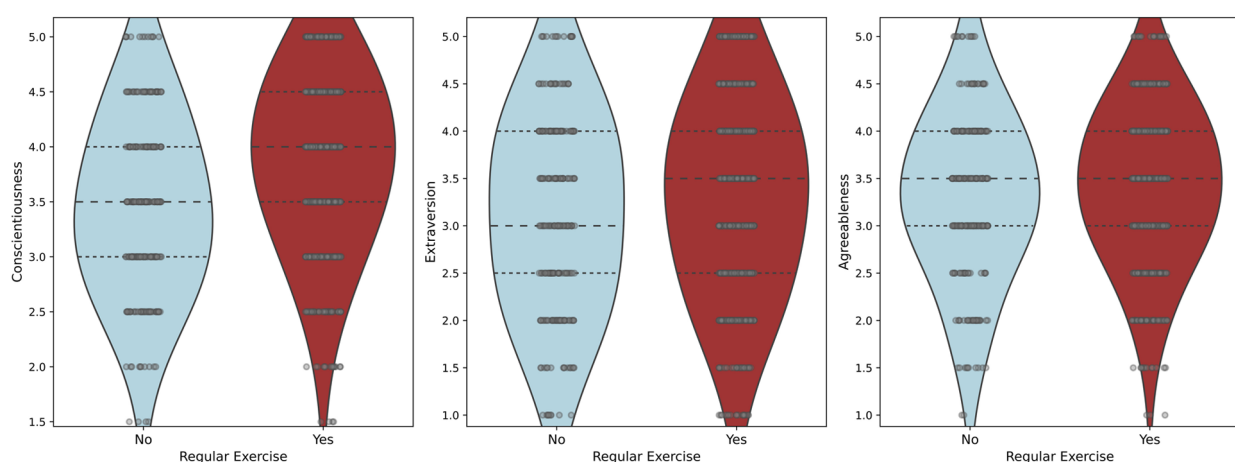


FIGURE 2

A Comparison of the non-exercising and the exercising group on conscientiousness, extraversion and agreeableness scores is presented using violin plots.

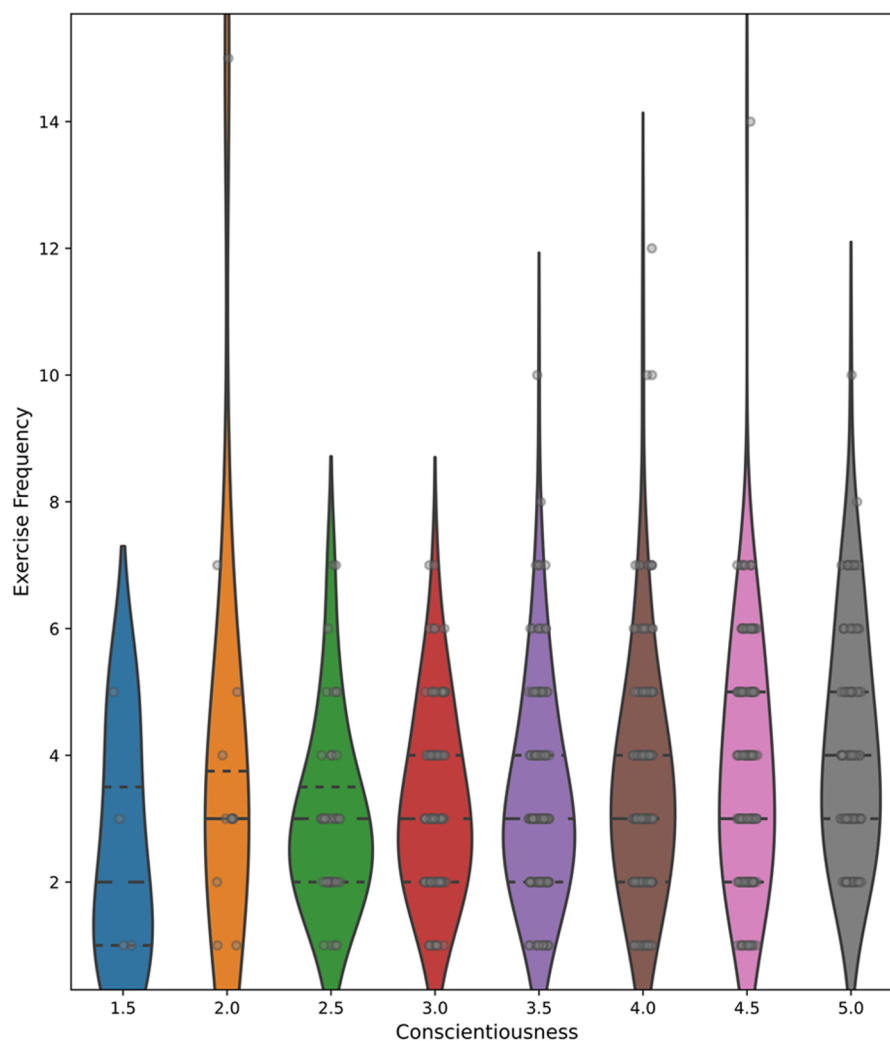


FIGURE 3
Relationship between exercise frequency and conscientiousness score in the exercising group.

–12.72, MD = –1.34, Cohen’s $d = 1.48$, 95% CI [–1.05, –0.76]), revitalisation ($t(359) = -12.54$, MD = –1.21, Cohen’s $d = 1.13$, 95% CI [–1.22, –0.92]), stress management ($t(381) = -11.18$, MD = 1.20, Cohen’s $d = 1.31$, 95% CI [–1.06, –0.77]). Moreover, the extrinsic motive affiliation was also higher in the exercising group ($t(525) = -8.67$, MD = –1.05, Cohen’s $d = 1.77$, 95% CI [–0.73, –0.45]). The remaining internal (competition, nimbleness, positive health, strength and endurance) and external motives (appearance, ill health avoidance, positive health, social recognition) were between 10% and 20% higher for those who exercised. We found no statistically significant differences for the extrinsic motives of social pressure and weight management.

In conclusion, the most important motives in our study appear to be enjoyment, challenge, revitalisation, stress management and affiliation. Intrinsic motivation seems to be more important than extrinsic motivation when it comes to regular physical exercise.

A detailed summary of the EMI-2 results can be found in [Supplementary Table S4](#), corresponding violin plots in [Figure 5](#).

3.2.4 Social support

Contrary to our assumption, in our mentally healthy sample we found no significant relationship between experiencing exercise-related family support during childhood and the likelihood of engaging in regular exercise in the present. Among those in the mentally healthy sample who exercised in childhood, 70.1% had at least one other exercising family member. In comparison, only 27.1% of the inactive childhood group had an exercising family member.

Thus, it appears that family support itself during childhood does not directly influence an individual’s likelihood of exercising regularly, whereas the presence of other exercising family members does.

3.2.5 Facilitators and barriers to regular exercise

Examining the participants’ reported barriers and facilitators to regular exercise (or even more exercise in the case of the exercising sample), the main barriers for the physically inactive group were

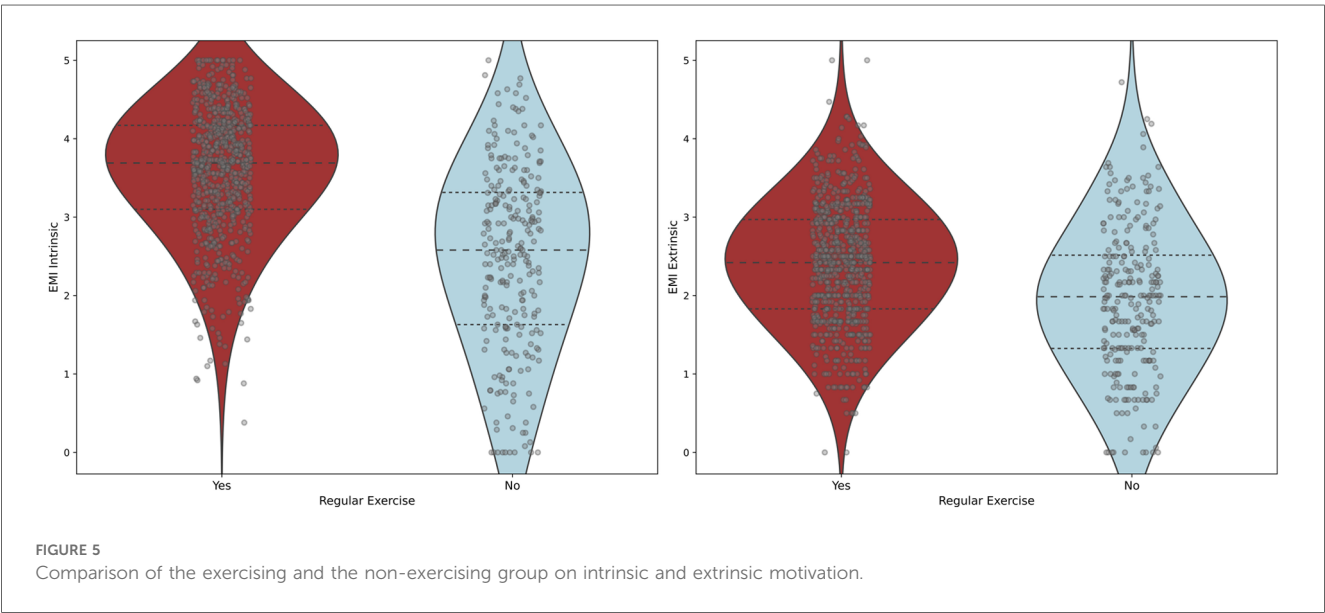
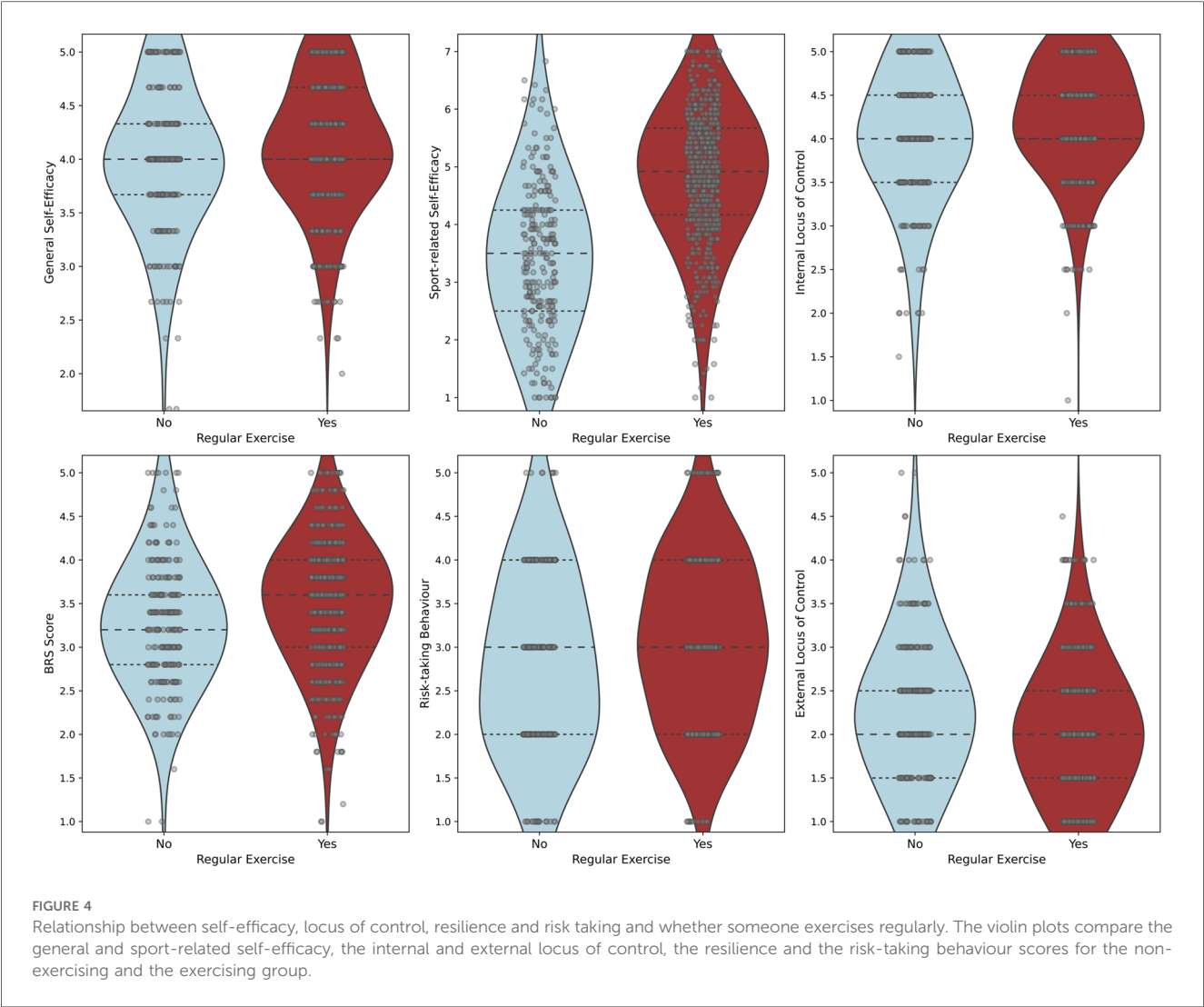


TABLE 2 Barriers to regular exercise.

	Non-exercising sample (<i>n</i> = 252–267)		Exercising sample (<i>n</i> = 693–718)		Mann-Whitney- <i>U</i> -test			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>p</i>	<i>U</i>	<i>Z</i>	<i>r</i>
Financial barriers	1.89	1.13	1.70	1.00	0.02	86,446.00	−2.32	−0.07
Lack of knowledge	2.46	1.26	1.59	0.87	<0.001	56,961.00	−10.60	−0.34
Missing offer	2.00	1.14	1.61	1.00	<0.001	74,921.50	−5.65	−0.18
Unaware	1.77	1.08	1.28	0.68	<0.001	71,152.00	−7.97	−0.26
No time due to family	2.29	1.36	1.82	1.07	<0.001	77,861.50	−4.80	−0.15
No time due to work	3.14	1.44	2.53	1.32	<0.001	71,394.50	−6.07	−0.19
No time due to other matters	2.50	1.22	1.83	1.01	<0.001	59,878.50	−7.86	−0.26
Too unathletic	2.35	1.28	1.48	0.81	<0.001	56,405.00	−10.93	−0.35
Shame	2.04	1.27	1.44	0.82	<0.001	70,964.00	−7.42	−0.24
Fear of embarrassment	2.09	1.28	1.52	0.88	<0.001	71,851.00	−6.86	−0.22
Concern for injury	1.75	0.98	1.65	0.92	0.125			
Lack of drive and energy	3.38	1.24	2.03	1.04	<0.001	40,640.00	−14.24	−0.45
Pain or discomfort during exercise	1.94	1.19	1.52	0.81	<0.001	78,191.50	−4.95	−0.16
Disappointed by previous experiences	1.95	1.16	1.50	0.83	<0.001	74,177.50	−6.06	−0.19
Bigger worries in life at the moment	2.59	1.38	1.74	0.99	<0.001	61,141.50	−9.11	−0.29

Table 2 shows the barriers to regular (or even more) physical exercise in both the exercising sample (*n* = 693–718) and the non-exercising sample (*n* = 252–267). Participants were requested to assess, on a scale of 1 (does not apply at all) to 5 (fully applies), the degree to which each item listed impeded their exercise behaviour. *M*, mean; *SD*, standard deviation.

TABLE 3 Facilitators to regular exercise.

	Non-exercising sample (<i>n</i> = 256–263)		Exercising sample (<i>n</i> = 697–717)		Mann-Whitney- <i>U</i> -test			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>p</i>	<i>U</i>	<i>Z</i>	<i>r</i>
Further education	2.06	1.12	1.85	1.09	0.002	80,645.00	−3.06	−0.08
Fixed appointments	3.44	1.31	3.42	1.38	0.92			
Flexible training in terms of time and place	3.10	1.27	3.06	1.37	0.71			
Reminder by phone or email	1.94	1.13	1.64	0.99	<0.001	75,475.50	−4.29	−0.13
Short distance to the training location	3.73	1.25	3.83	1.29	0.12			
Trainings free of charge	3.38	1.41	3.26	1.47	0.35			
Group with equally fit people	3.24	1.38	3.13	1.39	0.25			
Coaches with knowledge of physical conditions	2.53	1.43	2.40	1.43	0.19			

Table 3 shows the facilitators to regular (or even more) physical exercise in both the exercising sample (*n* = 697–717) and the non-exercising sample (*n* = 256–263). Participants were asked to assess, on a scale of 1 (does not apply at all) to 5 (fully applies), the extent to which each of the items listed would be helpful in order to increase their amount of physical exercise. *M*, mean; *SD*, standard deviation.

lack of time due to work and a lack of drive and energy (see Table 2). Both groups reported that a short distance to the training venue and fixed appointments were reported to be the most helpful (see Table 3).

Of note, study participants with lower scores on the personality trait of conscientiousness gave higher scores for the facilitator “reminders by phone or email” (*r* = −0.18, *p* < 0.001, *n* = 957).

3.2.6 Physical exercise during childhood

To evaluate the impact of exercise during childhood on present outcomes, we additionally gathered data on exercise-related characteristics in childhood. 78% of the mentally healthy sample reported having exercised regularly during childhood (76.9% in women and 80.1% in men). Approximately 80% of

individuals who participated in regular exercise during their respective childhoods were affiliated with sports clubs, with a 78.2% membership percentage below the age of 12 and 81.3% above the age of 12. Interestingly, individuals who exercised regularly in childhood were more likely to maintain their respective exercise habits in adulthood. 76.8% of those who exercised regularly during childhood still exercise regularly today, in contrast to only 60.1% in the comparison group [χ^2 (1) = 24.39, *p* < 0.001].

In our study, people who regularly exercised during childhood reported higher levels of education (*U* = 90,449.0, *Z* = −3.52, *p* < 0.001) and income (*U* = 90,882.5, *Z* = −2.93, *p* < 0.001) compared to those who did not. However, we found no difference in subjectively reported current health status or BMI.

3.2.6.1 Relationship between exercise behaviour during childhood and personality characteristics

Individuals who reported regularly engaging in exercise as children scored higher on extraversion ($p < 0.001$, $t(998) = -3.54$, MD = -0.27 , Cohen's $d = 1.01$, 95% CI [-0.42 , -0.12]) and lower on neuroticism ($p < 0.001$, $t(998) = 3.94$, MD = 0.28 , Cohen's $d = 0.94$, 95% CI [0.15 , 0.45]) than individuals who did not exercise regularly in childhood. Moreover, they showed significantly higher levels of both intrinsic and extrinsic motivation towards exercise ($p < 0.001$, $t(305) = -7.65$ and $t(987) = -4.40$, MD = -0.28 and -0.67 ; Cohen's $d = 1.01$ and 0.84 , 95% CI [-0.81 , -0.51] and [-0.49 , -0.19]). In a further comparison of the two groups, we also found significantly higher values of internal locus of control, resilience, self-efficacy and risk-taking for those who engaged in regular exercise during childhood. However, the personality traits agreeableness, conscientiousness, and openness, as well as external locus of control showed no significant difference.

3.2.6.2 Discontinuation of sport in childhood

More than two-thirds (69.0%) of participants from the mentally healthy sample reported cessation of participation in a sport during childhood/adolescence. The most common reason given by 42.0% (multiple choice) was "other hobbies were more important". The second most common reason was "no fun", given by 36.0%. The reasons "didn't get on with coach", "too much pressure to succeed" and "financial reasons" were selected by 8.6%, 6.2%, and 5.3% of participants, respectively.

Over 43.4% of study participants expressed a desire to engage in a certain sport during childhood but the inability to do so. The most common reason for this was "no facilities nearby" with 42.3%, followed by "no family support" with 33.1%, and "financial reasons" with 26.9%.

4 Discussion

This study aimed to identify determinants of exercise behaviour to contribute to a better understanding of how to promote optimal conditions for regular physical activity in the general population. The majority of participants in our study exercised regularly and met the WHO criteria of at least 150 min of moderate physical activity or 75 min of vigorous physical activity per week. While most of the participants reported a preference to exercise outdoors with friends or in groups, the number of individuals actually doing so was significantly lower. While there was no significant correlation between age and exercising behaviour, the presence of different motives and individual personality traits were linked to engaging in regular exercise. Specifically, we observed significant positive associations between exercise behaviour and the personality traits conscientiousness, extraversion, and agreeableness and between exercise behaviour and both intrinsic and extrinsic levels of motivation, with intrinsic motives appearing to play a more important role. In addition, levels of self-efficacy, resilience, internal locus of control and risk taking showed positive

associations with exercise behaviour. However, a significant negative association was found for an external locus of control.

Moreover, people who exercised regularly during childhood had a notably higher proportion of active family members compared to those who didn't exercise as children. Lastly, people who exercised regularly as children were more likely to exercise regularly as adults.

According to previous studies, only about half of the adult population met the WHO recommendations (1, 9), whereas in our sample about 4 out of 5 people did. This might be due to our recruitment being biased towards individuals with a sports-related background or because the topic might have appealed more to sports enthusiasts, resulting in a higher proportion of physically active participants in our study.

Our findings on the relationship between personality characteristics and exercise behaviour are in line with previous literature and said to be independent of factors such as gender, age or culture/country (35, 36). Individuals with high levels of conscientiousness are regarded as disciplined, self-regulated, dutiful, and deliberate (37), which favours the initiation and maintenance of physical exercise. Similarly, people with higher levels of extraversion are more prone to seek out social contact and sensory stimulation (37), which can be a part of engaging in exercise. Those with a higher level of agreeableness are considered to be compassionate, humble, trusting, cooperative, and altruistic (37) which can also be beneficial for maintaining physical exercise. Whereas the positive correlations between physical exercise and the personality traits extraversion, conscientiousness and agreeableness are in line with a recent cross-sectional study conducted in 4,244 German students and with previous meta-analyses (19, 35, 36), our study could not confirm a positive association between physical exercise and the personality trait openness as well as a negative association with neuroticism that has been previously suggested (19, 36). This discrepancy may be attributed to the exclusion of individuals diagnosed with a mental illness, a group known to exhibit elevated neuroticism scores (38). Said results underscore the necessity to tailor exercise regimens to individual needs and personality traits, such as, for example, cues and/or reminders via telephone for people low in conscientiousness. For individuals with low levels of extraversion and/or agreeableness, participation in open settings, such as open days or direct contact in public spaces may be beneficial.

Our finding of a positive association between intrinsic and extrinsic motivation and regular exercise behaviour is consistent with previous research (39). The motives rated as most significant in our exercising sample – enjoyment, stress management, challenge, revitalisation and affiliation – are also among the most commonly reported motives in other studies (40, 41). If prevention is to be further strengthened in the German health care system, it would be important to start with these motives. The keywords enjoyment, stress management, challenge, revitalisation and affiliation can be used to draw attention to exercise programs, promote workplace exercise and target health insurance members. Exercise regimens could be planned in cooperation with those concerned, thereby increasing intention to

exercise. Previous studies have shown that motivation can be influenced by using behaviour change techniques. These behaviour change techniques may include, for example, behavioural goal setting, action planning, behavioural feedback, behavioural instruction, or behavioural demonstration (42).

Other studies also found a positive relationship between self-efficacy and exercise behaviour (43). Intervention studies have used a variety of methods to increase self-efficacy levels, such as face-to-face and telephone counselling, email feedback, discussion groups or behaviour change classes. They have shown small but significant effects on self-efficacy and subsequently on physical activity levels, focusing mainly on lifestyle physical activity such as walking and gardening (43). Future research should build on this to identify further effective interventions to increase self-efficacy and, therefore, exercise and physical activity in the general population.

In our study, people who exercise regularly show increased self-efficacy, a stronger internal locus of control and higher overall and intrinsic motivation compared to non-exercisers. In addition, the majority of our study population prefer to exercise with others rather than alone. This is consistent with the self-determination theory (13).

Regarding additional barriers and facilitators of regular exercise, many participants indicated that proximity as well as flexible training times and locations would be helpful. Correspondingly, the most common reason given for not exercising regularly during childhood was a lack of sports facilities in the area. To address this, more low-threshold public exercise opportunities should be provided in public areas and where few sports facilities exist. This could be achieved by the establishment of weekly exercise groups at different levels that can be joined without prior registration and free of charge. The construction and maintenance of public fitness facilities like outdoor gyms, safe and accessible cycle paths and public parks could also animate people and encourage them to spend more time outdoors exercising. Accordingly, a study conducted in Chile found that the presence of more outdoor gyms increases the physical activity in the population and increases the likelihood of meeting the WHO recommendations for physical activity (44).

Low-threshold and low-cost or no-cost opportunities in childcare facilities should also be created and promoted, especially for those from socially disadvantaged backgrounds, as these children generally have less opportunity to engage in physical activity (45). Our data supports this notion as many individuals reported not engaging in or quitting their preferred sport due to a lack of financial resources. A Brazilian study found that the majority of outdoor gym users were people with low income, so the installation of outdoor gyms could reduce social inequalities in physical exercise (46).

Another approach would be to introduce and promote more free, well-developed fitness apps, supported, for example, by health insurance bonus programs. This would have the advantage of being flexible in terms of place and time, but the disadvantage of losing the social aspect of exercise, which also seems to play an important role, as most of our study

participants stated that they prefer to exercise with others rather than alone.

Our data also shows a significant association between the exercise behaviour of family members and respondents during their respective childhoods. Moreover, engaging in regular exercise during childhood seems to make regular exercise more likely in the present. Thus, the exercise behaviour of family members appears to have a significant and lasting influence on exercise levels of people in child- and adulthood. In conclusion, exercise interventions, particularly those targeting family members could be beneficial to increasing physical activity levels in the population. Establishing programs parents and children attend together could be a possible solution to said problem.

When interpreting our findings, several limitations have to be considered. Although the online format of our survey allowed us to reach a large number of participants from different backgrounds, there are constraints within this format. As our survey was predominantly advertised in sporting environments and at universities, our results are not representative of the wider population. It is possible that a sampling bias occurred whereby individuals who are less educated and do not exercise regularly are under-represented. This is also supported by the fact that 68% of participants have the highest German school-leaving qualification. Additionally, self-selection bias towards physically active people as a result of the survey's subject matter may have occurred. Due to the relatively time-consuming design of the questionnaire, 12.7% did not complete the survey, possibly introducing further bias. Additionally, the implementation of self-report instruments in our study poses potential for social desirability and recall biases. The use of self-report alone to classify participants into the mentally healthy group may have introduced diagnostic uncertainty. Expert interviews may be a future way to address this issue in smaller follow-up studies. Finally, the cross-sectional design of our study does not allow us to draw conclusions about the causality of observed relationships.

5 Conclusion

Based on our findings, we recommend that more low-threshold public exercise opportunities (e.g., public fitness facilities) should be provided in public areas with few sports facilities and in childcare facilities. Low-cost exercise opportunities should also be created and promoted, especially for socially disadvantaged groups.

We further observed that the motives enjoyment, stress management, challenge, revitalisation, and affiliation play a crucial role for engaging in regular exercise. Therefore, it is essential to target and strengthen said motives in the general population.

Moreover, interventions to increase (exercise-related) self-efficacy could also be helpful in promoting regular exercise. Future studies should explore the direction of the relationship between personality traits and exercise, and how to best tailor exercise opportunities to the individual needs of exercise participants. We believe that addressing these suggestions in the future can make a significant contribution to promoting exercise,

which in turn can significantly contribute to improving both physical and mental health in the population.

Data availability statement

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

Ethics statement

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The project was approved by the local Ethics Committee of the Faculty of Medicine at the LMU Munich (registration number: 22-0625KB).

Author contributions

AW: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Software, Writing – original draft, Writing – review & editing. KK: Conceptualization, Data curation, Investigation, Methodology, Project administration, Writing – review & editing. LR: Formal Analysis, Validation, Writing – review & editing. TF: Writing – review & editing. RS: Visualization, Writing – review & editing. AH: Supervision, Writing – review & editing. AS: Supervision, Writing – review & editing. PF: Resources, Supervision, Writing – review & editing. IM: Conceptualization, Project administration, Resources, Supervision, Validation, Writing – review & editing.

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Conflict of interest

AH was member of advisory boards of Boehringer-Ingelheim, Lundbeck, Janssen, Otsuka, Rovi and Recordati and received paid speakership by these companies as well as by AbbVie and Advanz. He is editor of the German schizophrenia guideline. PF is a co-editor of the German (DGPPN) schizophrenia treatment guidelines and a co-author of the WFSBP schizophrenia treatment guidelines; he is on the advisory boards and receives speaker fees from Janssen, Lundbeck, Otsuka, Servier and Richter.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Contributions of Hope in physical activity and exercise goal attainment in college students

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Background: College students significantly decrease physical activity (PA) over the course of a four-year degree, increasing the risk for chronic disease. Research shows that psychological constructs impact behavior and goal attainment. However, little is known regarding the effect of psychological variables on PA levels in students. This study examined the association of psychological factors, PA, and exercise goals in college students.

Methods: Students completed two questionnaires within one semester approximately 8 weeks apart. The first (Time 1) included the Adult Hope Scale, Life Orientation Test-Revised, Self-Efficacy to Regulate Exercise, International Physical Activity Questionnaire (IPAQ), and goal assessments. The second (Time 2) included the IPAQ, and scales for goal progress and success. One-hundred seven participants completed both surveys and included an exercise goal.

Results: Predictors of exercise goal attainment included moderate PA at Time 1, goal importance, hope-agency, and the hope-agency by major interaction. Predictors of vigorous PA at Time 2 included hope-agency and moderate PA. The only predictor of moderate PA at Time 2 was moderate PA at Time 1. The only predictor of total PA at Time 2 was moderate PA at Time 1.

Conclusion: Higher hope-agency scores predicted self-reported vigorous PA. We also provide evidence that trait hope influences perceived exercise goal achievement over time.

KEYWORDS

hope, optimism, exercise, physical activity, student

1 Introduction

National physical activity guidelines state that adults should participate in at least 150 min of moderate aerobic activity per week ([American College of Sports Medicine, 2018](#)). Alarming, over 40% of young adults between the ages of 18 and 24 do not meet these physical activity guidelines ([American College of Sports Medicine, 2018](#)). Almost half of young adults in this age range are enrolled in college ([U.S. Department of Commerce, Census Bureau, Current Population Survey, 2021](#)). Multiple studies demonstrate high sedentary behavior in college students and that the college years are a time when most young adults see a decrease in physical activity ([Sparling and Snow, 2002](#); [Caspersen et al., 2000](#)), contributing to weight gain in this cohort ([Pope et al., 2017](#); [Carnethon et al., 2004](#); [Caspersen et al., 2000](#)). For example, one study reported that undergraduates in the United Kingdom spent most of their time in three sedentary categories: studying, screen time, and socializing ([Rouse and Biddle,](#)

2010). A study in the United States reported that undergraduate students on average spend 10 h a day in sedentary activities (Peterson et al., 2018). Lastly, in China, youth have recently more than doubled their amount of sedentary time (Zhang et al., 2012), demonstrating a global shift toward physical inactivity.

Failure to acquire or maintain health-promoting behaviors can impede future success and well-being in these young adults (Schulenberg et al., 2003). Furthermore, benefits of physical activity are well known across all demographics (Groppe et al., 2012; Dunsten et al., 2010), including improved quality of life and decreased morbidity and mortality. However, the psychological foundations as to why undergraduate students adopt and maintain physical activity behaviors are still unclear (Anderson and Feldman, 2020; Caspersen et al., 2000; Higgins et al., 2014). Therefore, identifying psychological factors that promote or impede physical activity behavior in this young adult age group is warranted.

Prior research suggests that many psychological factors predict behavior among undergraduate students, including hope (Anderson and Feldman, 2020). Snyder defined hope as “the perceived capability to derive pathways to desired goals and motivate oneself via agency thinking to use those pathways (p. 249)” (Snyder, 2002). The underlying assumption of hope theory is that human actions are goal directed (Snyder, 2002). Pathways refers to the plans individuals create to reach their goals; whereas, agency thinking is the thoughts related to the ability to initiate and continue movement toward the goals. Hope theory posits that agency is a critical factor in achieving goals, especially when alternate paths are required, because it promotes flexibility and creativity to continue pursuing goals while facing adversity (Snyder, 2002). Early research revealed that individuals higher in hope exhibit positive emotions during goal pursuits and cope more effectively with stressors that could impede reaching the goal (Snyder et al., 1991; Snyder, 2002; Tennen et al., 2002).

The goals that people establish range vastly from a simple motor command that happens in seconds to abstract reasoning about life in the future. In a novel study, Feldman and colleagues demonstrated that hope predicts future goal attainment in college students, with goal topics varying widely (Feldman et al., 2009). Hope has since been predictive of behavior in a variety of domains (Snyder et al., 1991; Snyder, 1994), such as athletic performance in Division 1 track athletes (Curry et al., 1997), pain tolerance (Snyder et al., 2005), academic performance in law school (Rand et al., 2011), and grade expectancies in college students (Feldman et al., 2009). Despite the promising area of research on hope and human behavior, little is known regarding hope's effect on exercise-related goals or physical activity. In one of the rare studies evaluating hope and physical exercise, Anderson and Feldman (2020) revealed that agency, but not pathways, predicted frequency of exercise in adults, even after controlling for exercise-self-efficacy and optimism. However, this study was cross-sectional; therefore, whether hope can predict future exercise behavior remains unknown. Additionally, no research has evaluated whether hope predicts exercise-related goal attainment.

To address this gap in the literature, the purpose of this longitudinal observational study was twofold. First, we tested whether hope predicted perceived exercise goal attainment in undergraduate students. Second, we determined whether hope longitudinally predicted physical activity behavior in these students. We assessed hope, goals, goal importance, physical activity levels, self-efficacy for exercise, and optimism in undergraduate students during the first

month of the semester. During the last month of the semester, we assessed perceived goal attainment and physical activity levels. We hypothesized that hope, particularly agency, would predict exercise goal attainment and moderate to vigorous physical activity in undergraduates, even after controlling for relevant demographics and other psychological variables.

2 Methods

2.1 Participants

Participants included 107 Indiana University-Purdue University Indianapolis (IUPUI) undergraduate students (93 females and 14 males) that were 18 to 43 years of age ($M = 20.39$, $SD = 4.28$). Inclusion criteria for the study required participants to be enrolled at IUPUI as an undergraduate student. Participants were excluded if they were under 18 years of age. Participants were recruited using two methods. Participants were recruited from the Introduction to Psychology courses at IUPUI. Students in these courses partake in research studies as one means of fulfilling the requirements of their introductory course. Students were also recruited from undergraduate courses offered through the School of Health and Human Science (SHHS), with most of these students enrolled in exercise science majors. Students recruited from SHHS received an in-person scripted verbal explanation of the study, the website link and QR code to participate, along with the researcher's contact information.

2.2 Procedure

Approval to administer the survey and execute this study was provided by the Institutional Review Board from Indiana University. Data collection occurred at two time points, separated by approximately 2 months. The first part of this study occurred within the first 4 weeks of the fall semester. Students were provided a link to the Time 1 questionnaires utilizing the survey tool Qualtrics. Once they opened the link, participants were immediately presented with the informed consent document and were instructed to acknowledge that they read and understood the informed consent document before beginning the questionnaires. Next, participants were prompted to begin the Time 1 Questionnaire, which started by asking about demographic information followed by asking about their personal top five goals they were currently pursuing. Next, they were presented with the goal importance scales, adult hope scale (Snyder et al., 1991), Life orientation test – revised (Scheier et al., 1994), Self-efficacy to regulate exercise scale (Bandura, 2006), and international physical activity questionnaire – short form (Lee et al., 2011). Once they completed the questionnaires, a standardized message thanked them for their participation and reminded them that a researcher would follow up in approximately 8 weeks.

Approximately 8 weeks after students completed the Time 1 questionnaire, they were sent the Time 2 questionnaire email. This email was individualized for each participant to remind them of their unique goals from the responses on the Time 1 questionnaire and a link to complete the Time 2 questionnaires. The Time 2 questionnaires included the International Physical Activity Questionnaire-Short form and assessment of the participants' perceived level of goal attainment

for each goal. Following completion of the Time 2 questionnaire, the participants received a copy of the debriefing form and researcher contact information if they should need any further information or have questions pertaining to the study.

2.3 Outcome measures

2.3.1 Demographics

Participants were asked to provide their age, biological sex, college major, standing class, height, weight, living arrangements, employed working hours, college credits enrollment, grade point average, and marital status.

2.3.2 Goals survey and goal importance

At Time 1, students were asked to list their top five goals with the following question, “Please provide a short description of the 5 most important goals that you are currently pursuing.” Participants rated the importance of each goal on a 0 to 10 numeric rating scale, with 0 indicating not at all important and 10 indicating extremely important (Feldman et al., 2009).

2.3.3 Goal attainment

At Time 2, participants were asked the following two questions to assess goal attainment (Feldman et al., 2009):

- (1) “Indicate what percentage of progress you made toward achieving this goal.” Participants selected from a range of 0 to 100%.
- (2) “How successful were you with each goal?” Participants rated their success on a scale of 0 (not successful at all) to 6 (very successful).

Similar to the Feldman et al. (2009) study, the values obtained for each question were standardized and then summed to yield an overall goal attainment index for statistical analysis.

2.3.4 Adult hope scale

AHS is a measure of trait hope in adults formed from two subscales measuring agency and pathways thinking (Snyder et al., 1991). The AHS includes 12 statements that participants rate from 1 (definitely false) to 8 (definitely true) for how the statements describe them. Of the 12 items, four measure agency (e.g., “I energetically pursue my goals”), four measure pathways (e.g., “I can think of many ways in life to get the things that are most important to me”), and four are distractors that are not included in the final summation. The AHS has shown good convergent and divergent validity. Total scores range from 8 to 64.

2.3.5 Life orientation test-revised

The LOT-R is a ten-question scale measuring trait optimism (Scheier et al., 1994). The LOT-R asks participants to rate on a 5-point scale from 0 (strongly disagree) to 4 (strongly agree) to what extent they agree with 10 statements. (e.g., “Overall, I expect more good things to happen to me than bad”). The LOT-R has been tested for accuracy and has good validity (Chiesi et al., 2013). Total scores range from 0 to 40.

2.3.6 International physical activity questionnaire-short form

The IPAQ is a measure of physical activity that asks subjects to recall the amount of time during the past week spent on vigorous activity, moderate-intensity activity and walking (e.g., “During the last 7 days, on how many days did you walk at least 10 min?”) (Lee et al., 2011). Scores were calculated in terms of MET-minutes/week for vigorous activity, moderate activity, walking, and Total activity. The IPAQ-SF has shown acceptable concurrent and construct validity and test-retest reliability (0.66–0.89) (Craig et al., 2003; Lee et al., 2011).

2.3.7 Self-efficacy to regulate exercise scale

This questionnaire measures individual beliefs about their ability to perform and overcome barriers to exercise on a 100-point scale that captures emotional issues and external factors (Bandura, 2006; e.g., “how confident are you that you could exercise when in a bad mood?”). This scale has been tested and found valid (Bandura, 2006). Total scores range from 0 to 1,800.

2.4 Statistical analysis

For a power of 0.80 with alpha set at 0.05 and a moderate effect size of $f^2 = 0.15$, a power calculation revealed that 92 participants would be needed to adequately predict goal progress and success with up to five predictor variables.

Not all participants provided an exercise-related goal. The current study focused specifically on predicting exercise-related goal attainment, thus only participants who provided an exercise-related goal were included in the data analysis. Descriptive statistics were conducted for the whole sample (which provided an exercise goal) and each subgroup defined by exercise related major vs. non-exercise science related major. The separation between exercise-related majors and non-exercise-related majors was because students in exercise-related majors likely have had more education on exercise principles, and potentially greater exercise self-efficacy and PA levels. Shapiro-Wilk’s test of normality was used to determine the normality of the distribution of the outcome measures. All of the primary outcome measures, except for Self-efficacy to Regulate Exercise Scale, were distributed non-normally. Data were presented as frequency for sex, race, and class, and mean $\pm$ standard deviation (SD) or median (interquartile range) depending on the distribution of the data. Mann-Whitney U tests were used to determine whether non-normally distributed outcome variables differed by major (exercise vs. non-exercise), and independent t-tests were used to determine whether normally distributed outcome variables differed by major.

Bivariate Spearman rank correlations were conducted to determine the relationships between goal attainment and the IPAQ variables (moderate PA, vigorous PA, total PA) at Time 2 with personal variables (e.g., age, BMI), and Time 1 variables of IPAQ-vigorous PA, IPAQ-moderate PA, IPAQ-total PA, AHS-agency, AHS-pathways, LOT-R, EXSE, and goal importance. Next, separate multivariate linear regression analyses were conducted to determine predictors of goal attainment, vigorous PA, moderate PA, and total PA at Time 2. Variables chosen based on previous research that were significantly correlated with the dependent variables were initially entered into the regressions. Only significant predictors were retained in the final models. We also explored whether the interaction between major

(exercise science related vs. non-exercise science related) and AHS-agency, and major and AHS-pathways affected the results of the models. All statistics were conducted using IBM SPSS Statistics version 27. The p -value for significance was set at $p < 0.05$.

3 Results

3.1 Participant characteristics

The participants in this study were undergraduate students enrolled at IUPUI. Two-hundred and seventy-one students enrolled in the study, and 107 were retained for organically choosing an exercise goal and completing the entire study. Detailed characteristics of the whole sample ($n = 107$) and the sample divided into exercise related majors ($n = 53$) and non-exercise related majors ($n = 54$) are reported in Table 1. The students were mostly White, female, and between the ages of 18–43 (84.1% were between 18 and 21 years of age). A Mann–Whitney U test indicated that exercise-science majors had significantly greater LOTR scores (optimism) compared to non-exercise science majors, $p = 0.022$. Also, an independent t-test indicated that exercise-science majors had significantly greater self-efficacy to regulate exercise compared to non-exercise science majors, $p = 0.031$. No other variables differed between exercise-science and non-exercise science related majors (p 's > 0.05). Table 1 displays the demographic outcomes of the participants.

TABLE 1 Sample demographics and characteristics.

Variable	Sample ($n = 107$)	Non-ex major ($n = 54$)	Ex major ($n = 53$)
Age (y)	20.4 $\pm$ 4.3	21.1 $\pm$ 5.4	19.7 $\pm$ 2.5
BMI T1, kg/m ²	26.1 $\pm$ 5.9	26.9 $\pm$ 6.9	25.1 $\pm$ 4.3
Sex, % female	93 (86.9%)	49 (90.7%)	44 (83%)
Class			
Freshman	49 (45.8%)	28 (51.9%)	21 (39.6%)
Sophomore	27 (25.2%)	15 (27.8)	12 (22.6%)
Junior	19 (17.8%)	3 (5%)	16 (30.2%)
Senior	8 (7.5%)	4 (7.4%)	4 (7.5%)
Other	4 (3.7%)	4 (7.4%)	0 (0%)
IPAQ, met-min/wk Median [Q1, Q3]			
Walking	1,386 [462, 2,772]	1,584 [396, 4,307]	1,386 [578, 2,772]
Moderate	720 [0, 2,400]	720 [0, 2,400]	720 [240, 2,400]
Vigorous	960 [0, 2,880]	480 [0, 1,500]	1,920 [480, 3,600]
Total	4,884 [1,829, 9,264]	4,610 [1,503, 10,759]	4,884 [2,380, 8,919]
Self-efficacy to regulate exercise (0–1,800)	1,005 $\pm$ 375	922 $\pm$ 420.7	1085.7 $\pm$ 308.6
Optimism (0–40)	25 [21, 29]	23 [18, 28]	26 [23, 29]
Goal Importance (0–10)	9 [7, 10]	8 [7, 10]	9 [8, 10]
Hope			
Agency (4–32)	26 [23, 29]	26 [22.75, 29]	27 [23, 29]
Pathways (4–32)	25 [23, 27]	24.5 [22, 26.25]	26 [23, 28.5]
Total (8–64)	51 [46, 56]	50 [46, 55]	51 [46.5, 56.5]
Goal attainment, z score	0.28 [–1.60, 1.43]	0.08 [–1.93, 1.39]	0.63 [–1.41, 1.46]

Values denote means $\pm$ standard deviation, n (percentage of n), or median [interquartile range].

3.2 Correlational analyses

Spearman correlation coefficients are presented in Table 2. Goal attainment was significantly and positively correlated with several variables at Time 1, including moderate PA, vigorous PA, Total PA, exercise self-efficacy, optimism, goal importance, and hope agency. Goal attainment was also negatively correlated with BMI ($r = -0.25$, $p = 0.017$). Total PA at Time 2 was significantly and positively associated with all of the Time 1 PA variables, having the strongest relationships with moderate PA and total PA. Vigorous PA at Time 2 was positively associated with moderate PA, vigorous PA, Total PA, exercise self-efficacy, goal importance, and hope-agency at Time 1. Moderate PA at Time 2 was only significantly and positively associated with moderate PA, total PA, and exercise self-efficacy at Time 1.

3.3 Multivariate linear regression analyses

3.3.1 Hypothesis 1: hope at the beginning of the semester will predict exercise goal attainment near the end of the semester

Potential predictors were chosen from the variables significantly correlated with goal attainment. We also explored the interaction terms of major (exercise vs. non-exercise) and the psychological variables as predictors (e.g., major and hope-agency, major and exercise self-efficacy). To create the interaction term, the psychological variables

TABLE 2 Correlation coefficients for the association of goal attainment and PA variables at Time 2 with psychological variables and PA variables at Time 1.

Variable	Goal attainment	Total PA Time 2	Vigorous PA Time 2	Moderate PA Time 2
IPAQ Time 1				
Walking	−0.019	0.237*	0.065	0.099
Moderate	0.303**	0.468**	0.415**	0.376**
Vigorous	0.323**	0.268**	0.381**	0.099
Total	0.238*	0.457**	0.339**	0.273**
Exercise self-efficacy	0.287**	0.169	0.394**	0.391**
Optimism	0.218*	0.068	0.167	0.111
Goal Importance	0.222*	0.139	0.195*	0.049
Hope				
Agency	0.224*	0.105	0.193*	0.057
Pathways	0.045	−0.026	0.077	0.127
Total	0.164	0.048	0.163	0.098

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). PA, Physical activity; IPAQ, International Physical Activity Questionnaire.

TABLE 3 Multivariate linear regression analyses predicting goal attainment (*n* = 107).

	B	Std. Error	Beta	t	Sig.
Major	0.125	0.334	0.034	0.373	0.710
Goal importance	0.220	0.095	0.216	2.309	0.023
Moderate physical activity	0.000	0.000	0.252	2.749	0.007
Hope agency	0.710	0.208	0.407	3.417	0.001
Agency by major interaction	−0.910	0.318	−0.343	−2.864	0.005

were first standardized as a z-score and then multiplied with major. The final regression model included only significant variables, other than keeping major as a predictor. The final model was significant ($p < 0.001$) with an R^2 of 0.215. Significant predictors of goal attainment included moderate PA at Time 1, goal importance, hope-agency, and the hope-agency by major interaction term. See Table 3 for results of the regression analysis. The relationship between hope-agency and goal attainment was stronger for those in non-exercise-related majors compared to exercise-related majors as shown in Figure 1.

3.3.2 Hypothesis 2: hope at the beginning of the semester will predict physical activity near the end of the semester

Potential predictors were chosen from the variables significantly correlated with each PA variable at Time 2. We also explored the interaction terms of major (exercise vs. non-exercise) and the psychological variables as predictors (e.g., major and hope-agency, major and exercise self-efficacy), but the interaction terms were not significant predictors of any of the PA variables. The final regression

models included only significant variables. The final model for moderate PA was significant ($p = 0.002$), with an R^2 of 0.153. The only significant predictor was moderate PA at Time 1. The final model for vigorous PA was also significant ($p < 0.001$), with an R^2 of 0.208. Significant predictors included moderate PA at Time 1 and hope-agency. Thus, those with higher levels of moderate PA and hope-agency at the beginning of the semester reported higher levels of vigorous PA at the end of the semester. Lastly, the final model for total PA was significant ($p < 0.001$) with an R^2 of 0.247. The only significant predictor was moderate PA at time 1 (Table 4).

4 Discussion

This longitudinal study tested hope as a predictor of perceived exercise goal attainment and self-reported physical activity in college-students. Several key findings emerged from the data. First, hope at the beginning of the semester, specifically the agency subscale, predicted perceived exercise goal attainment near the end of the semester. Second, hope-agency and previous physical activity predicted self-reported vigorous physical activity levels at the end of the semester. These findings bring science closer to understanding the role of hope in physical activity and exercise goal pursuit.

4.1 AHS prediction of perceived exercise goal attainment

The results partially supported our hypothesis that hope measured at the beginning of the semester would predict perceived exercise goal attainment at the end of the semester. Specifically, the subscale hope-agency, but not hope-pathways, at the beginning of the semester predicted perceived exercise goal attainment at the end of the semester. This finding provides additional evidence for the benefit of parsing out measures of hope into pathways and agency subscales when measuring its influence on behavior. Hope-agency was a significant predictor of exercise goal attainment even when controlling for goal importance and previous physical activity levels. Prior research has also reported that hope-agency versus hope-pathways is a more reliable predictor of goal attainment in college students (Feldman et al., 2009; Anderson and Feldman, 2020). These results suggest that determination to reach a goal (agency) may exert greater influence on perceived goal success than identifying pathways to achieving the goal. One theory as to why hope-pathways exerts little influence on goal-attainment is the short time span allocated in these studies (Feldman et al., 2009). Time may be a critical construct for generating multiple pathways to reaching an exercise goal (Feldman et al., 2009). For example, running a half-marathon, preparing for cross-fit games, or competing in a body-building competition takes many weeks, months, or years to prepare. Future research should investigate whether hope-pathways plays a larger role in goal attainment for goals with a longer duration for achievement.

Interestingly, our results also revealed that the relationship between hope-agency and perceived exercise goal attainment was stronger in non-exercise related major students compared to exercise related major students (Figure 1). Several reasons could explain why the relationship between hope and exercise goal attainment differed between these two groups of students. The

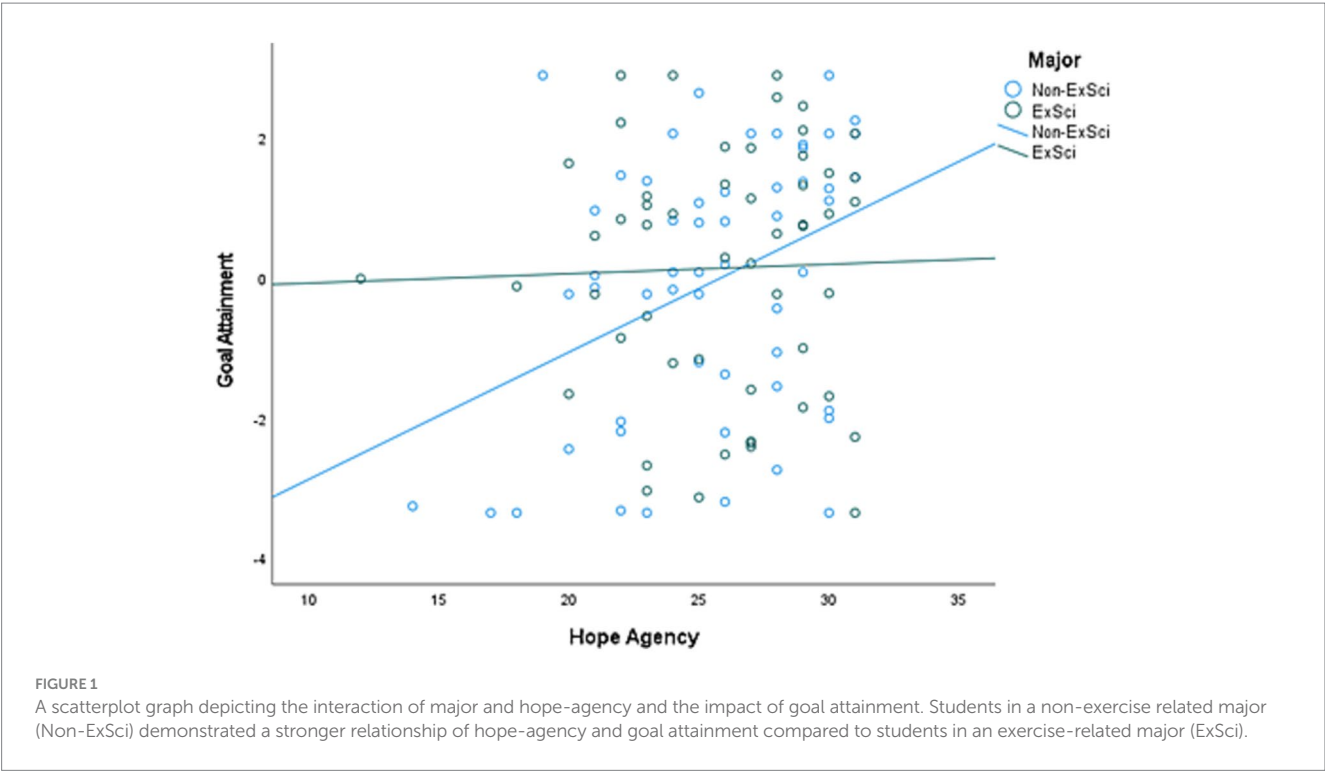


TABLE 4 Multiple regression analyses for PA variables at Time 2 (n = 107).

	B	Std. Error	Beta	t Sig.	
Vigorous PA Time 2					
Hope agency	562.895	246.7	0.209	2.282	0.025
Moderate PA	0.528	0.132	0.375	3.987	<0.001
Moderate PA Time 2					
Moderate PA	0.494	0.120	0.405	4.123	<0.001
Total PA Time 2					
Moderate PA	1.378	0.258	0.494	5.343	<0.001

PA, Physical activity.

exercise students, with exposure to exercise science courses, likely had greater knowledge of exercise principles and benefits. Additionally, those who pursue an exercise-related degree may have developed a deeper appreciation for exercise habits before college compared to those who chose a major not associated with exercise. Indeed, one study identified the top three reasons students pursue an exercise science – related degree to include interest, job opportunities, and aptitude (Vaartstra et al., 2017). In the current study, the exercise science students also demonstrated higher self-efficacy to regulate exercise and optimism compared to the non-exercise science students. Prior studies have demonstrated a positive relationship between physical activity and optimism (Kavussanu and McAuley, 1995; Pavey et al., 2015). Thus, interest and aptitude along with education and exposure to exercise-related courses may have washed out the effect of hope on exercise goal attainment in exercise science students. On the other hand, non-exercise majors may require more agentic cognitions to achieve their exercise goals. Further research is needed to understand what

psychological traits impact exercise behaviors broadly in different career trajectories.

While not the focus of the study, we also found that goal importance and self-reported moderate physical activity at the beginning of the semester predicted perceived exercise goal-attainment. Thus, students who rated their goal as more important and reported more moderate physical activity were more likely to perceive goal attainment at the end of the semester. Prior studies have shown goal importance to impact goal attainment (Feldman et al., 2009) and post-education vocational success (Nurmi et al., 2002). Furthermore, our results are in accordance with multiple studies demonstrating that engaging in PA is a good predictor of staying physically active later in life (Smith et al., 2015; Itoh et al., 2017).

Additionally, our results indicated that optimism, another foundational concept of positive psychology, did not predict exercise goal attainment. Hope and optimism have been used interchangeably in past literature despite being two distinct constructs and delineating these constructs provides further insight to goal-directed behavior (Tennen et al., 2002; Feldman et al., 2009). Dispositional optimism refers to general positive outcome expectations (Carver and Scheier, 1998); whereas, hope is the perceived ability to procure pathways and maintain agency to achieve a goal (Snyder, 2002). Hope may have a direct effect on goal attainment, whereas optimism has an indirect effect. Past studies analyzing optimism, but not hope, have shown an indirect effect of optimism on goal progress (Monzani et al., 2015) and therapeutic attendance to assist academic goals (Geers et al., 2010). A consideration may be those with higher measures of dispositional optimism are more likely to replace physical activity goals when faced with limitations to maintain psychological well-being (Duke et al., 2002). Optimism has also been shown to exert a greater impact on goal expectancy, compared to hope, when participants perceive the goal outcome as out of their control (Shanahan et al., 2020). Students who perceive their exercise goal as outside their control (i.e., the belief

that genetics determine fitness level, body composition) or encounter stressors (i.e., new environment, new peers, exams) may rely on optimistic cognitions to passively cope with failure to achieve their goal (Rand et al., 2011; Shanahan et al., 2020).

Lastly, self-efficacy to regulate exercise did not predict goal attainment or PA, which is in line with results found by Anderson and Feldman (2020). We found that self-efficacy to regulate exercise was significantly correlated with goal attainment and PA, but was not a significant predictor once hope, goal importance, and previous PA were accounted for. However, studies solely examining exercise self-efficacy show interventions which increase exercise self-efficacy increase energy expenditure in sedentary populations (Buckley, 2014). Notably, a key difference between self-efficacy and hope is that self-efficacy involves the belief that one is capable of a behavior; whereas hope involves commitment to engage in the behavior. Future research should continue to investigate the role of exercise self-efficacy in initiating and maintaining physical activity.

4.2 AHS prediction of physical activity

We hypothesized that hope at the beginning of the semester would predict physical activity near the end of the semester, and the data mostly supported our hypothesis. Hope-agency measured at the beginning of the semester predicted vigorous physical activity near the end of the semester, even after controlling for physical activity at the beginning of the semester. These results are similar to the Anderson and Feldman (2020) study that reported goal-specific hope correlated with the frequency of moderate and strenuous exercise. Interestingly, Anderson and Feldman observed that goal specific hope, but not trait hope (i.e., the measure used in the current study), predicted frequency of exercise. Several differences between the current study and the Anderson study could explain these contrasting findings regarding trait hope's prediction of physical activity/exercise. First, the focus of our study was the volume of physical activity rather than the frequency of exercise as in the Anderson study. Past literature has used physical activity and exercise synonymously; however, they are distinct and nuanced constructs (Caspersen et al., 1985). Both exercise and physical activity include bodily movement using skeletal muscle, energy expenditure, and correlate with physical fitness. Exercise differentiates from physical activity in regard to planning, structure, and objective goals to maintain or improve physical capabilities (Caspersen et al., 1985). Measuring exercise may only capture a small portion of time when an individual engages in deliberate, structured, and outcome-based movement compared to measuring physical activity which captures the waking hours of an individual and how much they move throughout their waking time. Though similar, these distinctions could explain why goal-specific hope, but not trait hope, was significant in predicting exercise in their study. Another factor that may have impacted different contributions of hope is that Anderson and Feldman used a cross-sectional study design, whereas, our study was longitudinal. Thus, our study focused on predicting future physical activity rather than current exercise or physical activity. Additionally, we did not measure goal-specific hope. Future research should investigate whether goal-specific hope would be a stronger predictor of perceived exercise goal attainment and physical activity compared to trait hope.

Importantly, our study along with Anderson and Feldman (2020) reveal that hope-agency is a stronger predictor of vigorous/strenuous

(respectively) physical activity compared to lower intensities. The importance of PA is exceptionally well documented, and vigorous PA contributes to increased health and well-being. Studies have shown that compared to light PA, vigorous PA offers greater reduction in mortality risk (Saint-Maurice et al., 2018; Gebel et al., 2015), reduced risk of type 2 diabetes (Hu et al., 1999), and greater improvements in physical impairments (Kaleth et al., 2013). Future research needs to determine whether the construct of hope can be utilized to facilitate college students meeting the physical activity guidelines of at least 150 min of moderate aerobic activity per week or 60 min of vigorous PA between 3 days per week.

Meeting the guidelines for PA typically begins with conscience intentions to be active, especially for students. Nothwehr et al. (2013) analyzed diet and physical activity-related behavioral strategies in a cross-sectional sample of adults in the Midwest region of the United States. They did not quantify physical activity, but instead captured intentions to be physically active and have physically active social interactions. Similar to our results, Nothwehr et al. (2013) demonstrated that hope-agency positively correlated with self-monitoring of physical activity. However, they also reported correlations with self-monitoring of physical activity and total hope, as well as self-monitoring of physical activity and hope-pathways. Though not surprising, the difference in recalling previous physical activity in the context of walking, moderate, and vigorous physical activity compared to reflecting on how one self-monitors PA may involve deeper processing of pathways thinking.

4.3 Hope theory

Our study expands the evidence in support of Hope Theory and adds further understanding about achieving goals related to exercise. There may be an emerging, and potentially evolving piece of Hope Theory, where agency is the primary driver of goal achievement, compared to pathway formation. Most people, especially students, have unlimited access to instantaneous information as a result of innovation in technology. Students may implicitly acknowledge the numerous paths to achieve physical activity and exercise goals and may place a greater emphasis (or lack of) on remaining dedicated to achieving their goals. More research is needed to understand how hope impacts goal-directed behavior as technology and the availability of information rapidly evolve.

4.4 Limitations

Our study provides novel insights to psychological factors that impact physical activity and exercise goal achievement in a collegiate setting. However, several limitations of this study should be acknowledged. First, while our data has notable implications for college students, these results may not apply to other populations, such as older adults or children. The second limitation is our study unexpectedly measured mostly female participants (86.9%). This predominantly female sample may restrict the generalizability of our findings to male populations. Third, it is also possible that a portion of the exercise science participants were student-athletes, although we did not collect this information. Student-athletes have a combination of education

and sports requirements. Prior research indicates that the student-athlete identity of college-aged student-athletes is pronounced (Lupo et al., 2017a), with greater motivation to succeed in the dual student-athlete role (Lupo et al., 2017b). Thus, college student-athletes would potentially be required and/or motivated to reach exercise-related goals as part of their athletic team participation. Future exercise-related research in college students should assess athletic sport team participation to allow for further sub-group analysis of the relationship between psychological factors and exercise. The fourth limitation is that the IPAQ questionnaire is a retrospective self-report of physical activity inquiring the participant about the previous 7 days. Self-report requires participants to accurately recall information and avoid modifying their responses to appear favorable. Recall introduces an honest bias of potentially retrieving incorrect responses to the amount or intensity of physical activity. Additionally, we asked participants to subjectively gauge how much progress and success they made in approximately 8 weeks toward goal attainment, which may not reflect actual goal attainment. Previous research has shown that people modify goals based on perceived attainability, internal resources, external resources, age, and coping with deficits (Duke et al., 2002). Subjective reporting of perceived goal attainment could be artificially inflated as a protective psychological mechanism to maintain participant congruence. It is possible that having higher hope leads one to overestimate achievement toward goals. Future studies should consider both, objectively and subjectively quantifying goal attainment to avoid mono-method bias. Finally, prior research indicates an increasing level of perceived stress, anxiety, and depression among college students (Brown, 2018). As physical and mental health are intrinsically related, future research should also investigate the role of these mental health factors on physical activity levels and exercise goal attainment in college students.

4.5 Conclusion

In conclusion, our longitudinal study demonstrated that higher hope scores predicted self-reported vigorous physical activity approximately 8 weeks later. We also provided the first evidence that trait hope influences perceived exercise goal achievement over time. Perceived exercise goal importance and feeling a sense of agency to achieve the goal predicted goal achievement. Future research should explore why developing pathways was not predictive of goal achievement in our study. Reaching a goal has been conceptualized as identifying the ways to achieve it and the will to do so. However, pathways was not a strong driver, like agency, in our sample. Lastly, we provided additional evidence that previous physical activity levels are still a strong predictor of future physical activity. Which begs the question, what sets a sedentary person into motion to pursue and achieve a healthy state of physical fitness?

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Indiana University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because the research presented no more than minimal risk of harm to subjects and involved no procedures for which written consent is normally required outside of the research context. Additionally, this was an online survey study. The informed consent was the first step in the survey and participants had to read through the informed consent form and check a box that they understood and agreed to participate.

Author contributions

CB: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Writing – original draft. HN: Writing – review & editing, Data curation, Project administration. AW: Data curation, Project administration, Writing – review & editing. PF: Data curation, Project administration, Writing – review & editing. KR: Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. KN: Formal analysis, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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How coach leadership behavior influences athletes' performance: the chain-mediated role of the coach-athlete relationship and psychological fatigue

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Objective: Athletes' psychological quality and competitive level are deeply influenced by coaches' leadership behavior. It is of far-reaching significance to systematically investigate the relationship between them for carrying out scientific training and improving athletes' competitive level. This study aims to investigate the relationships among coach leadership behavior, the coach-athlete relationship, psychological fatigue, and athletes' performance, providing insights into enhancing athletes' sports performance.

Methods: Using simple random sampling, 556 athletes (44.60% female) were recruited from professional training teams in the Xinjiang and Shanxi provinces of China as the study sample. The sample includes 47 s-class national athletes, 276 first-class national athletes, 171 master-class athletes, and 62 international-level athletes. Data were collected through offline surveys using the Coach Leadership Behavior Scale, the Tennis Performance Scale, the Coach-Athlete Relationship Questionnaire, and the Athlete Psychological Fatigue Questionnaire.

Results: Democratic leadership behavior, autocratic leadership behavior, training and instruction behavior, social support behavior, and positive feedback behavior are positively correlated with the "coach-athlete" relationship and athlete performance, and negatively correlated with psychological fatigue. The "coach-athlete" relationship and psychological fatigue can serve as both simple mediators and chain mediators between democratic leadership behavior, autocratic leadership behavior, training and instruction behavior, social support behavior, positive feedback behavior, and athlete performance.

Conclusion: This study systematically explored the complex relationships among coach leadership behavior, the coach-athlete relationship, psychological fatigue, and athletes' sports performance. The findings suggest that positive coach leadership behavior may contribute to the development of athletes' performance. Furthermore, the study underscores the significance of the coach-athlete relationship and psychological fatigue as key mechanisms through which coach leadership behavior influences athletes' sports performance.

KEYWORDS

coach leadership behavior, mediation, influence mechanism, coach-athlete relationship, athlete sport performance

1 Introduction

As the direct leaders of athletes in competitive sports and the initiators and drivers of leadership behaviors (Gao et al., 2021), coaches' leadership styles and behaviors have a significant impact on athletes' performance and skill development (Wang, 2023). The differences in coaching strategies, training methods, coaching philosophy, and planning among coaches are key factors that distinguish various leadership styles, and they form the foundation of a coach's distinctive leadership style. This unique leadership style shapes the behaviors that motivate athletes to adjust both physically and mentally, fully immerse themselves in competition, and perform at their best. Such leadership behaviors are critical for athletes to achieve their competitive goals as scheduled (Zhang and Ren, 2023) athletes' sports performance is an important indicator for evaluating an athlete's competitive level. A systematic study of this topic can help uncover the deep relationships between coaches and athletes, clarify the internal mechanisms affecting athletes' performance, and ultimately assist coaches in purposefully and effectively organizing their coaching activities. This, in turn, provides a scientific basis for developing athletes' self-efficacy (Cai and Wu, 2023), physical and mental fitness (Wang, 2023), personality development, and competitive abilities (Chien et al., 2019).

Although numerous studies have systematically explored how to improve athletes' performance—such as the impact of environmental changes on performance (Shi et al., 2024), the effects of surface material properties on athletes' sports performance (Wang, 2024), and the influence of external substance intake on the body's internal environment and performance (Fan et al., 2024), very few have focused on the crucial role coaches play in athletes' performance development. According to literature reviews, only Wang (2023) has researched the relationship between coach leadership behaviors and athletes' performance. However, due to the highly complex nature of the coach-athlete relationship, existing studies have not adequately explained the potential mechanisms linking the two. Specifically, current research tends to overlook the significant influence of coach behaviors on athletes' performance and how coaches, through their leadership behaviors, impact the development of athletes' performance. This has led to insufficient exploration of the specific mechanisms that may exist between them.

From the perspective of sports practice, both coaches and athletes play vital roles. Under the influence of coaching, athletes exhibit the most noticeable improvements in their competitive performance, while psychological cognition, personality, and social relationships are also affected. Furthermore, as leaders, managers, and strategists of the entire sports team, coaches' behaviors significantly influence the development of the entire team (Sun and Zhang, 2024). From the perspective of self-determination theory, the behavior of coaches, driven by their subjective agency, is influenced by their psychological needs and affects the psychological fatigue. This, in turn, can have a significant impact on the relationship between the coach and the athlete (Liu et al., 2023). Therefore, this study aims to build upon existing research to deeply explore the internal relationships through which different coaching leadership behaviors affect athlete performance. It focuses specifically on the chain mediation effects of the coach-athlete relationship and psychological fatigue a psychological state caused by sustained high-demand cognitive activity, characterized by feelings of fatigue and lack of energy

(Boksem and Tops, 2008), which refers to the interrelated influence among mediating variables, such as X first influencing M1, which then affects M2 and ultimately impacts Y. This approach not only helps further clarify the underlying mechanisms between coaching leadership behaviors and athlete performance but also aids in revealing practical interventions for improving athlete performance. Therefore, the significance of this study lies in enhancing our understanding of how coaching leadership behaviors influence the development of athlete performance and improving coaching effectiveness.

In summary, this study, by focusing on the coach-athlete relationship and psychological fatigue as mediators between coaching leadership behavior and athletes' sports performance, enriches the theoretical framework of this research area. It provides new evidence for interventions in athletes' sports performance, offering a more nuanced understanding of the indirect mechanisms influencing athletes' performance, and ultimately serves as a theoretical reference to help coaches more effectively enhance athletes' sports performance.

2 Literature review and research hypotheses

2.1 The direct effect of coach leadership behaviors on athlete performance

Athlete performance, as a direct reflection of an athlete's competitive level and an influential factor in competition outcomes, has long been a key focus in the fields of sports psychology and training science. Tian (2000) noted in his research that athletes' sports performance is the comprehensive external manifestation of an athlete's technical, psychological, physical, tactical, and intellectual abilities during training or competition. It reflects the quality of an athlete's training or competition level (Liu et al., 2016), and is a critical capability that athletes must continuously develop throughout their career. Coach leadership behavior is a set of behaviors displayed by coaches in influencing the training and competition processes of athletes. It is a key concept in sports psychology that reflects the relationship between coaches and athletes. Specifically, coaches' leadership behaviors—such as organizational planning, decision-making, communication, and motivation—impact athletes' psychological cognition, actions, emotional regulation, and sense of belonging (Gao, 2007).

Coach leadership behaviors are typically categorized into democratic leadership behavior, authoritarian leadership behavior, training guiding behavior, social support behavior, and positive feedback behavior. Each type of leadership behavior affects the development of athlete performance in different ways. For instance, democratic leadership behavior encourages athlete participation, enabling them to express opinions during training or competition and improve performance through harmonious interactions with their coach (Gao, 2007). Athletes under democratic leadership behavior tend to exhibit proactive development. In contrast, authoritarian leadership behavior emphasizes the coach's dominant planning, which may restrict athletes' autonomy, resulting in uncertain performance outcomes (Cui, 2007). However, authoritarian leadership behavior can also provide strong guidance for athletes with weaker self-discipline. The scientific development of athlete performance under this

leadership style remains a matter of debate (Qian et al., 2016). Furthermore, effective leadership plays a crucial role in optimizing team operations (Cotterill, 2013). Training guiding behavior can inspire and internalize motivation in athletes, ultimately enhancing their performance (Cai and Wu, 2013). Social support behavior, which fosters closer relationships between coaches and athletes and enhances athletes' sense of social belonging (Yan, 2014), can improve performance by addressing athletes' personal, familial, and self-related needs. Additionally, performance improvement relies on a proper incentive mechanism, known as positive feedback behavior. Research shows that appropriate motivation significantly enhances athlete performance (Perry and Stotsky, 2012).

Based on this analysis, it is evident that all types of leadership behaviors impact athlete performance. Therefore, this study proposes the following hypotheses: H1a: Democratic leadership behavior significantly impacts athlete performance. H1b: Authoritarian leadership behavior significantly impacts athlete performance. H1c: Training guiding behavior significantly impacts athlete performance. H1d: Social support behavior significantly impacts athlete performance. H1e: Positive feedback behavior significantly impacts athlete performance.

2.2 The mediating role of the coach-athlete relationship (CAR)

Extensive research indicates a complex mediating mechanism between coach leadership behavior and athlete performance. Competitive sports performance is the result of joint efforts between coaches and athletes. Coach leadership behavior may influence the development of athlete performance through the coach-athlete relationship (CAR). According to interdependence theory, CAR is often seen as an interpersonal exchange between an individual with experience needs and one providing experience. In this relationship, the individual lacking experience gains positive feedback behavior that contributes to their capability development (Jowett and Cockerill, 2003), leading to an unconscious emotional bond (Jowett and Ntoumanis, 2004) and emotional dependency at the cognitive level (Smoll and Smith, 1989), ultimately affecting athlete performance.

However, the outcome is contingent on the quality of the CAR. On one hand, inappropriate leadership behavior that does not align with the athlete's subjective needs may lead to a rupture in the CAR, negatively impacting performance (Guo and Hu, 2011). On the other hand, proper leadership behavior can harmonize the relationship, fostering high expectations for better performance (Ye et al., 2016a, 2016b) and promoting performance through positive interactions.

One dominant theory regarding CAR is Jowett's 3C model, which includes closeness, commitment, and complementarity (Yang and Jowett, 2010). Using this model, Jowett found that athlete personality influences CAR and, consequently, athlete performance (Jowett et al., 2012). Similarly, Yang et al. discovered that changes in a coach's personality—specifically increased conscientiousness and extraversion—positively influence CAR and athlete performance (Yang et al., 2015). Other research has demonstrated that a positive CAR can predict better performance and enhance athletes' qualities in facing challenges (Chang and Chen, 2023). As an important

relationship in competitive sports, CAR is influenced by coach leadership behavior and profoundly impacts athlete performance. Based on this, the following hypotheses are proposed: H2a: CAR significantly mediates the relationship between democratic leadership behavior and athlete performance. H2b: CAR significantly mediates the relationship between authoritarian leadership behavior and athlete performance. H2c: CAR significantly mediates the relationship between training guiding behavior and athlete performance. H2d: CAR significantly mediates the relationship between social support behavior and athlete performance. H2e: CAR significantly mediates the relationship between positive feedback behavior and athlete performance.

2.3 The mediating role of psychological fatigue

Psychological fatigue (PF) may be another important internal factor in the relationship between coach leadership behavior and athlete performance. PF is considered a key outcome of coach leadership behavior (Liu et al., 2023). According to self-determination theory, an individual's participation in activities is influenced by their perceived ability to make choices that meet intrinsic needs, motivational goals, and environmental information, ultimately driving autonomous decision-making (Deci and Ryan, 2000). Research has shown that a coach's failure to provide appropriate support can trigger PF in athletes (DeFreese and Smith, 2014). Inappropriate leadership behavior can lead to dissatisfaction during training and competition, resulting in negative emotions, PF, psychological harm, and poor performance (Li et al., 2017). PF not only impairs cognitive functioning but also negatively impacts psychological well-being and performance enhancement (Lorist et al., 2005). For example, a study on the effects of PF on swimmers' brain activity confirmed that PF has detrimental effects on performance and neural activity, suggesting that real-time monitoring of PF could mitigate its impact on performance (Li et al., 2023). However, research has also found that positive coach support can reduce the occurrence of PF (Guo and Yang, 2017). Based on this inference, psychological fatigue is likely to be a mediator in the relationship between coaching leadership behaviors and athletes' sport performance. However, current research on coaching leadership behaviors and athletes' sport performance mainly focuses on exploring conditional variables such as psychological preparation (Wang, 2023) and sports anxiety (Yan, 2023), with little attention paid to the role of psychological fatigue as a mediator in the relationship between coaching leadership behaviors and athletes' sport performance. Therefore, this study proposes the following hypotheses: H3a: psychological fatigue plays a significant mediating role in the relationship between democratic leadership behavior and sport performance; H3b: psychological fatigue plays a significant mediating role in the relationship between authoritarian leadership behavior and sport performance; H3c: psychological fatigue plays a significant mediating role in the relationship between training guiding behavior and sport performance; H3d: psychological fatigue plays a significant mediating role in the relationship between social support behavior and sport performance; H3e: psychological fatigue plays a significant mediating role in the relationship between positive feedback behavior and sport performance.

2.4 The chain mediating role of CAR and psychological fatigue

In addition to their individual influences, CAR and PF are important factors that affect athlete performance and are shaped by coach leadership behavior (Gao et al., 2021; Guo and Yang, 2017). Therefore, CAR and PF may play a chain-mediating role in the relationship between coach leadership behavior and athlete performance. CAR, characterized by emotional, cognitive, and behavioral exchanges between coaches and athletes, affects both athletic and psychological development (Jowett, 2009). Research has shown that CAR quality can predict athlete PF, with lower CAR quality increasing PF (Isoard-Gauthier et al., 2015; Cresswell and Eklund, 2007). In this sense, CAR is a key factor influencing PF. Studies suggest that a high-quality CAR negatively predicts PF, meaning that the better the CAR, the lower the athlete's PF (DeFreese and Smith, 2014). Existing research indicates that coach leadership behavior can directly affect athlete performance or indirectly influence it through CAR or PF. However, there is a lack of evidence on whether CAR and PF jointly play a chain-mediating role in this relationship. Given that performance is crucial for achieving excellent results and is influenced by coach leadership behavior, CAR, and PF, this study proposes the following hypothesis: H4: CAR and PF play a chain-mediating role in the relationship between coach leadership behavior and athlete performance.

3 Research methods

3.1 Research design and sampling method

Prior to conducting the survey, based on similar studies' sample effect sizes and considering differences in experimental design, it was determined that at least 300 participants would be necessary to reach the required sample size (Villafaina et al., 2021). Therefore, this study employed a random sampling method, selecting athletes from professional training teams in the provinces of Xinjiang and Shanxi, China. A total of 650 questionnaires were distributed. Due to some questionnaires being incorrectly or incompletely filled out, 556 valid responses were ultimately collected, resulting in an effective response rate of 85.54%. Among the participants, 308 were male (55.40%) and 248 were female (44.60%). The average age of the respondents was 19.34 years ($SD = 3.78$), with an average training experience of 7.03 years ($SD = 3.46$). In order to improve the comprehensiveness and authenticity of the study, we invite athletes of all levels as much as possible in the process of selecting athletes, so the final selection of samples involves athletes of different levels, with 47 (8.45%) at the second level, 276 (49.64%) at the first level, 171 (30.76%) at the national level, and 62 (11.15%) at the international level.

The study encompassed a wide range of sports, including basketball, volleyball, martial arts, shooting, triathlon, soccer, boxing, swimming, track and field, table tennis, badminton, tennis, and gymnastics. Although random sampling has certain limitations in statistical analysis, it is advantageous for quickly obtaining relevant information about the target population. Given the constraints of the survey conditions, this method proved to be practical. Direct or indirect contact with the athletes ensured the authenticity of the data collected (see Table 1).

3.2 Data collection procedure

The survey process for this study was carefully designed. Participants were verbally informed of the research objectives, and informed consent forms were provided to them upon invitation to participate. Consent was obtained from both the professional training team leaders and all athletes involved in the survey. We strictly adhered to the ethical guidelines of the American Psychological Association (APA), providing no rewards to participants while effectively safeguarding their privacy and the confidentiality of their data. This study received approval from the Ethics Review Committee of Chengdu Sport University, which supervised the entire research process (Approval N No. CTYLL2024004). The study was conducted with respect for the participants' rights.

The data collection and processing were assigned to graduate students specializing in sports psychology, who had undergone professional training to ensure the accuracy of data collection and handling. Before the survey, participants were informed that the data they provided would only be used for research purposes and would not serve any other functions. Strict anonymity was ensured. Detailed instructions for completing the survey were given, and participants were required to independently complete the questionnaire to ensure the authenticity of the research results. To maintain data integrity, the survey was completed and collected on-site.

The on-site completion and collection method was adopted to improve the accuracy of questionnaire responses and ensure high research quality. By adhering to strict data collection and ethical standards, we aimed to conduct a study with high reliability and ethical compliance.

3.3 Data analysis

Data processing and analysis were conducted based on the pre-set hypotheses of this study. First, invalid questionnaires were excluded. SPSS 24.0 software, the Bootstrap method, and the SPSS macro Process 4.1 plugin (Model 6) were used for data entry, common method bias testing, descriptive statistical analysis, correlation analysis, and regression analysis. Finally, AMOS 24.0 software was used to construct a structural equation model to verify the relationships between variables, including direct effects, mediation effects, and chain mediation effects.

3.4 Measurement tools

3.4.1 Coach leadership behavior scale

This study draws on the "Coaching Leadership Behavior Scale" developed by Qiu (1990), based on the "Leadership Scale for Sports" (LSS) formulated by Chelladurai and Saleh (1980). Compared to other scales for measuring coaching leadership behavior, this scale has more dimensions and a broader scope, making it helpful for a more in-depth examination of the varying degrees of coaching leadership behaviors. It provides stronger support for the development of this study. The scale, which contains 25 items, measures coach leadership behavior from the athlete's perspective. According to Chelladurai et al.'s classification of coach leadership behaviors, the scale was divided into five dimensions: democratic

TABLE 1 Demographic Information statistics ($N = 556$).

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	308	55.40
Female	248	44.60
Sports grade		
National secondary level	47	8.45
National level	276	49.64
National athletes	171	30.76
World-class athletes	62	11.15
Education		
High school or below	359	64.57
College or university	134	24.10
Postgraduate	63	11.33
Place of residence		
Urban	119	21.40
Village	437	78.60

leadership behavior, authoritarian leadership behavior, training guiding behavior, social support behavior, and positive feedback behavior. Responses were scored on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), with higher scores indicating better coach leadership behavior. The model fit indices were as follows: $X^2/df = 1.338$, $GFI = 0.951$, $CFI = 0.988$, $TLI = 0.986$, $RMSEA = 0.025$, $SRMR = 0.053$, demonstrating good construct validity. The Cronbach's α coefficient for the overall scale was 0.909, with coefficients of 0.892, 0.895, 0.895, 0.853, and 0.884 for the individual leadership behavior dimensions.

3.4.2 Tennis performance scale

This study uses the "Tennis Performance Evaluation Scale" developed by Zhang et al. (2006). The scale includes seven subscales: execution of the plan, loss of composure, low mood, determination, anxiety, flow, and effective tactics, with a total of 28 items. Since some of the respondents participated in non-racket sports, we modified two items in the questionnaire design: "hitting each ball" was changed to "hitting each ball (performing each movement well)" and "worrying about the serve" was changed to "worrying about the serve (worried about not performing the movement well)." This adjustment was made to ensure that athletes from non-racket sports could better understand the questionnaire content and align with the research objectives, thereby enhancing the validity of the scale's application. The scale uses a 4-point Likert scale ranging from 0 (not at all) to 3 (very strong), with reverse-scored items for numbers 17, 30, and 32. The model fit indices were $X^2/df = 1.815$, $GFI = 0.927$, $CFI = 0.974$, $TLI = 0.972$, $RMSEA = 0.038$, and $SRMR = 0.027$, indicating good construct validity. The Cronbach's α for the total scale was 0.973, with subscale α values of 0.844, 0.832, 0.827, 0.844, 0.841, 0.843, and 0.845.

3.4.3 Coach-athlete relationship questionnaire

The Coach-Athlete Relationship Questionnaire adapted by Zhong and Wang (2007), based on Jowett and Ntoumanis (2004), was employed. This questionnaire includes 11 items divided into three

dimensions: closeness, commitment, and complementarity. Responses were scored on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), with higher scores indicating a better coach-athlete relationship. Model fit indices were $X^2/df = 1.544$, $GFI = 0.979$, $CFI = 0.994$, $TLI = 0.992$, $RMSEA = 0.031$, and $SRMR = 0.036$, indicating good construct validity. The Cronbach's α for the total scale was 0.938, with dimension-specific α values of 0.837, 0.815, and 0.841.

3.4.4 Athlete psychological fatigue questionnaire

The Athlete Psychological Fatigue Questionnaire, adapted by Zhang and Mao (2010) from Raedeke and Smith (2001), was used to measure psychological fatigue. This 15-item questionnaire is divided into three dimensions: reduced sense of achievement, emotional/physical exhaustion, and negative evaluation of sport. Responses were scored on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), with higher scores indicating higher levels of psychological fatigue. Model fit indices were $X^2/df = 1.542$, $GFI = 0.968$, $CFI = 0.992$, $TLI = 0.991$, $RMSEA = 0.031$, and $SRMR = 0.035$, indicating good construct validity. The Cronbach's α for the overall scale was 0.962, with dimension-specific α values of 0.897, 0.892, and 0.895.

4 Results

4.1 Common method bias test

Given that the questionnaires were filled out anonymously and involved subjective judgments, there is a potential risk of common method bias. To address this, the Harman single-factor test was conducted through unrotated exploratory factor analysis on 79 variable items. The results showed that eight factors had eigenvalues greater than 1, and the first factor accounted for 32.18% of the variance, which is below the critical threshold of 40%. Therefore, this study concludes that there is no significant common method bias present among the variables, allowing for subsequent analyses.

4.2 Descriptive statistics and correlation analysis

Table 2 presents the results of the descriptive statistics and correlation analysis. The findings indicate significant positive correlations between democratic leadership behavior, authoritarian leadership behavior, training guiding behavior, social support behavior, positive feedback behavior, and both athlete performance and the coach-athlete relationship. These behaviors were negatively correlated with athlete psychological fatigue. Additionally, athlete performance was positively correlated with the coach-athlete relationship and negatively correlated with athlete psychological fatigue. The coach-athlete relationship also showed a negative correlation with athlete psychological fatigue.

These significant positive and negative correlations among the variables provide a solid foundation for further research to verify whether the coach-athlete relationship and athlete psychological fatigue mediate the relationship between democratic leadership behavior, authoritarian leadership behavior, training guiding behavior, social support behavior, positive feedback behavior, and athlete performance in a chain mediation model.

TABLE 2 Correlation analysis of variables (N = 556).

Variable	M	SD	1	2	3	4	5	6	7	8
1 Democratic leadership behavior	3.36	1.14	1							
2 Authoritarian leadership behavior	3.32	1.19	0.354**	1						
3 Training guiding behavior	3.29	1.18	0.403**	0.316**	1					
4 Social support behavior	3.36	1.18	0.330**	0.308**	0.325**	1				
5 Positive feedback behavior	3.43	1.15	0.319**	0.284**	0.283**	0.262**	1			
6 Athletes' performance	1.54	0.83	0.318**	0.312**	0.319**	0.336**	0.280**	1		
7 "Coach-athlete" relationship	3.36	1.12	0.374**	0.306**	0.349**	0.319**	0.266**	0.468**	1	
8 Psychological fatigue	3.32	1.15	−0.291**	−0.322**	−0.304**	−0.288**	−0.236**	−0.506**	−0.393**	1

* $p < 0.05$, ** $P < 0.01$, and so on.

4.3 Multicollinearity test

Given the significant correlations among the variables, there was a potential risk of multicollinearity affecting the stability of the final results. This study designated athlete performance as the dependent variable, with coach leadership behaviors, the coach-athlete relationship, and athlete psychological fatigue as independent variables for the collinearity diagnosis, standardizing each predictor variable. The results indicated tolerance values of 0.703, 0.738, and 0.771 for the predictor variables, all exceeding 0.1. The corresponding VIF values were 1.423, 1.374, and 1.297, all less than 5. This suggests that there is no multicollinearity issue among the variables, making them suitable for chain mediation effect testing.

4.4 Main analysis

4.4.1 Direct effects of variables

Using athlete performance as the dependent variable and coach leadership behaviors (democratic leadership behavior, authoritarian leadership behavior, training guiding behavior, social support behavior, and positive feedback behavior) as independent variables, the results showed that all five dimensions of coach leadership behavior significantly positively influenced athlete performance; Democratic leadership behavior: $\beta = 0.631$, $p < 0.01$; Authoritarian leadership behavior: $\beta = 0.560$, $p < 0.01$; Training guiding behavior: $\beta = 0.599$, $p < 0.01$; Social Support Behavior: $\beta = 0.549$, $p < 0.01$; Positive Feedback Behavior: $\beta = 0.487$, $p < 0.01$. This indicates that hypotheses H1a, H1b, H1c, H1d, and H1e are all supported; specifically, higher levels of coach leadership behaviors correlate with improved athlete performance. The reason is that the better the athletes' own competitive level or athletic ability, the more inclined they are to give higher evaluation when evaluating the coach's leadership behavior through self-introspection, which shows that the higher the coach's leadership behavior level, the higher the athletes' athletic performance level, and the two are in direct proportion.

4.4.2 Mediating effects of the coach-athlete relationship and athlete psychological fatigue

To further verify the research hypotheses (H2a—H2e, H3a—H3e, H4), this study first utilized the Process plugin to test each hypothesis individually. Additionally, to clearly observe the relationships of the

mediating variables within the different dimensions of coach leadership behavior and better understand the relationships among mediating variables, AMOS24.0 software was employed to establish a model using a stepwise method (Baron and Kenny, 1986). The results are shown in Table 3 and Figure 1.

The analysis results indicate the following: Firstly, the direct effect of democratic leadership behavior on athletes' sports performance is 0.0770, with a confidence interval that does not include 0. When the "coach-athlete" relationship and psychological fatigue are separately added, the mediation effects are 0.0779 and 0.0443, respectively, both excluding 0. This suggests that the "coach-athlete" relationship and psychological fatigue play separate and chain mediation roles in the process of democratic leadership behavior influencing athletes' sports performance. Secondly, the direct effect of authoritarian leadership behavior on athletes' sports performance is 0.0740, with a confidence interval that does not include 0. When the "coach-athlete" relationship and psychological fatigue are separately added, the mediation effects are 0.0628 and 0.0550, respectively, both excluding 0. This indicates that the "coach-athlete" relationship and psychological fatigue serve as both separate and chain mediators in the influence of authoritarian leadership behavior on athletes' sports performance. Thirdly, the direct effect of training guidance behavior on athletes' sports performance is 0.0767, with a confidence interval that does not include 0. When the "coach-athlete" relationship and psychological fatigue are separately added, the mediation effects are 0.0708 and 0.0481, respectively, both excluding 0. This demonstrates that the "coach-athlete" relationship and psychological fatigue have separate and chain mediation effects in the impact of training guidance behavior on athletes' sports performance. Fourthly, the direct effect of social support behavior on athletes' sports performance is 0.1012, with a confidence interval that does not include 0. When the "coach-athlete" relationship and psychological fatigue are separately added, the mediation effects are 0.0634 and 0.0448, respectively, both excluding 0. This shows that the "coach-athlete" relationship and psychological fatigue act as separate and chain mediators in the influence of social support behavior on athletes' sports performance. Fifthly, the direct effect of positive feedback behavior on athletes' sports performance is 0.0837, with a confidence interval that does not include 0. When the "coach-athlete" relationship and psychological fatigue are separately

TABLE 3 Results of multiple regression analysis.

Suppose	Path	Indirect effect	95%CI	Direct effect	95%CI
H2a	Democratic leadership behavior→ “coach-athlete” Relationship → Athletes’ sports performance	0.0779	[0.0525,0.1068]	0.0770	[0.0232,0.1307]
H3a	Democratic leadership behavior → Psychological fatigue → Athletes’ sports performance	0.0443	[0.0234,0.0657]		
H4a	Democratic leadership behavior→ “coach-athlete” Relationship → Psychological fatigue → Athletes’ sports performance	0.0327	[0.0217,0.0453]		
H2b	Authoritarian leadership behavior→ “coach-athlete” Relationship → Athletes’ sports performance	0.0628	[0.0412,0.0871]	0.0740	[0.0235,0.1244]
H3b	Authoritarian leadership behavior → Psychological fatigue → Athletes’ sports performance	0.0550	[0.0348,0.0766]		
H4b	Authoritarian leadership behavior→ “coach-athlete” Relationship → Psychological fatigue → Athletes’ sports performance	0.0245	[0.0157,0.0349]		
H2c	Training guiding behavior→ “coach-athlete” relationship→ athletes’ sports performance	0.0708	[0.0476,0.0981]	0.0767	[0.0252,0.1282]
H3c	Training guiding behavior → Psychological fatigue → Athletes’ sports performance	0.0481	[0.0279,0.0697]		
H4c	Training guiding behavior→ “coach-athlete” Relationship → Psychological fatigue → Athletes’ sports performance	0.0228	[0.0189,0.0410]		
H2d	Social support behavior→ “coach-athlete” Relationship → Athletes’ sports performance	0.0634	[0.0420,0.0886]	0.1012	[0.0508,0.1516]
H3d	Social support behavior → Psychological fatigue → Athletes’ sports performance	0.0448	[0.0252,0.0659]		
H4d	Social support behavior→ “coach-athlete” Relationship → Psychological fatigue → Athletes’ sports performance	0.0265	[0.0174,0.0385]		
H2e	Positive feedback behavior→ “coach-athlete” Relationship → Athletes’ sports performance	0.0564	[0.0345,0.0812]	0.0837	[0.0329,0.1345]
H3e	Positive feedback behavior → Psychological fatigue → Athletes’ sports performance	0.0369	[0.0172,0.0580]		
H4e	Positive feedback behavior→ “coach-athlete” Relationship → Psychological fatigue → Athletes’ sports performance	0.0247	[0.0154,0.0366]		

added, the mediation effects are 0.0564 and 0.0369, respectively, both excluding 0. This indicates that the “coach-athlete” relationship and psychological fatigue play separate and chain mediation roles in the process of positive feedback behavior affecting athletes’ sports performance. This study believes that the reason for the above research results is that athletes are in a relational environment that adapts to their own personality, ability and expectations, and it is easy to have good psychological adaptation at the psychological level, which greatly reduces the probability of psychological fatigue, that is, because athletes with different personalities have different understandings of the “coach-athlete” relationship, especially with the improvement of competitive level, the individual’s dependence on the relational environment is further deepened. It makes the sports practice carried out under the leadership behavior of coaches in different dimensions have a homogeneous influence on the relationship between coaches and athletes and the formation of psychological

fatigue, and also makes the athletes’ sports performance develop synchronously.

5 Discussion

5.1 The impact of coach leadership behavior on athletes’ sports performance

The research findings support hypotheses H1a-H1e, indicating that the five dimensions of coach leadership behavior (Democratic leadership behavior, Authoritarian leadership behavior, Training guiding behavior, Social support behavior, and Positive feedback behavior) all have significant positive impacts on athletes’ sports performance, consistent with previous research results (Wang, 2023). Related research suggests that democratic leadership behavior is more helpful for athletes to overcome burnout (Yu et al., 2024) and stimulate

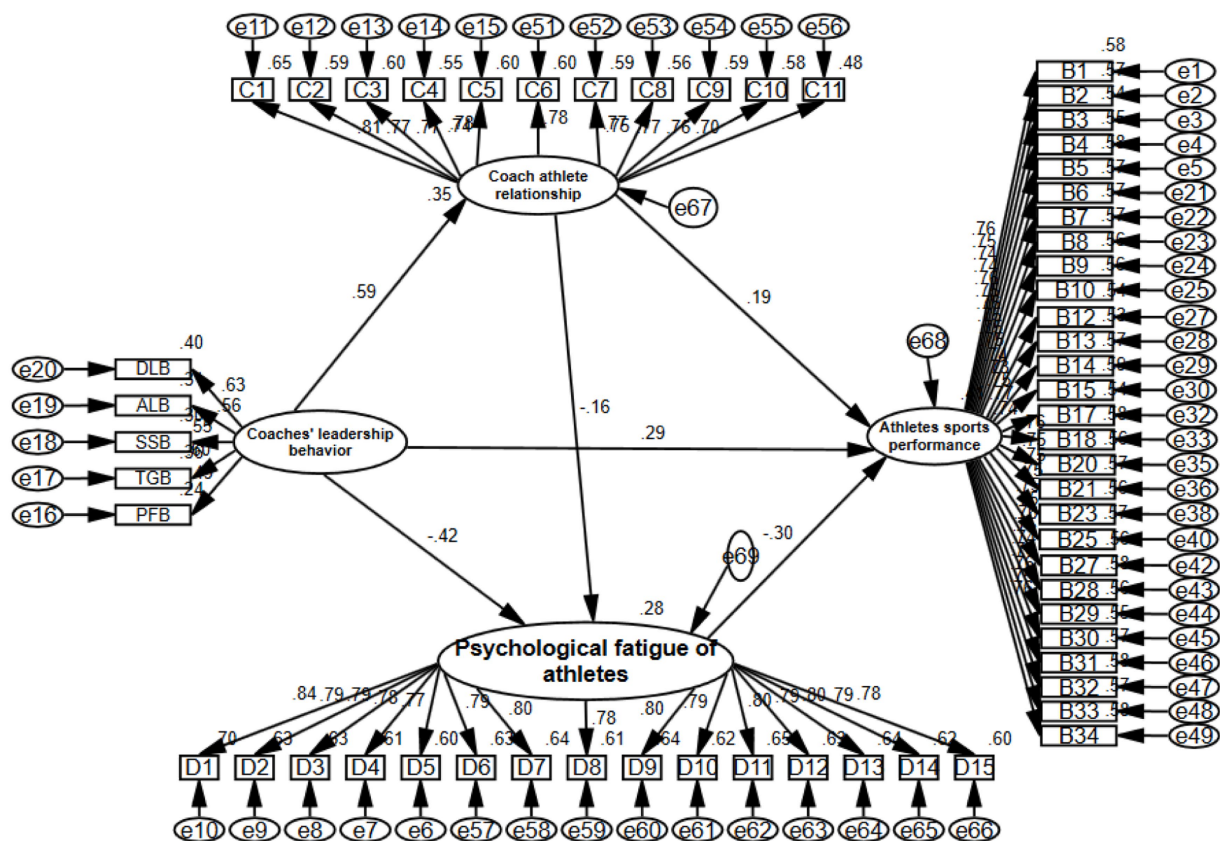


FIGURE 1

Chain mediation model diagram of the “Coach-Athlete” relationship and psychological fatigue. DLB (Democratic leadership behavior); ALB (Authoritarian leadership behavior); TGB (Training guiding behavior); SSB (Social support behavior); PFB (Positive feedback behavior).

their potential athletes' sports performance through profound introspection. This introspection stems from coaches leading athletes through encouragement and rewards under the influence of democratic leadership behavior (Smith et al., 2007), which has a significant impact on athletes' individual psychology and cognition, especially through the “coach-athlete” relationship (Zhu et al., 2017), exerting a notable indirect influence that fosters athletes' psychological admiration for coaches and enhances athletes' sports performance through self-reinforced skill levels (Guo et al., 2021). Authoritarian leadership behavior emphasizes athletes' development of athletic levels under the guidance of coaches' predetermined training plans, with athletes' sports performance closely linked to the rationality of these plans (Wang, 2023). Additionally, research points out that long-term stable and scientific training guidance behavior is the most direct and highly relevant factor for improving athletes' engagement in sports (Cai and Wu, 2013) and achieving excellent results through high-level athletes' sports performance. This leadership behavior can have an incentive and internalizing effect on athletes (Zhan, 2016). Furthermore, research on coaches' social support behavior indicates that coaches create an incentive atmosphere that positively promotes athletes' psychological, emotional, and behavioral aspects, thereby enhancing their athletes' sports performance (Cai, 2016). In this incentive atmosphere, coaches' positive feedback behavior is crucial for guiding the development of athletes' sports performance, better helping athletes psychologically engage in training and competitions

(Cai, 2016) to fully leverage their athletic abilities. Even athletes with stronger abilities to receive positive feedback behavior from coaches can, to some extent, exceed their usual levels of athletes' sports performance. Therefore, coaches should properly handle the relationship between leaders' behaviors in the process of coaching, and help improve sports performance scientifically. In summary, coach leadership behavior is a significant factor influencing athletes' sports performance, and there is a positive predictive relationship between each dimension of coach behavior and athletes' sports performance. Therefore, hypotheses H1a-H1e are supported.

5.2 The mediating role of the “coach-athlete” relationship

The research findings support hypotheses H2a-H2e, indicating that the “coach-athlete” relationship has a significant positive impact between the five sub-dimensions of coach leadership behavior and athletes' sports performance. This suggests that a higher level of coach leadership behavior leads to a better “coach-athlete” relationship and, consequently, better athletes' sports performance. Conversely, poorer leadership results in a worse relationship and performance. These findings align with previous research (Cao and Cao, 2021; Jin et al., 2022). Meanwhile, studies have confirmed that athletes' high levels of engagement in sports are due to the positive influence of coach

leadership behavior, mediated by a good “coach-athlete” relationship (Liu, 2014). The study also points out that coaches’ behaviors in guiding athletes’ training and providing necessary social support behavior for their athletic development can promote athletes’ engagement in sports. The impacts of democratic, authoritarian, and positive feedback behaviors on athletic engagement need to be realized through the “coach-athlete” relationship. In fact, research results from Yang (2007), Ban and Chen (2013), and Nicholls and Perry (2016) demonstrate a significant positive correlation between coach leadership behavior and the “coach-athlete” relationship, meaning that better coach leadership leads to a better “coach-athlete” relationship, ultimately affecting the development of athletes’ sports performance. The aforementioned research indicates that democratic leadership behavior is conducive to improving the quality and enhancing the quality of the “coach-athlete” relationship. Coach leadership can positively predict the three dimensions of the “coach-athlete” relationship, benefiting the development of athletes’ sports performance. However, it also points out that an unreasonable “coach-athlete” relationship is not only an indirect manifestation of poor leadership behavior but also an obstacle to the development of athletes’ sports performance. If some research points out that under the influence of good relationship, athletes are more willing to express their personal demands, form a strong sense of goal commitment, and are willing to work hard to achieve more ideal competitive performance (Ye et al., 2016a,b). With the positive development of the “coach-athlete” relationship, a harmonious cooperative environment forms between the two main entities in sports practice, effectively gathering positive factors that can enhance athletes’ sports performance, such as psychological positive guidance and training resource investment (Lefebvre et al., 2021), thereby promoting the development of athletes’ sports performance. Therefore, in the future training practice, relevant departments should attach importance to the cultivation of “coach-athlete” relationship and adopt various ways to promote the good development of this relationship, specifically, through gratitude and forgiveness, interpersonal management and conflict mediation. In summary, each sub-dimension of coach leadership behavior can influence athletes’ sports performance through the “coach-athlete” relationship, meaning that there is a positive predictive relationship between the five dimensions of coach leadership behavior and athletes’ sports performance, mediated by the “coach-athlete” relationship. Therefore, hypotheses H2a-H2e are supported.

5.3 The mediating role of psychological fatigue

The research findings support hypotheses H3a-H3e, indicating that psychological fatigue has a significant negative impact between the five sub-dimensions of coaches’ leadership behaviors and athletes’ performance. This suggests that higher levels of coaches’ leadership behaviors are associated with lower psychological fatigue and better athletes’ sports performance, and vice versa. These results align with the findings of Zhang et al. (2023), Sarason et al. (1990), and Raedeke and Smith (2004), demonstrating that different dimensions of coaches’ leadership significantly negatively predict athletes’ psychological fatigue. Altahayneh (2003) and Guo et al. (2021) argue that coaches’ leadership behaviors are crucial factors influencing athletes’ psychological fatigue. Furthermore, different dimensions of coaches’ leadership behaviors serve as reliable predictors of psychological

fatigue. Good coaches’ leadership behaviors are often associated with better psychological positivity, which can reduce athletes’ psychological fatigue. Conversely, high psychological maladjustment is linked to poor leadership behaviors, leading to increased feelings of psychological fatigue and subsequently affecting athletes’ sports performance development. Additionally, athletes are more likely to be influenced by interpersonal and linguistic environments, where negative messages increase their psychological burden and heighten feelings of psychological fatigue (2006). The study also found that among high-level athletes, irregular training organization, inhumane personnel management, inability to communicate with coaches, and insufficient psychological support are significant factors contributing to increased psychological fatigue. This is attributed to coaches’ authoritarian leadership behaviors. Conversely, athletes with low psychological fatigue often achieve success under the guidance of positive leadership behaviors, which in turn enhances their athletes’ sports performance. These studies suggest a close correlation between psychological fatigue and coaches’ leadership behaviors, with psychological fatigue being a key factor in negatively predicting coaches’ leadership behaviors (Levy et al., 2009; Curtin, 2020; Cahyono et al., 2023). The research also shows that psychological fatigue is the key factor to reduce sports performance. Therefore, in the future practice, athletes themselves can reduce psychological fatigue through self-suggestion, while coaches can reduce athletes’ psychological fatigue by guiding athletes’ attention shift, or chatting and mediation, thus laying the foundation for improving athletes’ sports performance. Athletes with high levels of psychological fatigue cannot affirm their competitive abilities, thereby decreasing their performance, while those with low levels of psychological fatigue have a stronger desire for athletes’ sports performance. Therefore, athletes’ psychological fatigue can effectively reflect their level of athletes’ sports performance (Russell et al., 2019; Pageaux and Lepers, 2018; Habay et al., 2021). Other studies have found that different dimensions of coaches’ leadership behaviors can indirectly affect athletes’ sports performance through psychological fatigue. Zhang and Price agree that coaches’ leadership behaviors are effective predictors of psychological fatigue and, in turn, have a negative impact on athletes’ sports performance (Zhang et al., 2023; Price and Weiss, 2000). Meanwhile, research confirms that an increasing number of athletes experience elevated psychological fatigue due to coaches’ improper leadership behaviors, prompting athletes to seek positive improvement methods to alleviate their psychological fatigue and enhance their athletes’ sports performance (Barcza-Renner et al., 2016). In summary, the sub-dimensions of coaches’ leadership behaviors can influence athletes’ performance through psychological fatigue, indicating a negative predictive role of psychological fatigue between the five dimensions of coaches’ leadership behaviors and athletes’ performance. Therefore, hypotheses H3a-H3e are supported.

5.4 The chain-mediating role of the “coach-athlete” relationship and psychological fatigue in the relationship between coaches’ leadership behaviors and athletes’ sports performance

The research findings support hypothesis H4, indicating that the “coach-athlete” relationship and psychological fatigue have a significant chain-mediating effect between coaches’ leadership

behaviors and athletes' performance. This suggests that under the guidance of good coaches' leadership behaviors, it is more likely to establish a positive "coach-athlete" relationship, effectively reduce psychological fatigue, and subsequently improve athletes' performance. The reverse is also true. As previous studies have confirmed, the "coach-athlete" relationship and psychological fatigue are mediators in the relationship between coaching leadership behavior and athlete performance. Moreover, existing research has shown a correlation between the "coach-athlete" relationship and psychological fatigue, indicating that better coach-athlete relationships negatively impact athletes' psychological fatigue, while poor coach-athlete relationships increase psychological fatigue (McGee and DeFreese, 2019; Davis et al., 2018). These findings, which align with the results of this study, further confirm the correctness of the research hypothesis. Additionally, previous research has also confirmed the correlation between the "coach-athlete" relationship and psychological fatigue, showing that better relationships reduce psychological fatigue, while poor relationships increase it. Furthermore, studies have found that improving the coach-athlete relationship not only reduces psychological fatigue but also enhances athletic performance. This highlights the fact that effective coaching leadership behavior can promote a harmonious coach-athlete relationship, leading to a reduction in psychological fatigue and, in turn, improving performance. Therefore, coaching leadership behavior can influence athlete performance through the chain mediation effect of the "coach-athlete" relationship and psychological fatigue, thus supporting the validity of hypothesis H4.

6 Conclusions and practical implications

This study demonstrates that coaching leadership behaviors, encompassing democratic leadership behavior, authoritarian leadership behavior, training guiding behavior, social support behavior, and positive feedback behavior, are positively correlated with the "coach-athlete" relationship and athletes' sport performance, while negatively correlated with psychological fatigue. The research indicates that coaches with better leadership behaviors are more likely to facilitate athletes' sport performance by establishing positive "coach-athlete" relationships and simultaneously reduce athletes' psychological fatigue. Notably, this study finds that both the "coach-athlete" relationship and psychological fatigue can independently or sequentially mediate the relationship between coaching leadership behaviors and athletes' sport performance.

This research carries several practical implications: First, it emphasizes the importance of coaching leadership behavior in the development of athlete performance, providing psychological strategies for athlete development in different coaching leadership behaviors or coaching contexts. Second, it offers insights into coaches' individual psychological mechanisms, furnishing methods and ideas for evaluating coaches and even the development of sports teams. Third, the findings of this study also have implications for the development of sports practice, aiding in identifying and addressing declines in sport performance caused by the "coach-athlete" relationship and individual athletes' psychological fatigue. Fourth, the results suggest that the standardized use of coaching leadership

behaviors, coupled with the harmonious development of the "coach-athlete" relationship, may help reduce psychological fatigue, enhance sport performance, and achieve more efficient competitive performance.

This study expands the theoretical framework of the relationship between coach's leadership behavior and athletes' sports performance, and shows that coach's leadership behavior not only directly affects sports performance, but also indirectly affects through coach-athlete relationship and psychological fatigue. This discovery is of great significance to psychology and competitive sports, and enriches the understanding of how coaches' leadership behavior affects athletes' sports performance. Future research can explore other potential intermediary factors, such as self-efficacy and motivation, to further clarify the relationship mechanism between coaches' leadership behavior and athletes' sports performance. In addition, cross-regional research can help to understand how different cultural differences affect this relationship, thus ensuring verification in different regions. With the development of AI, future research can use these technologies to provide more accurate strategies to enhance athletes' performance.

7 Limitations and future directions

Although this study contributes to the exploration of coaching theory and practice, it does have some limitations. First, in terms of the sampling method, the lack of random sampling may limit the generalizability of the study's findings. Additionally, due to geographical limitations, the study was restricted to only two provinces, and did not take into account potential external influences such as differences in sports habits, culture, or economics. As a result, the study's findings may not have fully considered the impact of these external factors. Second, this study only used a cross-sectional design, which lacks strong evidence for causal inferences and does not account for potential biases inherent in cross-sectional research. Third, as the data collection primarily relies on self-reported measures, there may be subjective biases that reduce the evidential support for the study's results.

To address these limitations, first, our next step in research will focus on collecting samples based on various demographic characteristics to enhance the generalizability of the findings. Given the numerous provinces in China and the significant differences between the north and south, east and west, there may be potential factors influencing the research process. Therefore, our future research will emphasize considering these aspects and conducting deep and detailed investigations. Second, in our future studies, we will adopt more objective sample measurement standards to enhance the scientific level of sample collection and processing. For example, with the development of science and technology, we can use new technology to collect and measure objective performance or data obtained through observation, thus further increasing the depth of research. Third, from the perspective of long-term sports development, time may be an important factor influencing the improvement of athletic performance. Therefore, future research will use longitudinal surveys to collect samples and examine the impact of coaching leadership behaviors on athlete performance during the process of change. This will make causal inferences more convincing.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Review Committee of Chengdu Sport University (Approval No CTYLL2024004). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RL: Data curation, Visualization, Writing – original draft, Writing – review & editing. SW: Supervision, Writing – review & editing. JL: Data curation, Software, Validation, Visualization, Writing – review & editing, Investigation, Resources.

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Does becoming a parent reduce sports participation? A longitudinal study of short- and long-term effects

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Introduction: Parenthood can have a negative effect on sport behaviour despite the known health benefits of participation in sports. Recent studies have shown that becoming a parent is related to a reduction in exercise. However, this relationship is less clear for men than women. In addition, most studies only focused on short-term effects. Therefore, it is unknown whether these effects remain prevalent one year after becoming a parent.

Method: Using twelve data waves of the Dutch Longitudinal Internet studies for the Social Sciences (LISS) panel, we examined the influence of becoming a parent on sport behaviour in the short- (<1 year) and long-term (>1 year). Given the known differences between men and women, we also examined possible gender differences in this change. Multilevel logistic regression of the data of 6,276 observations for 725 respondents showed that the short- and long-term effects of becoming a parent have different implications for the sport behaviour of men and women.

Results: While men's participation in sports is not affected by parenthood, women initially stop participating in sports, but they start again after one year. Additionally, women's frequency of engagement in sports is reduced when they become mothers. In contrast, the frequency of sport engagement is not affected when men become fathers. From a resource perspective, the results show how limited time and energy can differentially affect the sport behaviour of men and women after they become parents.

Discussion: Together with the different pathways of sport participation in the short- and long-term, these results can inform the development of interventions aimed at sustainable physical activity for new parents.

KEYWORDS

parenthood, sport participation, sport behaviour, gender differences, longitudinal data

1 Background

1.1 Relevance and research question

Our society has reached a pinnacle in physically inactive behaviour, which affects people in all age groups and from all socioeconomic levels (1). An inactive lifestyle contributes to increased health issues, decreased participation in society, work disability, and social isolation (2–4). Sustainable improvement of the level of physical activity in society is therefore important (5). A way to study this is to focus not on why people start participating in sports but instead why they stop.

There is evidence that during major life transitions, such as the transition from primary to secondary school or into parenthood, sport participation changes (6, 7).

Most, but not all, studies show that during these transitions, the frequency of sport participation decreases or that people stop playing sports (8). However, some studies suggest that the impact of life transitions is more subtle (7). People do not decrease their frequency of sport participation or stop playing sports but rather change their sport behaviour, for example, from participating in team sports to participating in individual sports.

To promote an active society, the transition into parenthood might be the most important focus. First, the evidence for the negative impact of this transition on sport behaviour is the most pronounced compared to those of other life transitions, such as the transition from primary to secondary education, getting married, starting the first job or moving (8). In addition, the sport behaviour of parents has a large influence on the sport behaviour of their children (9, 10). Finally, when children participate in sports during childhood, they are more likely to continue their sport behaviour later in life (11, 12). Therefore, understanding the short- and long-term effects of becoming a parent on sport behaviour can provide valuable insights into promoting a sustainable active society.

The majority of recent review studies (8, 13, 14) examining the influence of parenthood on physical activity have focused on nonsport activities (such as commuting or gardening). Although the main outcomes indicate that becoming a parent is related to a decrease in physical activity, this relationship is less clear for men than for women (8). In addition, most longitudinal studies have focused on the effects within the first year after childbirth (8, 13, 14). Therefore, it is unknown whether these effects remain constant after a longer period of time. In this study, we used longitudinal data up to twelve years to examine the impact of becoming a parent on sport behaviour. Using twelve waves of the representative Dutch LISS panel with 165 persons who became parents during the data collection period, we filled the abovementioned knowledge gaps by (1) examining the influence of becoming a parent on sport behaviour in the short (<1 year) and long term (>1 year) and (2) focusing on the possible gender difference in this sport behaviour. Consequently, the main question this study sought to answer was as follows: How does the sport behaviour of people who become parents change in the short and long term, and does this change differ between men and women?

1.2 Theory and hypotheses

1.2.1 Short-term effects: limited resources

When (social) action is viewed from a resource perspective (15–17), becoming a parent reduces the number of resources for sport participation since being a parent leads to scarce time (and energy) resources (18). Alternatively, people may perceive that they have less time or energy for sports (19). Since playing a sport is a relatively informal and optional activity, the experience of time pressure leads to individuals giving up this activity when more formal and obligatory tasks require attention, such as childcare (20). This is the most likely explanation for the decrease in sport behaviour that was found in previous studies

(8, 14, 21). Consequently, we expected to find a similar immediate decrease in both sport participation (Hypothesis 1a) and the frequency of sport participation (Hypothesis 1b).

In addition to this general decrease, we expected to observe gender differences. In general, women participate less in sports than men (22). Although parenting is becoming more equal between fathers and mothers, in western societies, there is still a large difference in childcare responsibilities between men and women, where women have (many) more responsibilities (23). As a result of this unequal distribution, mothers have less free time (24); hence, the time available for mothers to play sports is reduced compared to that for fathers (25). In addition, women have to give birth, which is physically demanding. Although from a gynaecological point of view, women are considered to be recovered six weeks after giving birth (26), it could take much longer to become fit enough to participate in sports again (27). Therefore, we expected that the decrease in sport participation (Hypothesis 2a) and the frequency of sport participation (Hypothesis 2b) would be more pronounced for women than for men.

Regardless of gender, the time restraints after becoming a parent do not automatically mean that people cease their sport participation altogether. They could also lead to a change in sport behaviour (7). Team sports, such as volleyball and football, are more time restricting due to fixed, and often mandatory, training times and sessions. In contrast, individual sports that can be performed at home, such as running and cycling, can be done whenever one prefers, without any restrictions or obligations (28). Although sports clubs—and especially team sports—have social value (e.g., friendships and fun) (29, 30), this often does not outweigh the time demands (7). Consequently, we expected parents to shift from team sports to more individual types of sports (Hypothesis 3).

1.2.2 Long-term effects: resources and cultural barriers

While the direct impact of parenthood may reduce the time for and prioritization of sports, the decrease in sport behaviour can take place over time. That is, as children grow older, they become more independent, especially when they start attending primary school. With this, the main tasks of parents shift from caring to educating (31). In addition, parenting becomes different over time; while in the beginning of parenthood, everything is still new and exciting, time and experience could make parenting come more naturally (32, 33). This could indicate that parents gradually have more time for themselves. Thus, we expected a rebound effect indicating that parents' sport participation (Hypothesis 4a) and frequency of sport participation (Hypothesis 4b) would increase as their children grew older.

In addition, we anticipated gender differences in this rebound effect, which should be opposite to the gender effect expected in the short term. First, because women are expected to have a larger decrease in sport participation and the frequency of sport participation in the short term, larger possibilities for the rebound effect result in the long term. Moreover, we anticipated that some of new mothers would stop participating in sports due to physical problems caused by pregnancy or giving birth (27).

The majority of these physical problems would disappear or diminish over time, resulting in an increased ability to participate in sports. Consequently, we expected that the rebound effect would be more pronounced for women than for men (Hypothesis 5).

Although we believed that the resources of parents for sports would increase over time, it seemed unlikely that this would result in increased participation in team sports, given the previously mentioned demands of this type of sport (28). It could be expected that parents would still want or require the flexibility to schedule their sport activities to include them into their other daily or weekly routines. These routines often do not overlap with the specific times of practices and games for team sports. Hence, we expected that as children got older parents will switch from team sports to individual sports (Hypothesis 6).

2 Methods

2.1 Data

The present study used the Longitudinal Internet Studies for the Social Sciences (LISS) panel developed by CentERdata (Tilburg University, The Netherlands), which can be freely downloaded from <https://www.lissdata.nl/>. The LISS panel started in 2007 and is based on a true probability sample of households from the Netherlands drawn from the population register by Statistics Netherlands. The LISS panel involves an internet-based panel that uses incentive payments to increase the response rate. Approximately 80% of the eligible persons living in the registered panel households participate in the panel (34). The monthly response rate of these participants varies between approximately 50% and 80%, depending on the questionnaire and month.

A study of the representativeness of the LISS panel in the first year after recruitment showed that some specific groups, for example, elderly women and nonwestern first-generation immigrants, were initially somewhat underrepresented in the LISS panel (35). Another study compared the composition of the LISS panel between April 2008 and April 2010 with the Dutch population (36), showing the same underrepresentation.

The respondent attrition rate is approximately 12% per year, and the household attrition rate is 10% per year. Descriptions of which specific demographic groups have especially high or low probabilities of becoming inactive or dropping out are given by De Vos (36, 37). To address attrition, new representative samples were drawn from the Dutch population in 2009, 2011, 2013 and 2014 to have enough respondents who reflect the Dutch population regarding (1) household type, (2) age, and (3) ethnicity.

2.2 Respondents

For the period 2008–2019, we used the individual-level data for the head of the household from the LISS “background variables” (LISS project number 1) “social integration and leisure” (LISS project number 4), “family and household” (LISS project

number 5) and “work and schooling” (LISS project number 6) modules, which were collected yearly.¹ We only selected the head of the household since this household member completed most of the LISS questionnaires. In addition, we only selected respondents who filled out each module at least two times without any missing values for the variables described below, resulting in 725 respondents and 6,276 observations, ranging from 2 to 12 measurement points with a mean of 6.967 and an SD of 3.289.

2.3 Measures

2.3.1 Dependent variables

To determine if participants *participated in sports*, we used the question ‘Do you practice sports?’ from the social integration and leisure module. This question could be answered as yes (1) or no (0). The mean of this question across all waves was .723, and the SD was .447.

When respondents indicated that they participated in sports, they were asked ‘How many hours do you spend playing sports per week, on average?’. This question was used to measure respondents’ *frequency of sport participation*. To be able to include nonplayers in the frequency of sport participation analyses, their scores were set to zero (0). The distribution of the number of hours spent playing sports was extremely right skewed, making these data unfit for linear regression analysis. To account for the variety in the frequency of sport participation, we recoded the number of hours spent playing sports into 4 categories: 0 h (27.69%), more than 0 and less than 2 h (12.01%), 2 or more hours and less than 4 h (31.04%) and 4 or more hours (29.25%).²

Respondents who indicated participating in sports were asked which sport they practiced. They could choose a maximum of three sports from a list of seventeen sports plus the option ‘other’. While the questionnaire did not include all 48 sports commonly listed in sport research guidelines, it covered the 17 most popular sports in the Netherlands. Less than 2% of respondents reported participating in sports not listed, which were excluded from the analyses. We reduced these seventeen sports to the categories *team sports* (football, handball, volleyball and indoor football; 9.38%), *individual sports at a sport centre* [badminton, squash, gymnastics, swimming, tennis, golf, fitness and music sports (aerobics, Zumba, etc.; 43.77%)], this category encompasses both sport clubs and commercial sport providers. And *individual sports at home* (running, cycling and walking; 36.31%). Because respondents could choose more than 1 sport, the percentages do not add up to 100. Our classification refines

¹In addition to the unique respondent and household numbers, checks on gender, date of birth and, if applicable, birth year of children, were used to make sure that the data from the same respondent was used in all waves and modules. A syntax for merging the datasets is provided in the supplementary materials.

²We performed robustness checks with the numbers and classifications of the categories, resulting in the same conclusions.

the approach by Van Houten et al. by distinguishing between team sports, individual sports at a sports center, and individual sports at home, based on resource demands such as subscription requirements and the effort needed to attend a sport location (7).

2.3.2 Independent variables

After asking the question ‘Do you have children?’, which was asked in all waves, we used the question “In which year were the child(ren) born?” to determine if a respondent had *become a parent (again)* between the two waves of the survey. This occurred 165 times (2.63% of the observations) between two waves.

To measure the *number of years after having a child*, we subtracted the year of birth of the last child born from the year in which the questionnaire was administered. This means that someone who became a parent (again) between 2 waves started again at 0.³ In addition, for these variables, we could only include respondents who were parents, resulting in data from 449 respondents. The number of years after the birth of the last child across all waves ranged between 0 and 49 with a mean of 14.415 and an SD of 10.225.

2.3.3 Control variables

We included the *age* of the respondents across all waves, which ranged from 16 to 84 years, with a mean of 44.051 and an SD of 13.870. Furthermore, we indicated if a respondent was *male* (46.69%) or *female* (53.31%) and if they had a *partner* (76.93%) or not (23.07%). Educational level was determined as the *highest completed educational level* in the year the questionnaire was administered. We included this educational level as the theoretical age at which respondents finished their education, ranging from 0 (no education at all) to 28 (PhD completed), with a mean of 19.89 and an SD of 3.034. Finally, we included the number of average *working hours* per week, ranging from 0 to 80 h, with a mean of 19.025 and an SD of 18.502.

The descriptive information of all variables can be found in [Supplementary Table A1](#).

2.4 Data analysis

2.4.1 Statistical methods

Our data are characterized by a multilevel structure: measures over time (years) are nested in respondents (38). Therefore, we used a two-level approach in which the yearly measures were nested within the respondents (39). In addition, we used three different dependent variables: (91) sport participation, (2) the frequency of sport participation and (3) the types of sports. The first and the last were dichotomic (0 1) variables; hence, to test our hypotheses concerning sport participation and types of

sports, we used the multilevel logistic regression command “xtlogit” with robust standard errors in STATA 15.1.⁴

To test our hypotheses concerning the frequency of sport participation, which was an ordinal variable (0 h, >0 h & <2 h, ≥2 h & <4 h, ≥4 h), we performed multilevel random-effects ordered logistic models using the “xtologit” command with robust standard errors in STATA 15.1. An ordered logit uses the ranked categories of a Likert scale to create thresholds (41).⁵ The coefficients from this estimate provide the direction of change and significance but not the absolute magnitude.

2.4.2 Model construction

We focused on the short-term and long-term effects of becoming a parent. Due to collinearity issues, the long-term effects could only be measured among people with children. Therefore, the short-term effect models were based on all respondents ($n = 725$) and focuses on the period of the first year of the newborn child’s life. The long-term effect models were based on respondents with children ($n = 449$), and focuses on the period from when the last born child is 1 year old. The model structure was virtually the same for all types of analyses. We started with a complete model without interaction terms. For the models regarding the short-term effect, we included the variable *becoming a parent (again)* and all control variables (Model 1). In the subsequent model (Model 2), the interaction term *becoming a parent * female sex* was added in addition to the already included variables. For the long-term effect models, we replaced the variable *becoming a parent (again)* by *the number of years after having a child*. We added the interaction terms *the number of years since becoming a parent * female sex*.

3 Results

3.1 Sport participation in the short term

[Table 1](#) shows the results of the multilevel logistic regression analyses on sport participation. We test our hypotheses one-

³We performed robustness checks for the birth of the first ($n=66$), second ($n=67$), and third ($n=27$) child. It appeared that this did not affect the effect size. However, due to the lower numbers, we observed higher standard errors. Nevertheless, we concluded that our data did not show a different effect for the birth of the first, second or third child.

⁴The conventional multilevel logistic regression model incorporated cluster-specific random effects to account for the within-cluster correlation of subject outcomes: $\text{logit}(\Pr(Y_{ij}=1)) = \alpha_0 + \alpha_{0j} + \alpha_1 X_{1ij} + \dots + \alpha_k X_{kij} + \beta_1 Z_{1j} + \dots + \beta_m Z_{mj}$ where $\alpha_{0j} \sim N(0, \tau^2)$. The assumption was made that the random effects were independent of the model covariates (X, Z) (40).

⁵In this instance, the dependent variable y was established as an ordered categorical dependent variable, with the values of 1, 2, 3 and 4 as the ranked (in order of the increasing weekly frequency of sport participation) categories. Using k to represent the thresholds, a rank was established as *If $y^* < k_1$ then $y=1$, If $k_1 < y^* < k_2$ then $y=2$ and so on until If $k_3 < y^* < k_4$ then $y=4$ and y^* was a latent variable (41). The probability of each rank outcome j could then be estimated as follows: $\Pr(y_j=j) = \Pr(k_{j-1} < \beta X_i + u_i < k_j)$ (41). This showed that the probability of a particular outcome j being chosen was dependent on βX_i falling between the thresholds k_j and k_{j-1} for each individual (41).*

TABLE 1 Multilevel logistic regression on sport participation.

	Model 1					Model 2				
	Odds ratio	Std. Err.	95% CI		<i>p</i>	Odds ratio	Std. Err.	95% CI		<i>p</i>
Becoming parent										
Not a parent as the reference	0.678	0.142	0.449	1.022	0.063	1.177	0.426	0.579	2.391	0.653
Sex										
Male as the reference	0.594	0.100	0.427	0.828	0.002	0.610	0.103	0.438	0.851	0.004
Becoming a parent * female sex						0.403	0.182	0.166	0.977	0.044
Age	0.976	0.006	0.963	0.988	0.000	0.976	0.006	0.963	0.988	0.000
Educational level	1.016	0.024	0.970	1.065	0.507	1.016	0.024	0.969	1.065	0.510
Partner										
No partner as a reference	1.023	0.170	0.739	1.417	0.889	1.028	0.171	0.743	1.424	0.867
Working hours	1.001	0.004	0.993	1.009	0.773	1.001	0.004	0.993	1.009	0.797
Constant	14.201	9.132	4.027	50.082	0.000	13.970	9.010	3.947	49.449	0.000
Variance										
Within individuals	1.832	0.078				1.832	0.078			
Between individuals	1.211	0.085				1.211	0.085			
Log pseudolikelihood	−3,081.33					−3,079.35				

Source: LISS 2008–2019. *N* = 6,276, parents = 725.

Bold values have a significant effect $p < 0.1$.

tailed, because we have directed hypotheses. This means that the p value can be divided by 2, so we call a p value of 0.1 significant. Model 1 showed, in accordance with Hypothesis 1a, that becoming a parent resulted in a smaller likelihood of participating in sports (OR.678) than not becoming a parent. Moreover, the likelihood of women participating in sports was almost half that of men (OR.594). Furthermore, it appeared that age influenced sport participation, with increasing age leading to a smaller chance of participating in sports (OR.976). The other control variables did not significantly affect sport participation.

In Model 2, the interaction term *becoming a parent * female sex* was added to determine the effect of becoming a parent for men and women. It appeared that, in accordance with Hypothesis 2a, the effect of becoming a parent was much smaller for men than for women. Figure 1 shows this effect graphically. Men without children were the reference group, with an odds ratio of 1. Men who became fathers had a higher likelihood of participating in sports (OR 1.177); however, this effect was not significant. The likelihood of women without children participating in sports was almost 40% lower (which is the main gender effect, $b = -0.494$ and OR = 610). However, the

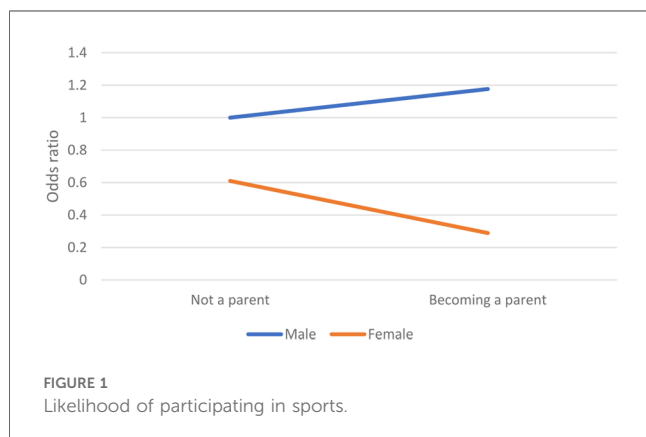
likelihood of women who became mothers was even smaller (this was the main gender effect $b = -0.494$ + the interaction term $b = -0.910$ results in a $b = -1.404$ with an OR of 0.289). Hence, the effect of becoming a parent on sport participation was more than five times larger for women than for men.

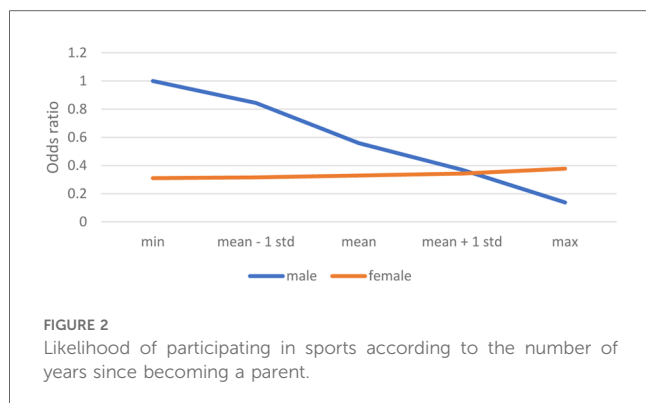
3.2 Sport participation in the long term

Supplementary Table A2 shows the results of the multilevel logistic regression analyses on sport participation with the variable the *number of years after having a child* included instead of the variable becoming a parent. It appeared that in Model 1, only women seemed to have a smaller likelihood of participating in sports than men (OR.555). In contrast to our expectation formulated in Hypothesis 4a, the number of number of years since becoming a parent did not significantly affect the likelihood of participating in sports. However, from Model 2, it appeared that the interaction variable the *number of years since becoming a parent * female sex* had a significant effect, which is graphically shown in Figure 2. Men with 0 years since becoming a parent were the reference category, with an OR of 1. While the likelihood of men's sport participation seemed to decrease over the years after they had become a parent, this effect was not significant. In contrast, women's likelihood of sports participation increased little, but significantly over time (the OR increased from.310 to.378). Hence, the data showed no overall rebound effect of sport participation after having a child, but they did show a rebound effect only for women, which is in accordance with Hypothesis 5.

3.3 Frequency of sport participation in the short term

Supplementary Table A3 shows the results of the multilevel random-effects ordered logistic models. The first model showed



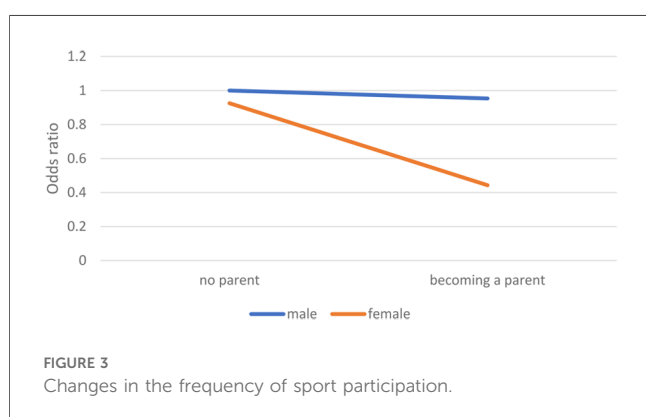


that, in accordance with Hypothesis 1b, becoming a parent resulted in a decreased likelihood of a higher frequency of sport participation (OR.663). In addition, and similar to the effect on sport participation, women had a much smaller likelihood than men (OR.451). Finally, the control variables indicated that with increased age, the likelihood of a high frequency of sport participation decreased, whereas the odds increased when people had a partner.

In Model 2, as shown in [Supplementary Table A3](#), we included the interaction variable *becoming a parent * female sex*, which is graphically represented in [Figure 3](#). Again, men without children were the reference category, with an OR of 1. Becoming a parent had a small negative but nonsignificant effect on the likelihood of men's frequency of sport participation. For women, however, the effect of giving birth on the frequency of sport participation was significant and much larger. Women who did not have children had an OR of .925, and they participated in sports slightly less frequently in comparison to men who did not have children. Women who had children, however, had an OR of .443, which was much lower. This gender difference is in accordance with Hypothesis 2b.

3.4 Frequency of sport participation in the long term

[Supplementary Table A4](#) shows the possible rebound effect of the number of years since becoming a parent on the frequency of sport participation. It appeared that there was no general rebound effect



(Model 1) or gender-specific rebound effect (Model 2) for the frequency of sport participation, as predicted in Hypotheses 4b and 5. It only appeared that women had a much smaller likelihood of a high frequency of sport participation compared to men.

3.5 Types of sports played in the short term

Finally, we analysed the effect of becoming a parent on the types of sports played in the short term and in the long term. The models of the multilevel logistic regression analyses are shown in [Supplementary Table A5](#). In the short term, we found that becoming a parent had a negative effect only on the likelihood of participating in sports at home (OR.549) and not on team sports or individual sports at another location. Hence, there was no evidence supporting Hypothesis 3, which predicted that team sports would become less popular and individual sports would become more popular. In addition, women also had a smaller likelihood of participation in team sports (OR.050). Having a partner significantly increases the odds of participating in team sports (OR 1.925).

3.6 Types of sports played in the long term

For long-term effects, when the number of years since becoming a parent was included in the analysis ([Supplementary Table A6](#)), we observed a significant effect of this variable on the likelihood of participating in team sports. The more years since the birth of a child, the lower the likelihood of participating in team sports (OR.851), which was in accordance with Hypothesis 6. However, we did not see a significant increase in participation in individual sports over time. In addition, we also observed a lower likelihood of women participating in both team sports (OR.112) and individual sports at home (OR.532). It appeared that having a partner more than doubled the likelihood of participating in sports at home (OR 2.165) than when someone had a child but no partner.

4 Discussion

4.1 Sport participation and the frequency of sport participation in the short term

In general, men participate in sports more than women (42, 43). Our results show that there is a gender difference for new parents and confirm that the transition into parenthood leads to a short-term decrease in sport participation and the frequency of sport participation only among mothers. This finding is in line with most of the previous literature showing that decreases in physical activity or sport participation and the frequency of sport participation are most pronounced for women (7, 8). Interestingly, while fatherhood does seem to result in a decrease in overall physical activity (14, 44), our results indicate that this is not caused by a decrease in sport behaviour. This finding may suggest that men still have enough resources for sports, despite

the time and energy required by the newborn child, which may have several explanations. One possible explanation may be that men prioritize sports over other leisure time activities. For example, men use active transportation (walking and biking) less often than women (45). As a result, men may decrease their overall physical activity but may save time that can be spent participating in sports. Another, methodological, reason could be the use of different measuring instruments. What is considered sport and what is considered physical activity can differ between different studies. For example, In our study walking is considered as a sport. In the Netherlands walking is a fairly big sport where people go on walking tours to earn certificates and medals. It is therefore not strange to consider walking as a sport in the Dutch context. However, in other countries this could not be the case and walking could be seen as a leisure activity and not a sport. To exclude this discrepancies, future studies should simultaneously study sport and exercise behaviour. However, this does not explain the gender difference we found. This difference between men and women may also reflect the persistent cultural gender difference in childcare responsibilities (46, 47). Finally, the decrease in sport participation and the frequency of sport participation seen in women could also be related to the physical challenges that women experience after childbirth (27).

4.2 Sport participation and the frequency of sport participation in the long term

This study is, to our knowledge, unique because we tracked sport behaviour up to twelve years after a child is born. For women, we found a small but significant effect that they started playing sports again when their child(ren) grew older. This provides support for the arguments that the time demands of parenting may decrease over time (32, 33) and that the physical changes caused by pregnancy and childbirth that women may experience are diminished (27). This is also in line with the study of Hamilton and White (48), who describe that parenthood also offers new opportunities to become active. In contrast, the sports participation of men seems marginally affected as children grow older, which may be partially explained by the lack of a decrease in sports participation in the short term. However, even if women start (again) with sports when the children are older, they lag behind enormously compared to the sports behaviour of men. This suggests that cultural norms and values where women have to take care of the children (46, 47) and/or sports is mainly for men (58) have a great influence.

Surprisingly, we did not find any long-term effect on the frequency of sport participation. Neither the expected rebound effect for the frequency of sport participation nor any other effects were found. We only found that men have a higher frequency of sport participation than women, regardless of the number of years since having a child, which is in accordance with the general finding that women participate in sports less than men (22). The lack of long-term effects of becoming a parent on the frequency of sport participation may be because we were unable to include frequency as an interval variable. Due to extremely right skewness of the frequency of sport participation, we had to include it as an

ordinal variable with only 4 categories. Despite the fact that we checked for robustness with different category classifications, the use of 4 categories decreases the amount of information and sensitivity of the data, which may explain why we hardly found any influence of the independent variables. Further research should use analytical techniques that can address this right skewness, such as Bayesian regression (49).

4.3 Types of sports played in the short term

Interestingly, the effects of becoming a parent on the different types of sports were opposite to our expectations; that is, only individual sports at home were less often mentioned as the sport people participated in after becoming a parent. There are several explanations possible. First we argue that this effect can be largely explained by the membership structure of team sports and individual sports at another location. Most often, memberships for sport clubs run for a whole year (50), and by maintaining a membership, new parents can still identify themselves as participants in the sport while they don't sport at all. Unfortunately, we do not have data on the number of hours that were actually spent performing the sport (only the total number of hours per week); therefore, it could be possible that the number of hours spent performing the team sport decreased or stopped. Further research should therefore include questions about the actual number of hours that are spent playing sports at a club or commercial provider to see whether new parents who play sports at a club or commercial provider indeed continue playing sports or simply identify themselves as participants but show the same dropout rate as people who participate in individual sports at home.

Another explanation based on Durkheim's integration theory (51) is that team sports and sport club memberships result in more social integration (52) and therefore provide a high(er) level of social pressure to return to the sport after the birth of a child. However, research in Norway (53) shows that social integration is much less common at commercial sport clubs, from which we would expect a difference between team sports and individual sports at another location, which was not supported by our data. This emphasizes that future research should focus on collecting data that include the sports context in which people exercise and the actual number of hours spent playing the sport in that context. In addition, this research should distinguish between four categories; team sports, individual club sports, individual commercial sports and individual sports from home instead of the three categories we used.

4.4 Types of sports in the long term

In the long term, however, we observed a decrease in team sport participation, while the number of years since childbirth did not affect individual sport participation either at another location or at home. This suggests that the cessation of team sports may not be related to the transition into parenthood *per se* but rather to how the demands of team sports can be incorporated into the family schedule (28). In addition, team sports are more physically

demanding than individual sports, for example, cycling or walking. Physical abilities tend to diminish over time, leading to more injuries or physical complaints, which can explain the general decrease in team sport participation over time (54). Although further research is needed that provides information about the actual frequency of sport participation according to sport type, it seems that the type of sports played is mostly affected by (time) resources and less affected by cultural barriers. However, we should mention the overrepresentation of men in team sports in the Netherlands (55) which is also the case in the sample of this study (12.48% of men and 6.47% of women indicated participation in team sports, $\chi^2 = 26.78$, $p < .01$). This difference is probably (partially) caused by gender norms and sport type (55) instead of resources. Further research should, therefore, (qualitatively) elaborate on the gender gap in team sports.

5 Conclusion

This study aimed to further understand the influence of becoming a parent on sport participation by examining both short- and long-term effects and by differentiating the effects for men and women. This was done by multilevel (ordered) logistic regression analyses on the data from 6,276 observations of 725 respondents in 12 waves of the Dutch LISS panel. Despite the limitations including the representativeness of these type of panels, the results highlight large differences between men and women. While men's sport participation does not seem to be affected by fatherhood, Women stop participating in sports in the short term, although in the long term, they show a modest recovery in their sport participation. Nevertheless, their activity levels remain lower compared to those of men. New parenthood does not affect the type of sports played by men and women differently. In the short term, individual sports at home became less popular, while in the long term, team sports became less popular.

These different pathways of sport participation over time provide valuable insights into the development of interventions aimed at new parents, which should focus mainly on women. The specific components for sustainable interventions to increase sport participation among (new) parents should follow from further (qualitative) research that disentangles mechanisms between resources (e.g., being physically able to participate in a sport and having the time and energy to do so) and cultural barriers (e.g., are mothers allowed to play sports instead of taking care of their children or do fathers facilitate that their partners participate in sport) that lead to the decrease in sport participation after becoming a parent. After all, remaining active through sports is not only beneficial for parental health (56) but also provides a great example for children to participate in sports at a later age (10, 57).

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: <https://www.dataarchive.lissdata.nl/study-units/view/1>.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the Radboud University Faculty of Social Sciences (ECSW-LT-2022-11-30-15458). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements. All methods were carried out in accordance with relevant guidelines and regulations.

Author contributions

HB: Conceptualization, Data curation, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing. FvA: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fspor.2025.1504793/full#supplementary-material>

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Older men in motion: bodies, masculinities, and redefinition of identity

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Introduction: This study explores the intersection of physical exercise, masculinity, and aging in older men, examining how these elements shape identity and bodily experiences. Aging is often framed through deficit-based narratives that emphasize decline; however, this research seeks to reframe aging as a process of adaptation and opportunity. By investigating how physical activity contributes to identity reconstruction, this study aims to provide insights into the broader social and structural factors influencing older men's engagement in exercise.

Methods: The study employs a qualitative research design, utilizing semi-structured interviews with 12 men aged 65–76. A narrative thematic analysis was conducted to examine participants' experiences, concerns, and expectations regarding physical activity. This approach allowed for an in-depth exploration of how exercise intersects with notions of masculinity and aging, as well as the barriers and facilitators that shape participation in physical activities.

Results: The analysis identified three key themes: (1) the transformative role of exercise in fostering emotional well-being and bodily awareness, (2) the renegotiation of traditional masculinity through engagement in non-traditional physical activities, and (3) the social connections cultivated through group-based exercise programs. Additionally, the study highlights social and structural barriers, such as limited access to facilities and economic constraints, which hinder participation in physical activity.

Discussion: Findings underscore the significance of physical activity not only for maintaining health but also as a space for identity reconstruction and resistance to conventional narratives of aging. The study suggests that exercise serves as a means of empowerment, allowing older men to navigate aging in ways that challenge societal expectations. Moreover, the identification of structural barriers emphasizes the need for inclusive public health policies and targeted interventions that promote active aging. By reframing aging as a dynamic process of adaptation rather than mere decline, this research contributes to a broader understanding of how older adults experience and engage with physical activity.

KEYWORDS

active aging, emotional well-being, affect, body awareness, physical exercise

1 Introduction

Aging, traditionally associated with loss, decline, and dependency, has long been framed within a deficit model that underscores physical frailty, cognitive deterioration, and social withdrawal. This perspective has contributed to cultural narratives that often marginalize older adults, portraying them as passive recipients of care rather than active agents in shaping their lives. However, contemporary approaches to aging challenge these reductive views, emphasizing its dynamic and transformative potential. Recent scholarship, including the work of [Dionigi et al. \(2013\)](#), has shed light on how older adults negotiate the aging process, focusing on their capacity for adaptation, identity renegotiation, and meaningful engagement with the world around them.

For older men, this transformative view of aging intersects with the complexities of masculinity. Masculinity, as a socially constructed identity, evolves over the life course, shaped by cultural expectations, generational norms, and personal experiences. Physical activity, in this context, emerges not only as a tool for maintaining health and well-being but also as a significant arena for older men to reconstruct their understanding of masculinity. By engaging in physical activity, older men can challenge traditional gender norms that emphasize dominance, physical strength, and competitiveness, instead embracing practices that prioritize emotional well-being, social connection, and self-care. This shift reflects a broader societal trend toward reimagining masculinity as a more fluid and inclusive construct ([Gough and Robertson, 2010](#)).

Despite these opportunities for transformation, older men's experiences with physical activity are not free from tension. The intersection of aging and masculinity often brings to the forefront societal expectations that perpetuate restrictive stereotypes. Cultural ideals of masculinity frequently valorize youth, vitality, and physical prowess, creating pressures that can exacerbate feelings of inadequacy as men age. Simultaneously, the physical changes associated with aging—such as reduced mobility, slower recovery times, and increased vulnerability to injury—pose challenges to older men's ability to engage in physical activities in the ways they once did. These tensions highlight the need to explore how older men navigate the dual influences of societal expectations and the realities of aging bodies ([Clarke et al., 2020](#); [Fernández-Ballesteros et al., 2017](#); [Phoenix et al., 2005](#)).

In this context, physical activity offers a unique space for older men to negotiate these complexities. Exercise becomes more than a practice for physical maintenance; it acts as a medium for exploring identity, fostering resilience, and cultivating social bonds. Through activities such as walking groups, yoga classes, or resistance training, older men can engage in embodied practices that challenge traditional narratives of decline. Instead, they can embrace aging as a process of growth, adaptation, and self-discovery. Furthermore, group physical activities provide opportunities for older men to combat social isolation, a common issue in retirement, by fostering inclusive and supportive environments ([Bredland et al., 2018](#); [Mulcahy, 2012](#); [Klinenberg, 2018](#)).

This study seeks to examine these dynamics by focusing on the particularities of masculinity and its influence on perceptions of the body, exercise, and social interaction in later life. Using a qualitative approach, it explores how older men perceive and experience physical activity, how they confront the bodily changes associated with aging, and how these practices affect their sense of identity and belonging. By delving into participants' narratives, this research illuminates the ways in which older men navigate the intersections of gender and aging, offering insights into how physical activity can serve as a space of resistance, adaptation, and personal reaffirmation ([Clarke et al., 2020](#); [Sparkes, 2015](#)).

The significance of this study lies in its potential to challenge deficit-based narratives of aging, providing a more nuanced understanding of how older men experience and embody their identities. By focusing on the interplay between the body, movement, and masculinity, this research contributes to broader discussions on active aging and the transformative potential of physical activity. It highlights how older men's engagement in exercise not only enhances their physical and emotional well-being but also offers a platform for renegotiating societal norms, fostering resilience, and cultivating meaningful connections. These findings hold implications for public health initiatives, social policy, and cultural discourse, underscoring the need to create inclusive and accessible environments that empower older adults to thrive in later life.

Through its exploration of these themes, this study aims to expand the understanding of aging as a dynamic and possibility-filled process, demonstrating how the intersections of gender, embodiment, and social context shape the lived experiences of older men. By doing so, it seeks to contribute to a richer and more inclusive narrative of aging, one that recognizes the diverse ways in which individuals navigate and redefine their identities in later life.

1.1 Corporeality, masculinity, and aging: dynamic and transformative perspectives

Aging in Western societies has traditionally been conceptualized through a model of decline, focusing on the loss of abilities, dependency, and physical and cognitive frailty ([Dionigi et al., 2013](#)). This approach has reinforced cultural narratives that associate aging with limitations and social disconnection, often obscuring the diversity of experiences during this stage of life. However, contemporary perspectives have challenged these one-dimensional views, proposing a more complex and dynamic understanding of the body as an entity in constant transformation, capable of generating meaning and capabilities throughout the life cycle ([Garrett, 2004](#)). This framework is grounded in theories of corporeality, which emphasize the relationship between bodies, individual experiences, and social contexts.

Corporeality provides a comprehensive lens to understand the body not merely as a physical entity, but as a space for cognitive, emotional, and social interaction. According to [Merleau-Ponty \(2012\)](#), the body is not simply an object but a medium through which the world is experienced and imbued with meaning. In the context of aging, this perspective allows for an examination of how older men perceive physical changes in their bodies and how these changes impact their identities and capabilities. This study reveals that despite the limitations associated with aging, physical activity can serve as a transformative resource that enables older men to reaffirm their autonomy, adapt to bodily transformations, and maintain an active connection with their environment ([Bredland et al., 2018](#); [Clarke et al., 2020](#); [Hydén, 1997](#); [Phoenix et al., 2005](#); [Sparkes, 2015](#)). Exercise, in this sense, emerges as a means of negotiating the aging process, reconfiguring both perceived capacities and personal identity.

Masculinity, understood as a social construction, plays a central role in this negotiation. Cultural norms and gender stereotypes have historically defined masculine ideals around attributes such as strength, resilience, and physical dominance ([Clarke et al., 2020](#); [Clarke, 2012](#); [Gough and Robertson, 2010](#); [Sparkes, 2015](#)). These traditional conceptions of masculinity have influenced how older men confront aging, particularly in the realm of physical exercise. However, recent experiences documented in this study reveal that many older

men are challenging these norms by engaging in non-traditional physical activities such as yoga or Pilates, which have historically been perceived as feminine practices (Phoenix et al., 2005; Sloan et al., 2010). These practices not only promote physical well-being but also offer an opportunity to reconfigure masculinity in aging, moving away from traditional ideals and adopting a more holistic approach to health and well-being (Gough and Robertson, 2010).

Group physical activities also play a key role in promoting active and socially integrated aging. This study highlights how group dynamics can overcome initial barriers associated with gender norms, creating inclusive spaces where older men find mutual support and acceptance (Mulcahy, 2012; Phoenix and Sparkes, 2008, 2010). These group activities, in addition to facilitating social interaction, also strengthen connections with the natural environment, allowing participants to enjoy outdoor activities that foster a renewed sense of autonomy and vitality (Garrett, 2024). The social dimension of exercise, therefore, not only contributes to physical well-being but also reinforces community ties and a sense of belonging.

In this context, physical activity becomes a space for identity renegotiation where older men can challenge dominant narratives of decline and vulnerability (Clarke et al., 2020; Phoenix and Sparkes, 2006, 2008; Sparkes, 2015). By engaging in physical practices that prioritize health, enjoyment, and social connection, participants reconfigure their corporeality, transforming perceived limitations into opportunities to explore new ways of being and inhabiting their bodies. This process, deeply interwoven with notions of masculinity, underscores how bodily practices can serve as a vehicle for reconfiguring not only personal identity but also the social dynamics surrounding aging (Sparkes, 2015).

In summary, theories of corporeality and active aging propose a transformative vision of male aging, emphasizing the capacity of older bodies to adapt, resist, and reinterpret social expectations (Bredland et al., 2018; Phoenix and Sparkes, 2006; Sparkes, 2015). Far from being an inevitable period of decline, aging emerges as a stage of creative potential and profound connection with oneself and others (Dionigi et al., 2013). These psychosocial transformations help explain why, in many contexts, aging is often experienced as a period of greater subjective well-being (Fernández-Ballesteros et al., 2017; Steptoe et al., 2015). In this sense, physical activity stands out as a crucial tool for challenging limiting social constructions, fostering autonomy, and exploring new ways of living and experiencing old age.

2 Methodology

2.1 Participants and training program

This study involved 12 men aged 65–76 years who participated in a physical activity program aimed at preventing cognitive decline. The program, known as “Cogn-Mover” (in an effort to integrate the concept of cognition, movement, and emotion) emphasized the integration of cognition, movement, and social interaction. It was structured around aerobic activities, primarily walking, combined with a variety of tasks and playful exercises designed to enhance attention, coordination, postural control, balance, spatial and temporal structuring, interaction, listening, and empathy. The program was part of a broader project called “Brain-Gym,” funded by the Spanish State Research Agency. Brain-Gym aimed to evaluate a cognitive training intervention using a Brain-Computer Interface (BCI) system to

stimulate specific neural circuits. Participants in the “Brain-Gym” project engaged in one individual BCI training session and one weekly group physical activity session for a duration of 12 weeks.

The “Cogn-Mover” sessions included a 10-min period for personal interaction and exchange before the 60-min main session, followed by 10–15 min for further interaction and farewell. These pre- and post-session phases enabled participants to engage with two of the study’s investigators, who also served as program facilitators. Conversations during these phases were often guided by physical activity journals maintained by participants, which documented their activity habits, physical sensations, and personal experiences. These exchanges inspired a deeper exploration of participants’ experiences through follow-up interviews.

All participants were Spanish and had grown up in socio-economic and cultural contexts where organized physical activity was not prioritized or widely promoted, especially in rural areas and urban neighborhoods with limited resources. Physical activity during their youth was typically associated with labor-intensive tasks, such as agricultural work, manual transportation, or walking, rather than structured exercise or sports. During their working years, responsibilities related to employment and family, combined with long hours and limited leisure opportunities, shaped their relationship with physical activity. Exercise was often regarded as a luxury, accessible primarily to younger individuals or those with ample free time. Furthermore, access to sports facilities and programs was scarce, particularly in less developed regions.

With retirement, participants experienced significant lifestyle changes. The cessation of work obligations provided time for self-care, while public health campaigns emphasizing the benefits of physical activity in preventing age-related conditions, such as cognitive decline and cardiovascular diseases, prompted a reevaluation of their habits and priorities.

The “Cogn-Mover” program consisted of weekly group sessions lasting 60 min over 12 weeks. These sessions were carefully designed to address both physical and cognitive health through practical and engaging activities, offering participants a holistic experience. The program employed a circuit-based format, incorporating exercises targeting joint mobility, balance, coordination, and functional strength. Activities were tailored to individual abilities, including gentle movements to improve flexibility, one-legged balance exercises, lateral movements, and tasks requiring reaction speed, such as responding to visual or auditory stimuli while performing specific movements. Cognitive engagement was integrated through dual-task activities, such as executing movements while processing cognitive stimuli, as well as group games aimed at stimulating memory and attention. The sessions concluded with stretching and relaxation exercises to promote well-being and reduce tension.

Beyond physical and cognitive health, the program was designed to foster community and social connections among older adults. It aligned with broader public health goals by promoting active aging and addressing the social isolation often experienced in this demographic. Furthermore, the program sought to challenge societal narratives of aging as a period of inevitable decline, instead highlighting the potential for growth and adaptation. The weekly sessions provided a dynamic, inclusive space where participants could rediscover their capabilities and engage meaningfully with others.

This holistic approach sought not only to improve physical condition but also to stimulate key cognitive processes, helping participants maintain active and healthy aging.

2.2 Data collection

Semi-structured interviews were conducted to allow participants to share their life stories concerning their bodies and physical activity. The interviews were transcribed verbatim and ranged from 50 to 75 min in duration.

Descriptive, emotional, sensory, experiential, and embodied data were collected (Lambert, 2020). Guiding questions were designed to evoke embodied and affective experiences related to movement throughout their lives. Examples of these questions included: What types of physical activity do you practice? Which ones do you enjoy the most? How does physical activity influence your perception of feeling strong or fragile? Is there any connection between physical activity and your sense of masculinity? What would you say about your body? Has your perception of your body changed over time? How has physical activity changed for you over the years? Are there situations in your daily life where you feel stronger or more vulnerable?

Since the study aims to construct narratives that position the body as a central interlocutor, it focuses on embodied and sensory experiences, reflecting on senses, emotions, responses, and triggers, as well as questions that encourage body-centered storytelling. The research explored how affect, sensitivity, and emotion emerged in these narratives and the capacities they generated or limited. Special attention was given to understanding the embodied energies present in the participants' stories and conversations, as they were lived and felt "in the flesh" (Chadwick, 2017).

All participants provided informed consent prior to their participation in the study. To ensure confidentiality, pseudonyms were used in place of participants' real names. The study has received favorable approval from the Research Ethics Committee for the implementation of the research Project [Ethical code PI 23-3325 NO HCUV].

2.3 Data analysis

A narrative thematic analysis was conducted to identify and examine patterns or themes within the stories shared by participants (Sparkes and Smith, 2014). This method integrates elements of narrative analysis with a thematic focus, capturing both the explicit content and the implicit dynamics of the narratives. To ensure rigor, two researchers independently reviewed and coded the interviews, identifying initial themes. These themes were then discussed collaboratively among the research team to refine and consolidate them into broader categories, ensuring they accurately reflected the participants' narratives. This iterative process facilitated diverse perspectives and a comprehensive understanding of the data. Furthermore, the analysis allowed us to explore not only the main themes but also the affective and embodied depth underlying the participants' narratives (Chadwick, 2017), valuing the complexity of individual experiences while identifying shared patterns that contribute to a holistic understanding of their lived experiences.

The following table (see Table 1) presents the categories derived from the narrative thematic analysis, along with the emerging themes associated with each category:

3 Results and discussion

The relationship between physical exercise, masculinity, and aging is analyzed through the narratives of participants, exploring the

TABLE 1 Study categories and emerging themes associated with each.

Categories	Emerging themes
Physical activity and well-being	Importance of physical activity in daily life Perceived benefits of exercise on physical and mental well-being Preferences for outdoor activities versus indoor activities Impact of exercise on health perception and mobility
Perception of masculinity	Reflections on masculinity in the context of physical exercise Perceived differences in physical abilities between men and women Influence of gender stereotypes on participation in physical activities
Aging and the body	Bodily changes with age and their acceptance Feelings of fragility versus strength associated with aging Concerns about the Loss of mobility and abilities with aging Social stigma associated with aging
Social integration	Group dynamics in physical activities Barriers and motivations for participation in community activities Experiences of inclusion and exclusion in recreational spaces
Perception and attitudes toward exercise	Attitudes toward one's own body and self-image Influence of exercise on self-esteem Differences in perceived physical well-being between men and women

dynamics of body, gender, and affect that emerge in their experiences. The results reveal a process of re-signifying the body and masculinity, while also uncovering the tensions and possibilities that physical movement offers in later life.

3.1 Physical activity and well-being

Participants consistently describe physical exercise as a cornerstone for maintaining vitality and a sense of purpose in daily life. Beyond the obvious physical benefits, exercise emerges as a deeply emotional and reflective practice. Carlos (70 years old) states: "When I go out for a run, it feels like everything else disappears for a while. It's my time to be with myself, to leave everything else behind." This narrative underscores how movement fosters emotional balance and serves as a coping mechanism for managing the psychological challenges of aging (Parra et al., 2019). Physical activity becomes not just a task, but a ritual—a moment of solitude and self-awareness that reconnects individuals with their bodies and minds.

Outdoor activities, in particular, hold special significance for participants, often described as a preferred context for exercise. Andrés (66 years old) shares: "I enjoy that more. Yesterday I went down to the valley, by the Esgueva River. Nature recharges your batteries." This highlights the role of natural environments in amplifying the sensory and affective dimensions of physical activity. The act of moving outdoors intertwines bodily and spatial awareness, creating a deeper sense of connection to one's surroundings. Phoenix and Sparkes (2008) emphasize that environments like these, act as catalysts for re-signifying aging, offering opportunities to redefine one's relationship with the body and the self. Moreover, this aligns with biophilia theories (Tidball, 2012;

Kellert and Wilson, 1993), which suggest that humans have an innate connection to nature, deeply rooted in our evolutionary past. This connection allows participants to find solace and revitalization in the natural world, transcending the physical aspects of exercise to tap into a profound sense of well-being.

Participants also emphasize how physical activity helps counteract feelings of vulnerability and loss of strength often associated with aging. Pablo (74 years old) reflects: “When I exercise, I feel like I’m getting stronger, as if that fragility you sometimes feel dissipates.” This sentiment encapsulates the transformative potential of movement, which not only reinforces the body but also redefines self-perception. Exercise becomes a means of reclaiming agency and autonomy in the face of physical decline, allowing participants to confront the aging process with resilience (Sparkes, 2015).

In addition, the narratives reveal how exercise is reframed as a source of pleasure rather than obligation. For example, Antonio (71 years old) explains: “When I walk outdoors, it’s not about how far I go or how fast. It’s about enjoying the moment and feeling good in my body.” This shift in focus—from achieving specific goals to experiencing movement for its intrinsic value—illustrates how participants embrace exercise as an act of celebration and self-care.

3.2 Perception of masculinity

The participants’ reflections on masculinity reveal a complex interplay between deconstruction of traditional gender norms and lingering societal expectations. Andrés (66 years old) observes: “Here at the gym, I see women lifting the same weights as men. It’s not like before; it does not matter who does what anymore.” This narrative reflects a shift in the perception of physical strength as an exclusively masculine trait, demonstrating how contemporary exercise spaces can challenge and dismantle traditional gender binaries (Tannenbaum and Frank, 2011).

However, tensions persist, particularly in how certain activities are culturally coded. Carlos (70 years old) states: “Sometimes I see other men and feel like they are still trapped in the idea that if you do something like yoga, you are no longer a real man.” This statement highlights the persistence of gendered stereotypes, which frame activities such as yoga as incompatible with traditional notions of masculinity. Such narratives underline the broader societal pressures older men face in reconciling their personal interests with societal expectations of gender roles.

Some participants, however, manage to transcend these stereotypes and redefine masculinity on their own terms. Uriel (73 years old) reflects: “I do Pilates, and I love it. At first, it felt strange, but then I realized that does not define who I am as a man. What matters is that I feel good.” This testimony illustrates the potential for a more fluid and inclusive understanding of masculinity, where physical activities traditionally considered feminine become spaces for self-expression and identity transformation. Merleau-Ponty’s (2012) concept of the body as a medium for experience resonates here, emphasizing how movement fosters a reimagining of one’s identity beyond rigid cultural constructs.

Participants also noted how engaging in diverse physical activities allowed them to redefine their notions of strength and capability. Andrés (66 years old) explained: “Strength is not just about lifting heavy weights anymore. It’s about endurance, flexibility, and feeling in control of my body.” This evolving definition of masculinity aligns with recent scholarship advocating for a more holistic view of gender identity in later life (Phoenix et al., 2005; Sparkes, 2015).

Additionally, the role of peer interaction in reshaping perceptions of masculinity cannot be overlooked. Group activities provided a context where traditional norms could be challenged collectively. Tomás (72 years old) shared: “Seeing other men my age trying yoga or Pilates made me realize it wasn’t just for women. It’s about health, not stereotypes.” This narrative highlights how social environments play a crucial role in enabling men to explore and embrace non-traditional activities, fostering a sense of solidarity and shared growth.

Participants’ reflections reveal an ongoing negotiation between societal expectations and personal fulfillment. Physical activity emerges as a space where masculinity is continually redefined, allowing men to break free from restrictive norms and embrace a more nuanced, adaptive understanding of their identities in later life.

3.3 Aging and the body

Participants in this study demonstrate a complex interplay of acceptance, adaptation, and resilience in their responses to the bodily changes associated with aging. Antonio (71 years old) reflects: “Over the years, I’ve learned to listen to my body more. I know when I can push myself and when I need to stop.” This statement underscores the importance of self-awareness and sensitivity toward the aging body, which acts not only as a biological entity but as an archive of memories and lessons accumulated over a lifetime (Niklasson et al., 2024). This approach to self-care emphasizes the evolving relationship individuals develop with their bodies, shifting from demands of peak performance to a more attuned understanding of bodily capabilities and limitations.

Despite this acceptance, the fear of losing physical capabilities remains a recurrent concern among participants. Carlos (70 years old) articulates this worry: “I worry that one day I will not be able to move the same way. That’s why I try to stay active, even though I do not recover as quickly as I used to.” His narrative reflects the tension between the desire to maintain an active lifestyle and the inevitable changes that accompany aging. Exercise, in this context, becomes a form of resistance against cultural narratives that equate aging with decline. Instead, it offers a proactive way to project future possibilities for the body and to remain engaged with life’s physical demands (Young et al., 2024).

Participants frequently express that aging has prompted a reevaluation of their relationship with their bodies, resulting in a more flexible and realistic approach to physical activity. Andrés (72 years old) captures this perspective, stating: “I know I cannot do the same things I used to, but that does not mean I’m going to stop trying. My body still has a lot to offer.” His optimism contrasts sharply with deficit-based discourses on aging, which often portray the aging body as solely a site of loss and fragility. Instead, Andrés reframes his limitations as opportunities for growth, self-discovery, and adaptation. This sentiment aligns with Dionigi et al. (2013), who emphasize that aging bodies are dynamic and capable of ongoing reinvention.

The narratives reveal that exercise is not merely a physical activity but also a symbolic act of agency and control. For many participants, movement represents an opportunity to push back against feelings of vulnerability and to assert autonomy over their aging bodies. Antonio (71 years) describes his routines as a way to “stay in control of what I can, even when my body changes.” This perspective highlights the capacity of physical activity to reinforce self-efficacy and mitigate anxieties about the aging process, turning

exercise into a transformative practice that strengthens both body and mind.

Furthermore, participants underscore the role of bodily awareness in navigating aging. This awareness is not static but evolves over time, as older adults learn to interpret and respond to the signals their bodies provide. The process involves reconciling past identities—shaped by youthful vigor and capability—with current realities that require adaptation. As Antonio (71 years) notes, this adjustment is not about resignation but about learning: *“I’ve learned to appreciate what my body can still do, even if it’s different from before.”* This notion of the body as a site of continuous learning reflects Garrett’s (2024) exploration of embodied adaptation, where individuals align their practices with their lived experiences, creating spaces of resilience and agency.

The role of movement extends beyond physical benefits; it becomes a source of emotional and existential renewal. Participants frequently describe exercise as a way to reconnect with their bodies and experience vitality. Pablo (74 years old) states: *“When I exercise, it reminds me that I’m still here, still capable.”* This connection reinforces the idea that bodies in motion are not just physical entities but also bearers of identity and purpose. Exercise helps participants resist the cultural tendency to marginalize older bodies, affirming their value and potential in a society that often prioritizes youth and productivity.

In addition, the study reveals how physical activity fosters a balance between acceptance and aspiration. While participants acknowledge that their bodies may not function as they once did, they remain committed to maintaining an active lifestyle. This balance reflects a broader shift from performance-driven goals to holistic engagement with movement. Andrés summarizes this shift: *“It’s not about doing more or being better than anyone. It’s about doing what feels right for me.”* This perspective echoes Phoenix and Sparkes’ (2008) findings that older adults often redefine physical activity as a personal and meaningful practice rather than a competitive or performance-based one.

Ultimately, the participants’ experiences illuminate the transformative potential of aging bodies. Exercise emerges not only as a strategy for maintaining health but also as a profound act of self-expression, resilience, and empowerment. These narratives challenge deficit-based views of aging, instead portraying it as a dynamic process where the body remains a site of possibility and renewal. By fostering autonomy, strengthening self-esteem, and providing avenues for self-discovery, physical activity becomes an essential tool for navigating the challenges and opportunities of aging.

3.4 Social integration

Group physical activities emerge as pivotal spaces for fostering inclusion, social connection, and a sense of belonging among older adults. José (68 years old) reflects: *“In the hiking group, aside from exercising, we share many things. I no longer feel as isolated as I did when I retired.”* This statement underscores how group dynamics can effectively counteract social isolation, a common issue in older adulthood, while providing a framework for building emotional and social bonds (Klinenberg, 2018; Mulcahy, 2012). The act of engaging in shared physical activities offers participants not only an opportunity for movement but also a platform for creating meaningful relationships that extend beyond the exercise itself.

Participants also emphasized how shared activities provided a sense of routine and purpose. Andrés (66 years old) explained: *“Having a set day for hiking gives structure to my week. I wake up knowing I’ll see the group and spend time outdoors—it’s something I look forward to.”* This testimony highlights how the predictability and regularity of group activities can help combat the aimlessness that some retirees report feeling after leaving the workforce.

Moreover, inclusive spaces can break down initial discomforts related to gender, age, or perceived physical abilities. Tomás (72 years old) shared: *“At first, I felt uncomfortable in the fitness classes because I did not know anyone, and I thought everyone else was more experienced. But now, I feel valued and welcomed.”* Such narratives reflect how environments that prioritize inclusion and mutual respect can create opportunities for learning, growth, and mutual support (Halaweh et al., 2016).

The social integration achieved through group activities also has a spillover effect into other aspects of participants’ lives. For example, Antonio (71 years old) mentioned: *“Since joining the walking group, I’ve become more confident talking to others. I’ve even reconnected with old friends because I feel more comfortable putting myself out there.”* These accounts highlight the transformative potential of group physical activities, not only for enhancing physical and emotional well-being but also for reinforcing community ties and enriching participants’ social lives.

3.5 Perceptions and attitudes toward exercise

Participants consistently described exercise as a practice deeply intertwined with self-care, self-awareness, and personal growth. Antonio (71 years old) remarked: *“Exercise is my meditation time. It’s when I can truly feel my body and understand what it needs.”* This view reflects the role of physical activity as a tool for reconnecting with one’s body, fostering mindfulness, and managing the demands of aging. Movement becomes a medium through which participants can navigate the physical and emotional challenges associated with growing older, transforming their relationship with their bodies (Dionigi et al., 2013; Hickey and Austin, 2007).

A recurring theme in participants’ narratives was the shift from viewing exercise as an obligation to embracing it as a source of joy and vitality. Uriel (73 years old) shared: *“Even though my body has changed, I still see exercise as something positive. I do not do it out of obligation but because it makes me feel alive.”* This perspective underscores how physical activity becomes an act of resistance against the narratives of decline that often accompany aging. Rather than being framed solely as a means of maintenance, exercise emerges as a celebration of bodily capabilities and a source of empowerment (Clarke et al., 2020; Bredland et al., 2018; Phoenix et al., 2005; Phoenix and Sparkes, 2008).

The participants also highlighted the flexibility and adaptability of their exercise routines. Andrés (72 years old) explained: *“I used to think exercise had to be intense to matter. Now, I realize that even gentle movements, like stretching or walking, can make a big difference in how I feel.”* This shift demonstrates how perceptions of exercise evolve over time, moving from performance-driven goals to an appreciation of its holistic benefits for body and mind.

Several participants noted that physical activity helped them reframe their self-image in the context of aging. Carlos (70 years old)

commented: “*When I exercise, I feel strong. It’s a reminder that my body is still capable, even if it’s different from when I was younger.*” Such reflections highlight how exercise can reinforce a positive self-perception, countering feelings of fragility and fostering resilience.

Additionally, some participants described physical activity as a gateway to rediscovering the pleasures of movement. Pablo (74 years old) shared: “*I never thought I’d enjoy yoga, but it’s become one of my favorite things. It’s not about pushing myself anymore—it’s about moving in a way that feels good.*” This statement exemplifies the transformative potential of exercise, where participants redefine their relationship with their bodies, focusing on well-being rather than external expectations or comparisons.

The narratives also revealed how physical activity fosters a sense of autonomy. Uriel (73 years old) explained: “*Exercise reminds me that I have control over my body, even as I age. It’s something I do for myself, on my own terms.*” This empowerment challenges deficit-based discourses surrounding aging, framing movement as a tool for maintaining independence and agency (Phoenix and Sparkes, 2008; Sparkes, 2015).

Through these reflections, it becomes evident that exercise transcends its physical benefits, emerging as a transformative practice that shapes attitudes, reinforces identity, and fosters resilience in the face of aging. The narratives illustrate how movement serves as both a celebration of capability and a vehicle for reimagining one’s relationship with the body, self, and the aging process.

4 Conclusion

The findings of this study highlight the central role of physical exercise as a space for the renegotiation of masculine identities and the embodied experiences of older men. Through narrative analysis, participants reveal how they challenge and transform traditional notions of masculinity, moving away from stereotypes focused solely on physical strength and endurance. Instead, they adopt practices emphasizing self-care, holistic health, and emotional well-being, reflecting a broader cultural shift toward more inclusive understandings of masculinity. These findings align with Gough and Robertson’s (2010) critique of hegemonic masculinity and Garrett’s (2004) insights on the social construction and potential transformation of gendered bodies. Exercise becomes a medium for reconfiguring relationships with their bodies and societal expectations, supporting a dynamic interplay between identity and movement.

Physical activity also emerges as a means of rethinking aging as a stage of possibilities and adaptations rather than an inevitable process of loss. While participants acknowledge the physical limitations that accompany aging, they emphasize how these constraints have fostered greater bodily awareness and reconnection with their physical selves. Niklasson et al. (2024) discuss the alignment of physical activity with lived experiences, which is evident in how participants perceive exercise as a space for resilience, autonomy, and self-esteem. Movement helps address fears associated with aging, such as fragility and the loss of mobility, enabling participants to confront these challenges with optimism and adaptability (Young et al., 2024).

The emotional and affective dimensions of exercise also play a central role in participants’ experiences. Exercise not only impacts their physical well-being but also revitalizes their sense of identity, purpose, and emotional connection. Carlos’s narrative about running

as a form of solitude and self-reconnection echoes Parra et al.’s (2019) findings on the emotional balance fostered by movement. Similarly, Andrés’s preference for outdoor activities highlights how natural environments amplify embodied experiences, offering a deeper connection to oneself and the surroundings. These insights align with biophilia theories (Tidball, 2012; Kellert and Wilson, 1993), which emphasize the inherent human connection to nature as a source of well-being.

The narratives further reveal a process of deconstructing and renegotiating masculinity. Participants reflect on their changing perceptions of traditional masculine ideals, as seen in Andrés’s observation about women lifting weights, which challenges the exclusivity of physical strength as a male attribute (Tannenbaum and Frank, 2011). However, tensions persist, particularly in activities like yoga, which some participants associate with a perceived loss of masculinity. These findings underscore the complexity of navigating masculinity in later life, where traditional norms intersect with evolving personal and social expectations. Nonetheless, narratives like Uriel’s embrace of Pilates demonstrate how older men redefine masculinity in fluid and adaptive ways, aligning with Merleau-Ponty’s (2012) perspective on the body as a site of transformation and identity renegotiation.

Social integration emerges as another significant dimension of physical exercise. Group activities are described as spaces that promote inclusion, combat social isolation, and foster meaningful interactions. José’s narrative about the hiking group echoes Klinenberg’s (2018) discussion of social infrastructure as a tool for combating loneliness and fostering community ties. These group settings also provide opportunities to overcome initial discomfort, as noted by Tomás, who eventually found a sense of belonging and support in his fitness class. These findings align with Halaweh et al.’s (2016) emphasis on the role of habitual physical activity in maintaining social roles and fostering inclusion. Furthermore, group dynamics create environments where participants can share experiences and develop emotional bonds, as noted by Mulcahy (2012) in discussions on affective assemblages.

This study broadens perspectives on active aging by emphasizing the interaction between moving bodies, notions of masculinity, and the affective and social dynamics shaping these experiences. It demonstrates how aging bodies resist deficit-based narratives, instead serving as spaces of possibility and transformation (Clarke et al., 2020; Bredland et al., 2018; Phoenix and Sparkes, 2008; Sparkes, 2015). Given the growing prominence of demographic aging, it is crucial to continue exploring the intersections of aging, gender, and physical activity across diverse cultural and social contexts. The findings of this study have important implications for health policy and practice. To promote active aging among older men, public health interventions should prioritize creating inclusive physical activity programs that address economic and geographical barriers. Additionally, campaigns should challenge traditional gender norms by emphasizing the holistic benefits of exercise, including emotional well-being and social integration. Policymakers should also invest in infrastructure, such as accessible sports facilities and outdoor spaces, to encourage participation across diverse communities.

Future research could compare the experiences of older men and women in exercise, considering variables such as social class, rural–urban divides, and generational differences. Furthermore, public policies and physical activity programs must foster inclusive and accessible environments to enhance the capacities and opportunities

of older adults. As Garrett (2024) emphasizes, these efforts can provide a nuanced and positive understanding of aging, not as a decline but as a dynamic process filled with possibilities.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Ethical code PI 23-3325 NO HCUV. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

GG-C: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. AG-M: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. AR: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. FH: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. PD-M: Conceptualization, Methodology, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

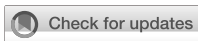
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Unveiling the power of social influence: how functional, emotional, and social values drive Pilates participation through an extended TPB model

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Purpose: This study investigates how functional, emotional, and social values shape Pilates participants' attitudes and behavioral intentions within an Extended Theory of Planned Behavior (ETPB) framework.

Method: A survey was conducted with 288 Pilates participants, and structural equation modeling was employed to analyze the relationships among perceived value, attitude, subjective norms, perceived behavioral control, and behavioral intention.

Results: The findings indicate that functional and social values positively influence attitudes, whereas emotional value has no significant effect. Moreover, subjective norms exert the strongest influence on behavioral intention, highlighting the importance of social factors in Pilates participation.

Discussion/conclusion: This study underscores the role of perceived value in shaping attitudes and confirms the dominant impact of subjective norms on behavioral intention. The findings offer theoretical contributions by refining the ETPB model and provide practical insights for enhancing engagement in Pilates programs.

Originality/value: This study contributes to the literature by applying an ETPB model to the context of Pilates, incorporating perceived value as an additional factor. It challenges the traditional emphasis on attitude as the primary predictor of behavioral intention by highlighting the dominant role of subjective norms. These insights offer a more nuanced understanding of the factors driving Pilates participation and provide practical implications for developing strategies to enhance engagement and retention in Pilates programs.

KEYWORDS

Pilates, perceived value, theory of planned behavior, behavioral intention, subjective norms, social influence

Introduction

'Pilates is not just exercise; it is a pathway to a balanced and harmonious body and mind' (Kim and Jeong, 2022).

Pilates, originally developed in the 1920s, has become a globally recognized exercise method known for enhancing physical health and well-being (Joseph and Simona, 2004).

Given its increasing popularity, it is crucial to understand the factors influencing participation. In South Korea, Pilates ranks among the most popular fitness activities, following golf and swimming, with health maintenance being the primary motivation for participation. The growing preference for Pilates can be attributed to its promotion through various media as a health and fitness program, leading to its perception as a viable option for daily exercise. Consequently, the participation rate in Pilates has been steadily increasing, and the number of related facilities has grown to meet the demand (Jang and Kim, 2019).

Perceived value plays a pivotal role in shaping consumer attitudes and behaviors (Zeithaml, 1988; Kim and Ryu, 2016). While prior studies have explored its role in various domains, research on its impact within the context of exercise participation, particularly Pilates, remains limited. This study addresses this gap by examining how different dimensions of perceived value influence attitudes and behavioral intentions in Pilates participation.

Various theories have been developed to understand and predict human behaviors. The Theory of Planned Behavior (TPB), proposed by Ajzen (1991), is a prominent theory in this regard, particularly in explaining exercise behavior at the decision-making level. Since Pilates participation is a voluntary exercise behavior, it aligns well with the TPB framework. The decision to engage in Pilates can be influenced by individuals' attitudes toward Pilates, perceived social norms, and their perceived ability to continue practicing it.

However, previous studies indicate that the TPB alone may not adequately encompass the intricacies of decisions regarding exercise participation. The TPB elucidates intention development via attitude, subjective norms, and perceived behavioral control; yet, supplementary elements, such as perceived value, can substantially affect individuals' motivation to engage in fitness activities (Kim and Moon, 2015). This study used an extended TPB (ETPB) model by integrating perceived value as an extra predictor, hence offering a more thorough comprehension of Pilates participation behavior.

Building upon this theoretical foundation, the TPB incorporates the concept of perceived behavioral control (PBC) into the Theory of Reasoned Action (TRA) to better predict individuals' behaviors and intentions. PBC refers to an individual's perceived ease or difficulty in performing a specific behavior (Ajzen, 1991), based on the perceived presence of factors that may impede or facilitate the behavior and the perceived power of these factors (Ajzen, 1991; Han et al., 2014). Incorporating PBC into behavior analysis has enhanced the predictive power for individual decision-making (Armitage and Conner, 2001; Ajzen and Fishbein, 2000).

In this theoretical context, Hagger et al. (2002) applied the TPB to predict exercise behavior, finding that attitudes toward exercise, subjective norms, and perceived behavioral control significantly influenced behavioral intention. Similar results were reported in studies predicting participation intention and actual participation in fitness exercises among female participants (Kwon et al., 2017) and continuous exercise participation among college students in physical education courses (Seo et al., 2015). These studies confirm that the TPB provides a robust framework for explaining behavioral intentions and exercise behaviors (Hausenblas et al., 1997).

While TPB has been widely applied in exercise research, its application to Pilates remains limited. This study addresses this gap by extending the TPB model to analyze Pilates participation. Unlike

previous studies that primarily focused on general fitness or other types of exercise, this research specifically investigates the effects of functional, emotional, and social values on attitudes toward Pilates. Moreover, it evaluates how these attitudes, along with subjective norms and perceived behavioral control, influence behavioral intentions and continuous participation intentions for Pilates. This study's primary contribution lies in its novel application of the TPB to the context of Pilates, providing insights that are specific to this increasingly popular form of exercise. By incorporating the concepts of functional, emotional, and social values, this research offers a more comprehensive understanding of the motivational factors influencing Pilates participation. Additionally, the findings are expected to inform strategies for fitness professionals and facility managers to enhance engagement and retention among Pilates participants. By developing a behavior model that predicts Pilates students' participation intentions and behaviors, this study contributes to the broader literature on exercise psychology and consumer behavior.

Despite the increasing popularity of Pilates as a fitness activity, empirical research on the psychological and behavioral determinants of Pilates participation remains limited (Kim and Jeong, 2022). While existing studies have extensively examined general exercise behaviors using the TPB framework (Lu et al., 2022; Zhang et al., 2022), few have specifically explored how perceived value influences Pilates engagement. Considering that Pilates prioritizes accuracy, control, and mind-body coordination—unlike traditional fitness programs—its motivating factors for participation may vary from those of typical workout activities. Comprehending these distinct characteristics is crucial for formulating focused ways to improve engagement and retention in Pilates programs. This gap highlights the necessity for additional research on how perceived value influences attitudes and behavioral intentions within the realm of Pilates.

Therefore, this study aims to examine the major values and participation intentions of Pilates students using an extended model of the Theory of Planned Behavior (TPB). Specifically, this study evaluates the effects of functional, emotional, and social value on attitudes toward Pilates and the impact of attitude, subjective norms, and perceived behavioral control on behavioral intention and continuous participation intention in Pilates. The findings are expected to inform strategies for guiding individuals to make rational decisions by developing a behavioral model predicting Pilates students' behavior.

Theoretical framework and research hypotheses

Perceived value

Value can be defined as consumers' overall evaluation of a product (Zeithaml, 1988). Value, developed from the benefits gained from a product and the cost related to these benefits, leads to a positive evaluation of the company in the long run. The value types can be categorized based on three dichotomous dimensions: self-oriented or other-oriented, active or reactive, and intrinsic or extrinsic (Holbrook, 1999). Consumers' perceived value is the fourth most important factor in attracting consumers, following quality, satisfaction, and loyalty (Jamal and Muhammad, 2011).

Perceived value is a multifaceted concept that includes functional, emotional, and social dimensions, which profoundly influence customer attitudes and behavioral intentions (Sweeney and Soutar, 2001). Recent studies have expanded the application of perceived value in exercise psychology. For instance, Kim and Moon (2015) examined how perceived value influences individuals' motivation to engage in fitness activities, highlighting its significant role in shaping exercise intentions. Similarly, Ha and Kim (2023) analyzed the behavioral intention of Pilates participants by applying an extended theory of planned behavior (ETPB) model, incorporating perceived value as a key factor. These findings support the integration of perceived value within the ETPB framework for understanding Pilates participation.

Previous studies show that perceived value is essential in shaping favorable attitudes towards exercise behavior, therefore affecting intentions to participate (Kim and Moon, 2015). Functional value denotes the tangible advantages of an activity, including the promotion of physical health and the development of skills. Emotional value encompasses the inherent pleasure and psychological fulfillment obtained from engagement. Social value denotes the relational and societal advantages linked to group-oriented activities (Sheth et al., 1991). This study used an Extended TPB model, asserting that functional, emotional, and social values influence the development of attitudes about Pilates involvement. Sheth et al. (1991) expanded the concept of perceived value by presenting five elements: social, emotional, functional, conditional, and epistemic. In this study, a multidimensional approach was taken to investigate perceived value, focusing on the analysis of perceived value based on the study by Sweeney et al. (1999), which categorized value into social, functional, and emotional dimensions.

The TPB posits that attitude is a key determinant of behavioral intention (Ajzen, 1991). While TPB traditionally emphasizes cognitive evaluations in shaping attitudes, recent studies have highlighted the importance of perceived value in this process (Sweeney and Soutar, 2001; Kim and Moon, 2015). Perceived value encompasses functional, emotional, and social aspects, which influence attitudes toward behavioral engagement. Accordingly, this study integrates the perceived value framework into TPB, hypothesizing that functional, emotional, and social value positively influence attitudes toward Pilates participation.

Similarly, Teng et al. (2014) assessed the intention to visit an eco-friendly restaurant using the VAB model, reporting that higher perceived value leads to a higher level of positive attitude, which in turn is associated with a stronger behavioral intention and visit intention. They also claimed that attitude mediates the causal relationship between perceived value and behavioral intention.

As described above, previous studies on the influence of perceived value on attitude suggest that perceived value is a variable applicable as an indicator for predicting potential customer behavior (Bae et al., 2015). Therefore, this study examined which values positively affect attitudes among Pilates participants by applying a multidimensional concept of perceived value. Additionally, the study investigated the influence of the attitudes formed through perceived value on the behavioral intention of Pilates participants by applying a model of the extended ETPB.

H1. Pilates participants' functional value will have a significant positive effect on their attitude toward Pilates.

H2. Pilates participants' emotional value will have a significant positive effect on their attitude toward Pilates.

H3. Pilates participants' social value will have a significant positive effect on their attitude toward Pilates.

Theory of planned behavior (TPB) and extended theory of planned behavior (ETPB)

Fishbein and Ajzen (1975) proposed the Theory of Planned Behavior (TPB), an extension of the Theory of Reasoned Action (TRA). The TPB suggests that behavioral intention and behavior prediction depend on three key factors: attitude toward the behavior, subjective norms, and perceived behavioral control (Ahmed et al., 2017). Attitude refers to positive or negative evaluations of performing the behavior (Seo and Lee, 2015), while subjective norms encompass social influences and represent the general views of significant others about the behavior (Cho, 2019). Perceived behavioral control relates to an individual's confidence or ability to control the necessary factors for performing a particular behavior, essentially reflecting the perceived ease or difficulty of performing the behavior (Ajzen, 1991; Kim, 2014). The TPB posits that these three factors influence an individual's intention to perform a behavior, which subsequently impacts the actual execution of the behavior (Taylor and Todd, 1995).

Ajzen (1991) also suggested that additional predictor variables could be included if they enhance the TPB's explanatory power. While the TPB is generally considered superior to existing behavioral theories in predicting behavioral intentions and actual behaviors (Dawkins and Frass, 2005; Lam and Hsu, 2004), some researchers argue that its explanatory power can still be insufficient. Therefore, they recommend adding antecedents that can improve the theoretical model's explanatory power (Bagozzi, 1981; Ouellette and Wood, 1998; Vallerand et al., 1993).

As a result, studies have emerged attempting to apply an ETPB model by incorporating additional variables into the TPB framework. For instance, Yoon et al. (2010) included perceived risk and prior knowledge to investigate Koreans' intention for international travel. Quintal et al. (2010) added perceived risk and uncertainty in their analysis. Lin and Chen (2006) incorporated prior knowledge, finding that it positively affects a consumer's purchase decision and decision-making process for choosing a brand, strongly impacting behavioral intention. Kim and Moon (2015) examined the influence of value on the behavioral intention for outdoor recreational activities among automobile campers.

Building on these previous studies, this research examines the influence of perceived value on the behavioral intention of Pilates participants through a conceptual extension of the TPB. Specifically, it considers perceived value as an additional variable alongside attitude, subjective norms, and perceived behavioral control, aiming to explore how these factors collectively influence Pilates participants' behavioral intentions.

Based on the theoretical framework, the following hypotheses were formulated: (See Figure 1).

H4. Pilates participants' attitudes will have a significant effect on their behavioral intention for Pilates.

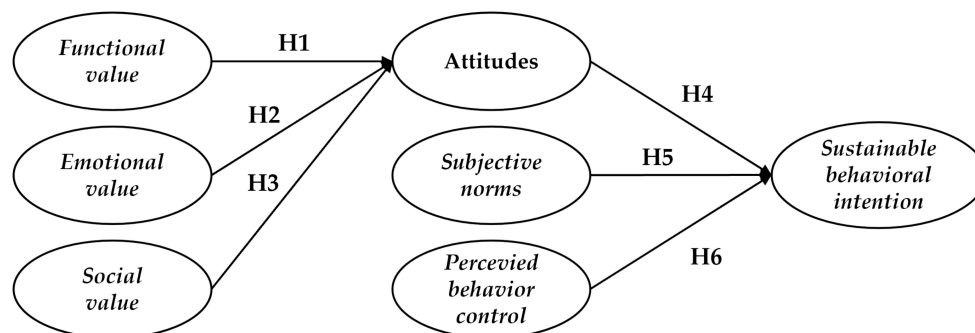


FIGURE 1
Conceptual model.

H5. Pilates participants' subjective norms will have a significant effect on their behavioral intention for Pilates.

H6. Pilates participants' perceived behavioral control will have a significant effect on their behavioral intention for Pilates.

A summary of the proposed hypotheses and their supporting literature is presented in [Table 1](#).

This study expands previous studies by exploring the influence of perceived value on Pilates participants' behavioral intentions through an extended TPB model. Perceived value is examined as an additional determinant alongside attitude, subjective norms, and perceived behavioral control to understand how these factors collectively shape Pilates engagement. While TPB has been widely applied in various fitness contexts—such as general exercise adherence ([Lu et al., 2022](#); [Zhang et al., 2022](#)) and recreational sports participation ([Kim and Kim, 2021](#))—limited studies have specifically investigated its relevance to Pilates. Unlike conventional fitness programs, Pilates emphasizes controlled movements, posture alignment, and mind–body integration, which may amplify the role of perceived value in forming participation attitudes. Given these unique characteristics, incorporating perceived value into the TPB framework provides a more comprehensive perspective on Pilates participation.

In summary, this study seeks to understand the relationships between perceived value, attitudes, subjective norms, perceived behavioral control, and the behavioral intentions of Pilates participants by extending the TPB framework. The findings are expected to provide valuable insights into the factors influencing Pilates participation, thereby informing strategies to enhance engagement and retention in Pilates programs.

Method

Data collection

Data was collected through a questionnaire survey conducted during personal on-site visits among Pilates participants. The questionnaire was administered in person using a paper-based survey. The participants were selected using convenience sampling, a non-probability sampling method. The target population comprised Pilates students enrolled in Pilates centers located in Busan, Ulsan,

and Gyeongbuk Province. The participants were selected using convenience sampling, a non-probability sampling method. The target population comprised individuals participating in Pilates classes in South Korea. Although the exact size of the total Pilates population is unknown, according to the 2021 data from Statistics Korea, the participation rate for yoga, taekwondo, and Pilates combined was approximately 7.2% among those engaged in sports activities. A total of 301 questionnaires were distributed, and participants were asked to complete the questionnaire using a self-administered survey method. After collection, 288 questionnaires were deemed suitable for analysis, as 13 questionnaires were excluded due to issues such as insincere or duplicate responses. [Table 2](#) provides the general characteristics of the participants.

Ethical considerations

This study adhered to ethical research guidelines, ensuring voluntary participation, anonymity, and data confidentiality. Participants were informed about the purpose of the study, and their consent was obtained before completing the survey. No personally identifiable information was collected, and all responses remained anonymous.

Measure

In this study, a questionnaire survey was conducted to collect data. Except for questions regarding the general characteristics of participants, each item on functional, emotional, and social values, subjective norms, perceived behavioral control, and behavioral intention was rated on a five-point Likert scale ranging from 'Strongly disagree/Not at all' to 'Strongly agree/Extremely'. The scale for perceived value, which explains attitudes toward behavior and is composed of the three dimensions of functional, emotional, and social values, was adapted from [Sweeney and Soutar \(2001\)](#). The original scale was modified and complemented for this study, incorporating elements from [Yoon et al. \(2011\)](#). The final scale to assess perceived value consisted of 11 items: four items on functional value, four items on emotional value, and three items on social value. For the TPB constructs, a modified version of the scale developed by [Ajzen and Driver \(1992\)](#) and [Ajzen \(2001\)](#) was used. This scale was adjusted and complemented to suit the purpose of this study, based on the

TABLE 1 Summary of hypotheses.

Hypothesis	Relationship
H1	Functional value → Attitude
H2	Emotional value → Attitude
H3	Social value → Attitude
H4	Attitude → Behavioral intention
H5	Subjective norms → Behavioral intention
H6	Perceived behavioral control → Behavioral intention

TABLE 2 Characteristics of subjects.

	Characteristics	N (%)
Gender	Male	38 (13.1)
	Female	250 (86.8)
Ages	10's	15 (0.5)
	20's	104 (36.1)
	30's	112 (38.8)
	40+ years old	57 (19.7)
Careers	Less than 6 months	61 (21.1)
	6 months – less than 1 year	74 (24.6)
	More than 1 year – Less than 2 years	62 (21.5)
	More than 2 years – Less than 3 years	59 (20.4)
	More than 3 years	32 (11.1)

modifications suggested by [So \(2021\)](#). The TPB scale used in this study consisted of 16 items: five items on attitude, four items on subjective norms, three items on perceived behavioral control, and four items on behavioral intention. [Table 3](#) presents the detailed survey measurement items, including the number of items per construct and their sources.

To ensure content validity, the modified survey items were reviewed by a physical education professor and two researchers holding PhDs in physical education. The experts evaluated if the modified items accurately measured the desired constructs related to Pilates participation. In response to their suggestions, slight adjustments were implemented to enhance clarity and relevance prior to finishing the questionnaire. Prior to distributing the primary survey, a pre-test was administered to a small cohort of Pilates participants ($N = 77$) to evaluate the clarity and comprehensibility of the revised items. Minor phrasing tweaks were implemented to improve clarity based on their suggestions. The finished questionnaire was prepared for data collection.

Statistical analysis

In this study, 288 completed questionnaires were selected as valid samples for data analysis. The analysis was carried out using SPSS 22.0 and AMOS 24.0 software. First, frequency analysis and descriptive statistics were performed to examine the demographic characteristics of the participants. This step provided an overview of the sample's demographic profile, including age, gender, and other relevant attributes. Next, reliability analysis was conducted using Cronbach's α

coefficient to assess the internal consistency of the scales. This ensured that the items within each scale were consistently measuring the same underlying construct. To assess the convergent validity of the measurement models, confirmatory factor analysis (CFA) was conducted using AMOS 24.0. This analysis verified that the items used in the scales adequately represented the underlying constructs they were intended to measure. Correlation analysis was then performed to test for multicollinearity among the variables. This step was crucial to ensure that the variables included in the model were sufficiently independent of each other. Finally, structural equation modeling (SEM) was employed to examine the causal relationships between the measured variables. SEM allowed for a comprehensive analysis of the hypothesized model, enabling the assessment of both direct and indirect effects among the constructs.

Confirmatory factor analysis and reliability analysis

Using the collected questionnaires as analysis data, confirmatory factor analysis (CFA) was conducted to determine if the internal structure of each variable was adequately constructed. This analysis was essential to confirm that the items were measuring the intended constructs properly. In addition to CFA, reliability analysis was performed using Cronbach's α coefficient to assess both construct validity and reliability. This step ensured that the measurement tools were consistently reliable and valid.

For model fit indices, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA) were applied. These indices were chosen because they are relatively insensitive to sample size and consider model simplicity ([Hair et al., 2010](#)). The thresholds for model fit indices were set as follows: CFI and TLI values of 0.90 or higher, and RMSEA values of 0.08 or lower ([Hu and Bentler, 1999](#); [Kline, 2011](#)). All threshold conditions were satisfied in this study. Furthermore, for each factor, the Average Variance Extracted (AVE) value was 0.6 or higher, indicating adequate convergent validity. The construct reliability and Cronbach's α coefficient were both 0.7 or higher, surpassing the threshold for reliability ([Hair et al., 2010](#)). These results confirm that the constructs measured in this study are both valid and reliable. [Table 4](#) provides the detailed results of the above analyses.

Discriminant validity was further assessed using the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. [Table 5](#) presents the Fornell-Larcker results, demonstrating that the square root of AVE values for each construct exceeded their corresponding inter-construct correlation coefficients, confirming discriminant validity. Furthermore, [Table 6](#) reports the HTMT ratios, all of which were below the conservative threshold of 0.85 ([Henseler et al., 2015](#)), further verifying discriminant validity. These results indicate that the constructs in this study are distinct and measure separate theoretical concepts.

In addition to correlation analysis, Variance Inflation Factor (VIF) values were computed to evaluate multicollinearity among predictor variables. The findings indicated that all VIF values varied from 1.98 to 2.74, much below the established threshold of 10 ([Thompson et al., 2017](#)), hence demonstrating the absence of multicollinearity concerns.

TABLE 3 Summarized survey measurement items.

Construct		Example survey item
Functional value	1	Pilates helps me improve my physical strength.
	2	Pilates improves my flexibility and balance.
	3	Pilates enhances my overall physical condition.
	4	Pilates is beneficial for my daily activities.
Emotional value	1	I feel happy and satisfied after doing Pilates.
	2	Pilates helps me relieve stress.
	3	Pilates gives me a sense of accomplishment.
	4	Pilates participation makes me emotionally fulfilled.
Social value	1	I enjoy doing Pilates because I can interact with others.
	2	Pilates participation strengthens my social relationships.
	3	Pilates makes me feel part of a community.
Attitude	1	I have a positive attitude toward participating in Pilates.
	2	Pilates is an enjoyable activity.
	3	I believe that doing Pilates is beneficial for me.
	4	I am satisfied with my decision to do Pilates.
	5	I consider Pilates as an important part of my lifestyle.
Subjective norms	1	People who are important to me think I should do Pilates.
	2	My family and friends encourage me to do Pilates.
	3	Many people around me think Pilates is a good activity.
	4	My peers influence my decision to participate in Pilates.
Perceived behavioral control	1	I believe I can consistently participate in Pilates.
	2	I have the necessary resources to continue doing Pilates.
	3	I can overcome any obstacles that might prevent me from doing Pilates.
Behavioral intention	1	I intend to continue doing Pilates in the future.
	2	I plan to regularly attend Pilates sessions.
	3	I will recommend Pilates to my friends.
	4	I will make an effort to prioritize Pilates in my schedule.

Results

Correlation analysis

Correlation analysis is a valuable tool for hypothesis verification in exploratory research, as it provides a broad overview of the relationships between variables. By showing the strength of the relationships between key variables, correlation analysis helps to outline the connections used in all research hypotheses before performing detailed hypothesis testing. In this study, Pearson's correlation analysis was conducted to examine the correlations and directionality for each scale related to each research unit. Table 5 presents the results of this analysis. The analysis results revealed that the relationships between variables aligned with the hypotheses formulated in this study. Additionally, all correlation coefficients were lower than 0.80, indicating that multicollinearity was not a concern. The results of the correlation analysis suggest that the variables are sufficiently independent to be included in the subsequent structural equation modeling (SEM) analysis, thereby supporting the validity of the constructs used in this study.

Tests of model fit for the research model

Based on previous studies, the tests of model fit for the research model were conducted using several fit indices, including the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). These indices were chosen for their ability to evaluate the model's fit while considering its simplicity and suitability. The assessment of the proposed model's fit yielded the following results: a CFI of 0.927, a TLI of 0.916, and an RMSEA of 0.077. According to the conventional thresholds, a CFI and TLI greater than 0.90 indicate a good fit, and an RMSEA less than 0.08 also signifies a good fit (Hu and Bentler, 1999; Kline, 2011). These results indicate that the proposed model fits well with the data, demonstrating both simplicity and suitability. Table 7 provides the detailed results of the model fit indices.

Hypothesis verification

The path coefficients between the variables, as depicted in Table 8, are presented in accordance with the hypotheses of this study to verify

TABLE 4 Summarized results for the validity and reliability assessments.

Variable		Items	Standardization factor	Concept trust	AVE	α
Perceived value	Functional value (FV)	1	0.784	0.894	0.680	0.893
		2	0.881			
		3	0.830			
		4	0.802			
	Emotional value (EV)	5	0.710	0.906	0.709	0.911
		6	0.796			
		7	0.901			
		8	0.942			
	Social value (SV)	9	0.761	0.834	0.628	0.833
		10	0.787			
		11	0.828			
Theory of behavior	Attitudes (AT)	1	0.844	0.937	0.751	0.924
		2	0.923			
		3	0.838			
		4	0.900			
		5	0.826			
	Subjective norms (SN)	6	0.870	0.951	0.829	0.951
		7	0.910			
		8	0.909			
		9	0.952			
	Perceived behavioral control (PBC)	10	0.741	0.860	0.674	0.770
		11	0.932			
		12	0.778			
Sustainable Behavioral Intention (SBI)		1	0.889	0.962	0.864	0.967
		2	0.849			
		3	0.972			
		4	1.002			

$\chi^2 = 651.024$, $df = 301$, CFI = 0.959, TLI = 0.953, RMSEA = 0.058.

TABLE 5 Discriminant validity.

	FV	EV	SV	ATT	SN	PBC	SBI
FV	0.82						
EV	0.517**	0.85					
SV	0.576**	0.646**	0.81				
ATT	0.235**	0.287**	0.134**	0.87			
SN	0.165**	0.169**	0.067**	0.763**	0.88		
PBC	0.226**	0.185**	0.190**	0.604**	0.503**	0.82	
SBI	0.010**	−0.037**	−0.113**	0.029**	0.130**	0.125**	0.93

** $p < 0.01$. The bold values in table represent the square root of the average variance extracted (AVE), which is used to assess discriminant validity.

TABLE 6 Fornell-Larcker criterion for discriminant validity.

	FV	EV	SV	ATT	SN	PBC	SBI
FV	1.00						
EV	0.67	1.00					
SV	0.72	0.75	1.00				
ATT	0.31	0.37	0.22	1.00			
SN	0.22	0.25	0.15	0.85	1.00		
PBC	0.27	0.22	0.21	0.65	0.55	1.00	
SBI	0.02	−0.05	−0.14	0.03	0.17	0.15	1.00

TABLE 7 Model fit.

	χ^2	df	CFI	TLI	RMSEA
Fit	933.897	306	0.927	0.916	0.077

their validity. H1: The analysis examining the relationship between functional value and attitude (PBT) estimated the path coefficient to be 0.174 ($t = 2.148$, $p < 0.05$), indicating that functional value has a significant positive effect on attitude. H2: The analysis identifying the relationship between emotional value and attitude (PBT) yielded a path coefficient of 0.126 ($t = 1.685$, $p = 0.092$), suggesting that emotional value does not significantly affect attitude. H3: The analysis identifying the relationship between social value and attitude (PBT) produced a path coefficient of 0.364 ($t = 3.900$, $p < 0.001$), indicating that social value has a significant positive effect on attitude. H4: The analysis identifying the relationship between attitude and behavioral intention estimated the path coefficient to be 0.192 ($t = 3.576$, $p < 0.001$), indicating that attitude positively affects behavioral intention. H5: The analysis of the relationship between subjective norms and behavioral intention found a path coefficient of 0.199 ($t = 3.185$, $p < 0.001$), indicating that subjective norms have a statistically significant effect on behavioral intention. H6: The analysis identifying the relationship between perceived behavioral control and behavioral intention estimated the path coefficient to be 0.127 ($t = 1.981$, $p < 0.05$), indicating that perceived behavioral control has a significant positive effect on behavioral intention. These results provide support for most of the hypotheses, demonstrating significant relationships between the majority of the constructs examined in this study. The only exception was the hypothesis regarding the relationship between emotional value and attitude, which did not reach statistical significance.

Discussion

Theoretical implications

This study attempted to predict the behavior of Pilates participants based on the perceived value related to the formation process of Pilates participation intention. The results showed that among the three subfactors of perceived value, functional and social values positively affect attitudes toward Pilates, while emotional value does not have a significant effect. Additionally, subjective norms and perceived behavioral control positively affected Pilates behavioral intention.

First, the analysis of the relationships between functional, emotional, and social values and attitudes revealed that functional and social values positively influence the formation of attitudes toward Pilates among participants, but emotional value does not. The decision to regard functional and social values exclusively as determinants of attitude, instead of subjective norms or perceived behavioral control, is based on theoretical rationale. Previous studies indicate that perceived value predominantly affects an individual's evaluative judgment (i.e., attitude) on an activity, as it embodies own evaluations of advantages and compromises rather than external influences or perceived limitations (Ajzen, 1991; Sweeney and Soutar, 2001). This internal appraisal process differentiates attitude from subjective norms and perceived behavioral control, which are more affected by external social and environmental influences. Consequently, value functions as a fundamental precursor of attitude, bolstering its influence on behavioral intention within the TPB framework.

Functional value impacts attitudes because it encompasses the practical benefits participants perceive from Pilates, such as improved physical health, strength, and flexibility. These tangible outcomes are directly aligned with the participants' initial motivations for engaging in Pilates. The finding of this study aligns with prior research suggesting that functional value significantly influences attitude formation. Um and Yoon (2021) demonstrated that perceived functional value of a tourism gentrification experience positively shaped their attitudes, reinforcing the idea that tangible benefits play a crucial role in shaping evaluative judgments. Social value, on the other hand, had a more substantial impact on attitudes compared to functional value. This indicates that the improvement of interpersonal relationships, economic benefits, and time efficiency are significant factors in shaping positive attitudes towards Pilates. The community and social interactions experienced during Pilates classes contribute to a sense of belonging and support, which enhances participants' overall satisfaction and commitment to the practice. The finding of

TABLE 8 Hypothesis test by structural parameter estimates.

	Factors	Path (β)	S.E.	t	Results
H1	Functional value → Attitudes	0.174	0.092	2.148*	Accepted
H2	Emotional value → Attitudes	0.126	0.072	1.685	Verified
H3	Social value → Attitudes	0.364	0.070	3.900***	Accepted
H4	Attitudes → behavioral intention	0.192	0.054	3.576***	Accepted
H5	Subjective Norms → behavioral intention	0.199	0.061	3.185***	Accepted
H6	perceived behavioral control → behavioral intention	0.127	0.067	1.981*	Accepted

*** $p < 0.001$; * $p < 0.5$.

this study is consistent with previous research demonstrating that social value significantly influences attitudes. Roh et al. (2022) found that green perceived value, encompassing social value, had a substantial impact on consumer attitudes toward organic food consumption, reinforcing the role of social factors in shaping evaluative judgments. Emotional value, however, did not significantly impact attitudes, which contrasts with other research emphasizing the importance of emotions in influencing attitudes (Roh et al., 2022). A potential reason for this divergence is that Pilates participants may emphasize concrete benefits, such as physical enhancement and social interaction, over emotional satisfaction when developing attitudes toward participation. In contrast to group-based fitness programs like Zumba or dance aerobics, which rely on emotional engagement as a primary motivator, Pilates prioritizes precision and control. This emphasis on skill and organized movement patterns may cause individuals to view functional and social advantages as more significant in influencing their attitudes than emotional considerations.

These findings contribute to the broader literature by validating the role of perceived value within the extended TPB framework. In contrast to conventional fitness pursuits, where emotional involvement greatly affects attitudes, Pilates participants seem to be primarily motivated by pragmatic and social advantages. This observation highlights the necessity for customized engagement tactics that correspond with the distinct attributes of Pilates practice.

Second, with respect to the prediction about the formation process of Pilates behavioral intention of Pilates participants, the analysis results of relationships between attitude, subjective norms, perceived behavioral control, and behavioral intention revealed that attitude, subjective norms, and perceived behavioral control all have a positive impact on behavioral intention. These results are consistent with studies such as those on the purchase intention for green products among Tai consumers by Maichum et al. (2016), which reported that attitude, subjective norms, and perceived behavioral control all positively affect purchase intention. Similarly, Lee (2012) reported the positive effects of TPB variables on participation in sports among the physically disabled, and Jang and Kim (2019) found that these variables positively affect the behavioral intention for continuous exercise participation among college students.

However, subjective norms were found to have the most substantial influence on behavioral intention, which is contrary to many previous sports studies where attitude was identified as the most critical factor (Seonwoo and Jeong, 2021). The influence of subjective norms indicates that the opinions and behaviors of significant others, such as instructors, peers, and social groups, play a crucial role in shaping participants' intentions to continue Pilates. This finding suggests that social influence and the desire to meet the expectations

of important others are strong motivators for continued engagement (Kim and Jeong, 2024; Yu and Jeong, 2022). Perceived behavioral control also significantly impacts behavioral intention as it reflects the participants' confidence in their ability to perform Pilates exercises and overcome potential barriers. When participants feel capable and supported, they are more likely to intend to continue. Therefore, improving perceived behavioral control can involve ensuring that the Pilates environment, including location, equipment, amenities, and transportation, is conducive to participation.

These results confirm the robustness of the extended TPB model in explaining Pilates participation behavior. This study illustrates the preeminent role of social factors in determining behavioral intention, hence contesting traditional views that see attitude as the foremost determinant of intention. This discovery significantly contributes to exercise psychology by highlighting the impact of external factors on long-term participation behaviors.

Therefore, the findings of this study have significant academic implications. They suggest that in the context of Pilates, social and functional values play a more crucial role in shaping attitudes than previously thought, with social values being particularly influential. This highlights the need for further research into the social dimensions of fitness activities and their impact on participation. Moreover, the strong influence of subjective norms on behavioral intention challenges the traditional emphasis on attitudes as the primary predictor. This underscores the importance of considering social influences and perceived support systems in studies of exercise behavior. These insights contribute to the broader understanding of how different values and social factors interact to shape health-related behaviors, offering a more nuanced view of the factors driving Pilates participation. By recognizing the significant role of social influences, future research can better address the complex interplay of factors that motivate individuals to engage in and sustain fitness activities like Pilates.

Practical implications

To promote the continuous growth of the Pilates industry, Pilates studios should invest in developing differentiated programs that reflect the emotional and sensory dimensions of participants. This will ensure that Pilates participation is perceived as enjoyable and attractive. Exercise programs with inventive elements that stimulate students' interest are likely to be more effective than typical, indistinctive programs.

Enhancing social value within Pilates studios can be achieved by fostering a sense of community and encouraging social interactions.

This can be done through organizing social events, group classes, and workshops that allow participants to connect and build relationships. Creating an environment where participants feel a sense of belonging and support can significantly enhance their commitment and enjoyment of Pilates.

Instructor training is another critical area for improvement. Ensuring that instructors are well-trained to provide positive reinforcement, build strong relationships with participants, and create an encouraging atmosphere can enhance participants' perceived behavioral control and foster positive attitudes towards Pilates.

Improving the physical environment of Pilates studios is also essential. Studios should be easily accessible, well-equipped, and provide amenities such as comfortable changing rooms and relaxation areas. Addressing logistical barriers and ensuring a high-quality environment can improve overall participant satisfaction and encourage continued participation.

Promotional campaigns should highlight the functional and social benefits of Pilates. Emphasizing how Pilates can improve physical health, enhance social connections, and provide a valuable use of time can attract more participants and reinforce the benefits of continued participation.

Finally, implementing regular feedback systems to gather participants' opinions and suggestions can help studios continually improve their programs and services. By responding to the evolving needs and preferences of participants, studios can ensure they remain relevant and engaging, ultimately supporting long-term retention and satisfaction.

Conclusion

This study analyzed the behavioral intention of Pilates participants by applying an ETPB model, incorporating perceived value (functional, social, and emotional value) as an additional factor in the existing TPB model. The results suggested that the behavioral intention of Pilates participants can be improved through attitudes towards Pilates exercise and perceived behavioral control, both of which are also influenced by subjective norms. In addition, the perceived value significantly impacts both behavioral attitude and behavioral intention.

The study revealed that social value has a more substantial impact on attitudes compared to functional value. This finding indicates that the improvement of interpersonal relationships, economic benefits, and time efficiency are significant factors in shaping positive attitudes towards Pilates. The community and social interactions experienced during Pilates classes contribute to a sense of belonging and support, enhancing participants' overall satisfaction and commitment to the practice. On the other hand, emotional value did not significantly influence attitudes, possibly because the immediate and measurable benefits of functional and social values overshadow the more subjective and personal aspects of emotional experiences. Participants might prioritize practical and social outcomes over emotional ones when evaluating their attitudes towards Pilates.

The analysis also showed that subjective norms have the most substantial influence on behavioral intention, which contrasts with many previous sports studies where attitude was identified as the

most critical factor. This suggests that the opinions and behaviors of significant others, such as instructors, peers, and social groups, play a crucial role in shaping participants' intentions to continue Pilates. Social influence and the desire to meet the expectations of important others are strong motivators for continued engagement. Perceived behavioral control also significantly impacts behavioral intention, reflecting the participants' confidence in their ability to perform Pilates exercises and overcome potential barriers. When participants feel capable and supported, they are more likely to intend to continue.

To improve the behavioral intention of Pilates participants, efforts should focus on preventing the reduction of positive attitudes and enhancing perceived behavioral control for Pilates activities. It is also necessary to elevate the functional value of Pilates exercises and promote the formation of active social value accompanying participation in Pilates. Holding various events to induce participation, such as programs linked to social clubs of people with shared hobbies or interests, can be effective. Providing up-to-date information on facilities, locations, and participation effects through the homepage and various media can also increase perceived value.

Concerning the limitations of this study, although the perceived value had already been formed to some extent and affected the performance of Pilates behavior among participants, this study did not conduct a comparative analysis of perceived value considering the participants' length of experience with Pilates. Future research should include a comparative analysis considering this factor to provide more elaborate interpretations and suggestions. Additionally, various explanatory variables reflecting motivation should be employed in future analyses of behavioral intention by extending the TPB. This approach will provide a broader understanding of the behavioral intention of Pilates participants and produce meaningful research outcomes that can be actively applied in the field. Moreover, future research could incorporate a mean comparison test to examine potential differences across demographic groups, such as gender and career. Analyzing whether these demographic factors influence perceived value and behavioral intention could provide deeper insights into individual variations in Pilates participation. Furthermore, future research should consider comparing Pilates practitioners with non-practitioners to determine whether the observed relationships hold across different groups. This comparison may offer important new information about the variables affecting both initial and ongoing involvement. Additionally, exploring the potential mediating impact of functional and social values on the relationship among attitude, subjective norms, perceived behavioral control, and behavioral intention may augment the model's explanatory capacity. This method may elucidate the indirect mechanisms by which perceived value influences behavioral outcomes. In addition, this study offers useful information into Pilates participation; nevertheless, the generalizability of the findings is constrained by the reliance on convenience sampling and data collecting from select Pilates centers in a restricted region. Further studies should incorporate a more heterogeneous sample from other geographic and cultural contexts to improve the external validity of the results. Finally, future study could further refine the model by incorporating demographic control variables to explore their potential moderating effects. However, given that the primary objective of this study was to

validate the theoretical framework of the extended TPB model, the exclusion of control variables does not undermine the validity of the findings.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Korean National University of Transportation Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Writing – original draft. YJ: Investigation, Methodology,

Project administration, Resources, Writing – review & editing. YJ: Software, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Effectiveness and acceptance of virtual reality vs. traditional exercise in obese adults: a pilot randomized trial

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Introduction: Obesity is a significant global health concern, increasing the risk of various diseases and health complications. Effective and engaging exercise interventions are urgently needed for obesity management. This pilot study examines the effectiveness of virtual reality (VR)-based exercise compared to traditional exercise, both combined with Self-Determination Theory (SDT)-based counseling, individuals with obesity.

Methods: Forty individuals with overweight/obesity were randomly assigned to either a VR-based exercise group (intervention) or a traditional exercise group (control), with both groups receiving SDT-based counseling over 4 weeks. Assessments were conducted pre- and post-intervention.

Results: Participants in the VR-based exercise group showed significant reductions in BMI (2.6%) and body fat mass (5.3%) and consequently in hips circumference, compared to the control group. They also exhibited greater increases in physical activity levels, and improved psychological outcomes, including basic psychological needs (BPN), self-efficacy, self-esteem, and attitudes toward the program comparing with the control group. Moreover, the intervention group scored higher in interest/enjoyment and attitudes towards exercise compared with the control group and showed great results in perceived enjoyment, intention for future use, usability, and positive perceptions of using the VR system. Based on the participants' interviews, VR-based exercise was found to be more enjoyable and engaging.

Discussion: These findings suggest that VR-based exercise combined with counseling is more effective than traditional exercise in reducing weight, increasing physical activity, and improving psychological outcomes individuals with obesity. The immersive nature of VR may enhance motivation and adherence to exercise programs, offering a promising alternative for obesity management. However, the study's small sample size, short duration, and reliance on self-reported measures may limit its generalizability. Future research should explore long-term adherence, effectiveness in diverse populations, psychological mechanisms behind engagement, and comparisons with emerging fitness technologies like AI-powered platforms.

KEYWORDS

obesity, VR, exercise, behavioral change, counseling, SDT

1 Introduction

Obesity is a major risk factor for numerous noncommunicable diseases (NCDs), such as diabetes, cardiovascular diseases, and certain types of cancer (1). It is also associated with numerous mental health issues like depression, poor quality of life and body dissatisfaction. Many individuals with obesity experience psychological distress due to being subjected to weight stigma and discrimination. Given these serious health implications, effective management strategies for obesity are crucial (2–4). The role of exercise programs and physical activity is crucial, as they are key components in the treatment of obesity. Beyond promoting weight loss through increased energy expenditure, physical activity also enhances overall metabolic and cardiovascular health. It can lead to significant improvements in biomarkers for people with obesity, such as lower serum triglycerides and reduced arterial stiffness. Participation in exercise programs can also lead to improved cardiorespiratory health muscle strength, quality of life, and sustained exercise behavior. Additionally, physical activity offers notable benefits for brain health, including better sleep quality and reduced depressive symptoms. It also positively impacts emotional well-being and overall quality of life (5). Individuals can engage in various forms of exercise to manage obesity. Programs incorporating moderate-intensity aerobic exercise and moderate-to-high intensity resistance training are particularly recommended for adults aiming to achieve these health goals (6). Other researchers support that high-intensity interval training (HIIT) can significantly improve mental health-related indices in overweight and obese adults, with improvements equal to or greater than those observed for moderate-intensity continuous training (7). Nonetheless, regular exercise and healthy nutrition contribute to weight control, disease prevention, maintenance, and metabolic fitness in obesity, with endurance training being the most effective (8, 9).

Effective obesity management requires a multifactorial approach that addresses not only diet and exercise but also psychological and behavioral factors to foster long-term change (10). Multi-component interventions that incorporate behavioral modification, cognitive strategies, and values-based approaches have been shown to enhance adherence, confidence, and intrinsic motivation, leading to improved health outcomes (11, 12). Individualized nutrition counseling plays a crucial role, influencing both physical and mental well-being, as it has been linked to reduced depressive symptoms and sustained weight loss (13). Obesity is often linked to lower self-esteem, with studies highlighting a negative relationship between excess weight and body image (4, 14). A positive body image and a flexible approach to eating restraint have been associated with better weight control outcomes (15). Similarly, self-efficacy—one's confidence in their ability to adopt healthy behaviors—has been identified as a strong predictor of successful weight management and increased physical activity, enhancing adherence to dietary and exercise guidelines (16). Self-regulation skills, such as self-monitoring, also contribute to weight loss success, with research showing a direct link between self-monitoring and higher weight

loss rates in individuals with obesity (17). Additionally, positive attitudes toward nutrition and physical activity are key determinants of long-term behavioral change, reinforcing intention, perceived control, and engagement in healthy habits (18, 19). Among behavioral strategies, goal setting has been recognized as an effective tool in obesity management, with studies demonstrating its role in increasing effort and commitment to physical activity (20). Recent findings highlight the importance of setting Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) goals, which have been positively associated with weight loss outcomes in community-based programs (21). In clinical settings, goal-setting has been successfully applied in cardiac rehabilitation and nutrition interventions, further emphasizing its relevance to weight management (22, 23). Therefore, counseling, behavioral change strategies, and traditional exercise interventions are beneficial, and in recent years, innovative approaches like Virtual Reality (VR) have shown promise in improving obesity management outcomes.

VR is a computer-generated simulation of a real or imaginary three-dimensional environment that allows users to explore and interact with it. Over recent decades, VR has expanded beyond entertainment and leisure, finding applications in exercise, education, rehabilitation, health, and various other fields [(24) accessed on 8 July 2024]. Several studies have explored the effects of VR exercise and support the idea that it is suitable for yielding positive outcomes in physiological, psychological, and recovery-related factors when compared to traditional exercise (25). A systematic review found that VR technology has great potential for assessing and treating obesity due to its interactivity, flexibility, and customization to individual needs, making it compatible with existing psychological theories and practices (26). Research shows that people tend to respond to virtual environments as if they were real, and individuals generally accept this technology (27). A study found that VR self-conversations based on motivational interviewing can help individuals with obesity improve habit change readiness, self-efficacy, and reduce dysfunctional eating behaviors and anxiety (28). VR, when combined with cognitive behavioral therapy or weight loss programs, supports significant weight loss, though maintaining it is challenging (26). Another study suggests that VR integration into behavioral weight loss treatments may help sustain weight loss (29). Additionally, incorporating VR into physical activity programs could counteract reduced engagement due to weight-based victimization (30).

Despite the growing use of VR in health interventions, little research has examined its combination with Self-Determination Theory (SDT)-based counseling for obesity management. SDT posits that motivation and well-being are enhanced when individuals experience autonomy, competence, and social support, which are crucial for sustaining behavioral changes (31, 32). In obesity treatment, SDT-based interventions have shown positive effects on promotion of health behavioral change like physical activity adherence, and psychological well-being (33, 34). While existing studies have demonstrated encouraging results, most have focused on VR or counseling as standalone

approaches. VR interventions have been effective in promoting physical activity, improving self-efficacy and self-esteem, managing psychological distress and supporting weight loss (26, 35, 36). Furthermore, research suggests that VR reduces perceived exertion, making exercise feel easier and potentially increasing engagement in physical activity (37). Additionally, VR interventions combined with cognitive-behavioral techniques have improved motivation and self-esteem while reducing disordered eating behaviors (38). However, the potential combination of VR-based exercise and SDT-based counseling remains largely unexplored. It is highlighted the importance to address this gap by the evaluation of the combined effects of VR exercise and SDT-based counseling on physical activity, psychological well-being, and behavioral outcomes in individuals with obesity. Given that obesity management requires sustainable behavioral modifications (e.g., eating habits, physical activity, medication adherence), integrating behavioral change strategies—such as SDT-based motivation—with VR's engaging and immersive exercise experience may provide a more holistic and effective approach (11).

For the management of obesity, a combination of exercise and counseling appears to be effective. Additionally, individuals can exercise using VR systems and respond to virtual stimuli in a way that closely mirrors real-life experiences (39). However, there are few studies in the literature that have examined the impact of VR-based exercise combined with SDT-based counseling in individuals with obesity. VR systems have been successfully used and well-accepted by obese individuals to change behaviors and lifestyles for combating obesity through virtual self-talk and psycho-educational counseling (28). It is supported that it effectively improves body image satisfaction and promotes health self-efficacy individuals with overweight or obesity through self-monitoring of diet, physical activity, and weight (26). Additionally, according to a study involving overweight women, it was found that exercise in a virtual environment had a positive effect on exercise enjoyment, immersion in exercise, reduction in BMI, and depressive symptoms (40). Lastly, according to a

systematic review, exercise in a virtual reality environment has been shown to have a positive impact and is a promising tool for managing smoking, diet, obesity, and increasing physical activity levels (41).

The primary aim of this study was to evaluate the impact of a VR-based exercise intervention combined with SDT-based counseling on key anthropometric, psychological and behavioral outcomes in individuals with overweight and obesity. Specifically, the study compared changes in BMI, body fat mass, basic psychological needs, attitudes towards the program, self-esteem, self-efficacy, and physical activity engagement between participants performing VR-based exercise and those engaging in traditional, self-selected exercise paired with SDT-based counseling. The secondary aim was to assess participants' attitudes, interest, and enjoyment regarding each exercise modality, as well as the acceptance, usability, and overall enjoyment of the VR exercise platform.

2 Methods and materials

2.1 Trial design

This study followed a Randomized Controlled Trial (RCT) design with a control group. The study protocol was approved by the Institution Ethics Committee (Approval No. 1829, 13 October 2021).

2.2 Participants

In our study, 40 individuals with overweight/obesity (24 female and 16 male) with a BMI > 25 kg/m², aged from 18 to 65 years old participated. Demographic characteristics of the participants are presented in Table 1. All participants were informed about the study's objectives and signed the consent form for participation in research studies. Two groups of 20 individuals each were assigned: (a) VR exercise group, and (b) No VR exercise group (control group). The randomization process proceeded as follows: The first participant was randomly assigned to a group using a coin flip. Following this, participants were alternately assigned to the experimental and control groups. Specifically, after the initial random assignment, one participant was allocated to the experimental group, while the next was assigned to the control group, continuing this alternating pattern until the desired number of participants was reached.

2.2.1 Recruitment—setting: community setting intervention

Participants were recruited through an open call to the community of Volos, an urban city in central Greece. This initiative aimed to inform local residents and provide them with the opportunity to express their interest in participating in the study. Then, more specifically, individuals were informed about the project and agreed to participate.

TABLE 1 Demographic characteristics and anthropometric values.

Variable	Units	Group	Mean ± SD	Frequency
Age	years	Intervention	40.60 ± 11.93	–
		Control	45.65 ± 12.17	–
Height	m	Intervention	1.67 ± 0.10	–
		Control	1.73 ± 0.08	–
Weight	kg	Intervention	90.36 ± 16.69	–
		Control	97.86 ± 11.54	–
BMI	kg/m ²	Intervention	32.69 ± 5.25	–
		Control	32.64 ± 2.70	–
Body fat mass	kg	Intervention	36.81 ± 9.47	–
		Control	37.40 ± 8.06	–
Gender	–	Intervention	–	30% male, 70% female
		Control	–	50% male, 50% female
Education	–	Intervention	–	Secondary 30%, Tertiary 70%
		Control	–	Secondary 25%, Tertiary 75%

An informational brochure was created to inform the public about this initiative and encourage their participation ([Supplementary Material 1](#)). The brochure was published on social media and distributed in various crowded locations, including sports facilities. On the brochure, there was a QR code that directed them to an online participation form which included study inclusion and exclusion criteria such as age, weight, height, and if they have been diagnosed with neurological, orthopedic, cognitive, or psychiatric conditions, poor or no vision, and vertigo, as well as their contact details (phone number or email) to invite them to the first meeting.

2.3 Intervention

The intervention program was grounded in SDT to facilitate behavior change in participants with overweight and obesity. Based on the core principles of SDT, which include autonomy, relatedness, and competence, the following intervention was designed including exercising in VR environment combined with 3 counseling sessions to promote engagement in physical activity among individuals with overweight and obesity and guide them toward a healthier lifestyle for the intervention group. The behavior changes techniques (42) used and applied in the intervention for every need are presented in [Supplementary Material 2](#).

2.4 Materials

2.4.1 Brochure, forms and booklet

To cover the needs of the intervention, the following materials were created. An informational brochure about the existence of the VR exercise program and counseling, a consent form describing in detail the study procedures and ensuring personal data privacy according to GDPR (“I hereby consent to the collection, processing, and secure handling of my personal data in accordance with data privacy and protection regulations.”), a booklet that includes information and advice about exercise, diet and ways to overcome psychological difficulties in their efforts to systematically participate in exercise and nutrition programs ([Supplementary Material 3](#)) a Daily Self-Monitoring Form in which participants recorded daily step count, water intake, consumption of sugary foods, the quantity of fruits and vegetables eaten, and the duration of physical activity and a Goal-Setting Form in which participants recorded their goals for physical activity, nutrition, and water intake for the next week and complete the Implementation Intention Plan for each goal ([Supplementary Material 4, 5](#)) The goal-setting forms were completed after every counseling session and based on the goal-setting theory (43).

2.4.2 VR exercise application

The VR exercise app used for the intervention program is called PowerBeats VR. PowerBeatsVR is an immersive VR exercise application designed to enhance physical activity through an engaging and interactive environment. Participants engage in

a variety of workout routines that combine cardio and strength training exercises with rhythmic movements and music. All of them are transported into visually stimulating VR worlds, ranging from futuristic settings to natural landscapes (such as desert, sky, space, and medieval), which make the workout experience more enjoyable. The application offers a range of pre-designed workout routines catering to different fitness levels and goals. Participants can choose routines based on their preferences, focusing on cardio, strength, or a combination of both. The exercises are synchronized with energetic music, motivating participants to move in time with the beat. This feature not only makes the workout fun but also helps maintain a consistent exercise rhythm. During the workout, participants engage in interactive gameplay elements such as punching orbs, dodging obstacles, and performing various body movements. This gamified approach keeps participants engaged and focused throughout the session. The exercise sessions typically lasted for 15–60 minutes, with participants encouraged to engage in at least three sessions per week. The intensity of the workouts varied from moderate to vigorous, based on the participants’ fitness levels and preferences. Real-time feedback provided metrics such as calories burned and exercise duration, helping participants track their progress and stay motivated. Participants could set personal fitness goals within the app and monitor their achievements over time and have a personalized exercise experience throughout the intervention. The app kept a detailed record of completed workouts, allowing users to see their progress and make adjustments to their fitness plans as needed. PowerBeatsVR allowed participants to customize their workout sessions by selecting different difficulty levels, workout durations, and types of exercises, ensuring that the workout remained challenging and suitable for the participant’s fitness level ([Supplementary Material 6, 7](#)).

2.4.3 Counseling sessions

The 3 counseling sessions were designed to promote behavioral changes towards exercise, diet, and a healthy lifestyle. These sessions were provided to both groups at the beginning of the first week, the end of the second week, and the end of the fourth week of the intervention. Each session was based on the core principles of SDT, focusing on enhancing autonomy, relatedness, and competence. The content of the sessions included:

- Session 1: Introduction to the importance of physical activity and healthy eating, initial goal setting using SMART principles (Specific, Measurable, Achievable, Relevant, Time-bound)—a framework known to enhance goal effectiveness (44–46), and strategies to overcome psychological barriers.
- Session 2: Review of progress, adjustment of goals, strategies for maintaining motivation, and discussion on the importance of social support and relatedness.
- Session 3: Final evaluation of progress, setting long-term goals, strategies for maintaining behavior changes post-intervention, and discussion on competence and self-efficacy.

Goal-setting techniques were used throughout the sessions to help participants set and achieve both short-term and long-term goals

related to daily steps, exercise duration, types of physical activities, nutrition choices, and water intake. The control group followed the counseling sessions without the opportunity to use the VR exercise system.

2.5 Procedures

After their categorization into the Intervention group (VR exercise) and Control group (No VR exercise), based on systematic allocation, all participants were contacted by phone, the study's procedure was explained and the first meeting was organized. All phases of the intervention (VR-based exercise sessions and counseling) were delivered by an exercise specialist with expertise in exercise psychology.

During the initial meeting, participants from both groups were informed in detail about the study phases, provided their consent, and completed the first questionnaire. Participants were informed about the aim of the study, that it was to evaluate the effects of each exercise intervention, in combination with counseling, on physical, psychological, and behavioral factors. However, individuals were not explicitly told that the primary focus was on comparing VR-based exercise with traditional exercise. This approach aimed to minimize potential bias in their responses and engagement levels. Each participant received printed Daily Self-Monitoring Forms to fill out daily for the following week. This session also included counseling, goal-setting, and the distribution of the booklet with information and advice (47). Participants completed the goal-setting form with their goals for the following week and were encouraged to complete the goal-setting form every week, check their achievements, and adjust their goals according to SMART goal-setting (44–46). Additionally, all, scheduled an appointment with our partner nutritionist for body measurements, including height, weight, waist, hip and neck circumference, and body fat mass.

Subsequently, only participants from the intervention group conducted a trial exercise session with the VR application, familiarizing themselves with the VR equipment, receiving detailed usage instructions, and having the opportunity to ask questions before starting the first VR exercise session. Safety measures were implemented to ensure participant well-being during the VR exercise sessions. To minimize the risk of motion sickness, participants were gradually introduced to the VR environment, starting with low-intensity movements and progressively increasing intensity based on individual tolerance. Additionally, regular breaks were encouraged, and participants could stop the session at any time if they experienced discomfort. The exercise specialist was present during all VR sessions to monitor participants, provide immediate assistance if needed, and ensure proper use of the equipment to prevent injuries.

From this point, both groups had 4 weeks to exercise, with the Intervention group having the option to use the VR system as an additional exercise method whenever desired. All participants from the Intervention group were allowed to exercise in the VR environment as much as they wanted, from 3 to 7 times per

week. Participants arranged an appointment with the exercise specialist and had access to the VR device in an agreed convenient place (home or gym). The VR exercise was tailored to the individual fitness levels of each participant. Needed adjustments were made for participants who experienced physical discomfort or other constraints. These modifications ensured the safety and comfort of participants without compromising the overall intervention goals. Participants in the control group were free to engage in various forms of exercise, with an emphasis on aerobic activities such as cycling, swimming, gym-based group fitness classes (moderate to high intensity), and running. However, no structured exercise program was assigned, and no dietary intervention was implemented. The same counseling intervention as the experimental group was provided, but without the VR-based exercise component. Similarly, participants in the intervention group also had the option to engage in these types of exercises. Both the intervention and control groups had the flexibility to select preferred types of physical activity, ensuring that intensity ranged from moderate to vigorous. All participants were encouraged to engage in exercise at least three times per week, with each session lasting more than 30 minutes. Self-monitoring and progress tracking were also encouraged. Daily Self-Monitoring Forms were completed during the first, third, and final week of the program. Communication with the exercise specialist was maintained via Viber, providing the opportunity to discuss any issues—including barriers to physical activity faced by individuals with overweight and obesity—and seek solutions, instructions, or support regarding the exercise regimen. Additionally, general dietary tips for maintaining a healthy and balanced diet were available, but no structured dietary intervention was provided. Viber was used as a direct communication channel, allowing continuous support throughout the study. Whenever guidance, motivation, or clarification was needed, the exercise specialist was available. This real-time accessibility helped address concerns immediately, reinforce adherence to the intervention, and enhance accountability. The ability to maintain constant communication also fostered a sense of connection and encouragement, which is crucial for sustaining behavioral changes and promoting long-term engagement in physical activity. Participants had the opportunity to create small groups and exercise together. Both groups were free to choose their preferred way of exercising, selecting the hours and type of exercise according to individual schedules, goals, and advice from the exercise specialist. However, participation in an organized and structured exercise program was not required.

At the end of the second week, an additional meeting was held for counseling, discussion, and feedback on their progress. The participants completed once again the goal-setting form and set new goals for the following week. After the 4-week intervention, we conducted a final meeting where participants from both groups underwent body measurements again with our partner nutritionist, completed final questionnaires and interview, and attended the last counseling session. This session included discussions about their progress with the intervention and goal-setting for the future.

2.5.1 Follow-Up

Four weeks post-intervention, participants from both groups were invited to complete a follow-up questionnaire assessing their adherence to exercise. Measures included self-reported physical activity levels and goal-setting progress. Additionally, participants were asked about their long-term intentions for physical activity, motivation levels, and any challenges they faced in maintaining their exercise routines post-intervention.

2.6 Measures

2.6.1 Anthropometric measures

Each participant scheduled an individual appointment with our partner nutritionist at a convenient date and time. To ensure consistency, the follow-up assessment was conducted at approximately the same time of day as the initial measurement. Anthropometric assessments, including weight, body fat percentage, and fat mass, were conducted using the CHARDER MA601 body composition analyzer. Participants were instructed to follow standard pre-assessment guidelines, including avoiding food, caffeine, and vigorous physical activity for at least 3 hours prior to the measurement and emptying their bladder before the assessment to minimize variations due to fluid retention. Wearing light clothing and no shoes were encouraged to ensure accuracy. Height was measured using the Charider HM250U ultrasonic stadiometer.

2.6.2 First meeting questionnaire

Both groups filled in questionnaires including questions about demographic characteristics (birth date, gender, occupation, educational level), use of technology [Personal Innovativeness questionnaire, (48)], psychological distress [GHQ-12, (49)], body image [BI-AAQ, (50)], self-efficacy [exercise self-efficacy scale (51)], level of physical activity (Leisure-Time Exercise Questionnaire (LTEQ), scored using the formula: $(9 \times \text{Vigorous}) + (5 \times \text{Moderate}) + (3 \times \text{Light})$ calculated and utilized as a Leisure Index Score, (52)], self-esteem [Rosenberg self-esteem scale, (53)], the degree to which participants' psychological needs are met within an exercise context [BPNES, (54)], attitudes toward participation in the program, intention, perceived behavioral control and subjective norms [TPB Questionnaire, (55)].

2.6.3 Last meeting questionnaire

Participants filled in questionnaires with questions about the level of physical activity (LTEQ), the degree to which participants' psychological needs are met within an exercise context (BPNES), attitudes toward participation in the program, intention, perceived behavioral control and subjective norms (TPB Questionnaire), attitudes towards exercise (VR exercise for the Intervention group) (55), interest/enjoyment of exercise (VR exercise for the Intervention group) [IMI, (56)], self-efficacy, self-esteem, and a semi-structured interview with questions about their exercise (with the VR system for the Intervention group)

and counseling experience, their adherence to the exercise program and if they achieved their goals, such as “How do you think your participation in the program helped you change your behavior regarding exercise and nutrition?” and “How do you intend to continue exercising in the future?”. Participants of the Intervention group also responded to questions about perceived enjoyment from the VR exercise program (57), intention for future use (55, 57), system usability [SUS, (58)] and VR equipment (59).

2.7 Retention strategies

In the study, participant retention strategies were employed to maintain the number of participants throughout the study. Some sample retention strategies that were used include:

- Communication: Regular communication with participants through Viber and encouraging them not to drop out of the process. The Viber chat was always active to discuss tips for adherence to the exercise program or diet, problems that may appear, and other issues including barriers of people with overweight or obesity towards physical activity and exercise.
- Self—Rewards: During the goal-setting process, each participant was encouraged to plan their goal and a reward for themselves upon successfully achieving their goal. For instance, if they manage to reach a daily step count of 8,000 for two weeks, they could treat themselves to a spa day as a reward.
- Encouraging communication and monitoring: Active engagement by monitoring participants' involvement and addressing issues that arise promptly. Self-monitoring their daily exercise and nutrition is a nice way to enhance their behavior change effort.

The adherence to the intervention was monitored through the Daily Self-Monitoring Forms which were checked at the end of each week, and participants received regular feedback from the exercise specialist. Additionally, participants from the VR group were asked to track their VR exercise sessions through the application, which recorded metrics such as calories burned and session duration. The exercise specialist maintained regular communication with participants via Viber to address any barriers to participation and provide motivation.

2.8 Data analysis

For the quantitative data analysis, a power of 85% and confidence interval of 95% were adopted, with an estimated value for a type I error of 5% for the sample size calculation in this study. Descriptive statistics and frequencies were used for demographic characteristics and baseline measurements. The Kolmogorov–Smirnov Test was performed, confirming that the sample followed a normal distribution, and Mauchly's Test of Sphericity was conducted, indicating that the assumption of sphericity was also met. The two-way repeated measures ANOVA analysis was used to determine the influence of the

intervention and differences between the two groups in all variables. The two-way repeated measures ANOVA analysis was used due to the controlled structure of the study, where all participants completed assessments at fixed time points, and there were no missing data. Correlation analysis was also conducted to examine the relationship between the baseline measures and pre-post-intervention measures. All statistical analyses were performed with IBM SPSS (Statistics Version 29) and the level of significance was set at $p < .05$.

Semi-structured interviews were audio-recorded and transcribed verbatim. The qualitative data were then analyzed using thematic analysis. Two independent researchers familiarized themselves with the transcripts by reading them multiple times and engaged in an inductive coding process to identify initial codes reflecting emerging patterns. These codes were collated into potential themes and iteratively refined through discussions to resolve any discrepancies, ensuring consistency and rigor. This systematic approach allowed us to identify key themes related to participants' experiences, attitudes, and perceptions of both VR-based and traditional exercise interventions.

3 Results

3.1 Baseline measurements: personal innovativeness, general mental distress, body image

Descriptive statistics were applied to calculate the means and standard deviations for baseline measures of personal innovativeness, general mental health, and body image. The results are presented in Table 2. A correlation analysis was conducted and the results revealed several significant relations. Personal innovativeness was found to have a strong positive correlation with self-efficacy pre-intervention ($r = .59, p < .001$), a significant positive correlation with interest/enjoyment (IMI) ($r = .42, p = .008$) and with physical activity levels at follow-up (LTEQ) ($r = .40, p = .010$). General mental distress showed a significant positive correlation with body image ($r = .31, p = .049$). Finally, body image demonstrated a small positive correlation with physical activity levels at follow-up (LTEQ) ($r = .33, p = .035$).

3.2 BMI & body fat mass

A two-way repeated measures ANOVA was conducted to examine the differences in BMI and body fat between the

intervention and control groups for two measurements (pre- and post-intervention). The results revealed a statistically significant group-time interaction for both BMI $F(1,38) = 30.89, p < .001$, 95% CI [30.39,34.13], and body fat $F(1,38) = 28.35, p < .001$, 95% CI [31.86,39.80]. Additionally, there were statistically significant differences between the pre-intervention and post-intervention measurements within the intervention group for both BMI $F(1,38) = 79.15, p < .001$ 95% CI [pre: 30.796, 34.574; post: 29.983, 33.687] and body fat $F(1,38) = 68.40, p < .001$ 95% CI [pre: 32.83, 40.79; post: 30.88, 38.83], with post-intervention scores being lower than pre-intervention scores. However, no statistically significant differences in BMI were found between the two groups at either pre- $F(1,38) = .001, p = .97$, or post-intervention measurement $F(1,38) = .30, p = .59$. Similarly, no statistically significant differences in body fat were observed between the two groups at either pre- $F(1,38) = .04, p = .84$ or post-intervention measurement $F(1,38) = .73, p = .40$. The means and SD are presented in Table 3.

3.3 Hips circumference

A two-way repeated measures ANOVA was performed to examine the differences in the variable hips circumference between the intervention and control group for two measurements (pre- and post-intervention). The results revealed that there was a statistically significant group-time interaction $F(1,38) = 45.46, p < .001$. There were also statistically significant differences between the pre-intervention and post-intervention measurements of the hip circumference in the intervention group $F(1,38) = 113.77, p < .001$ with the post-intervention scores being lower than the pre-intervention. However, there were no statistically significant differences between the two groups neither pre- ($1,38) = .081, p = .778$ nor post-intervention $F(1,38) = .178, p = .676$. There were no statistically significant differences in waist and neck circumferences observed. The means and SD are presented in Table 3.

3.4 Basic psychological needs, attitudes toward the program and intentions to exercise, self-efficacy & self-esteem

A two-way repeated measures ANOVA examined the differences in Basic Psychological Needs (BPN) (Autonomy, Competence, Relatedness), Attitudes toward the program and intentions to exercise, self-efficacy, and self-esteem between the

TABLE 2 Psychometric scores at pre-intervention for each group.

Variable	Intervention group			Control group		
	Mean $\pm$ SD	Minimum	Maximum	Mean $\pm$ SD	Minimum	Maximum
Personal Innovativeness	4.11 $\pm$.72	3.00	5.00	3.49 $\pm$ 1.02	1.25	5.00
General mental distress	4.3 $\pm$ 2.87	1.00	10.00	4.95 $\pm$ 3.47	0	11.00
Body Image	4.13 $\pm$ 1.61	1.30	7.00	2.86 $\pm$ 1.34	1.0	5.10

TABLE 3 Statistics at post intervention for each group.

Variable	Intervention group			Control group		
	Mean $\pm$ SD pre	Mean $\pm$ SD post	Cohen's d	Mean $\pm$ SD pre	Mean $\pm$ SD post	Cohen's d
BMI (kg/m ²)	32.69 $\pm$ 5.25	31.84 $\pm$ 5.08**	0.16	32.64 $\pm$ 2.71	32.54 $\pm$ 2.77	0.04
Body fat mass (kg)	36.81 $\pm$ 9.47	34.86 $\pm$ 9.28**	0.21	37.40 $\pm$ 8.06	37.22 $\pm$ 8.25	0.02
Body fat (%)	39.75 $\pm$ 6.03	39.09 $\pm$ 6.58	0.10	38.05 $\pm$ 6.12	37.97 $\pm$ 6.10	0.01
Hips (cm)	114.45 $\pm$ 6.00	112.80 $\pm$ 5.88**	0.28	113.85 $\pm$ 7.29	113.68 $\pm$ 7.19	0.02
BPN	4.09 $\pm$ 0.77	4.53 $\pm$ 0.52*	0.67	3.95 $\pm$ 0.54	4.08 $\pm$ 0.58	0.23
Autonomy	4.14 $\pm$ 0.83	4.48 $\pm$ 0.68	0.45	3.95 $\pm$ 0.55	4.11 $\pm$ 0.69	0.26
Competence	4.00 $\pm$ 0.81	4.44 $\pm$ 0.48*	0.59	3.85 $\pm$ 0.75	3.94 $\pm$ 0.67	0.13
Relatedness	4.11 $\pm$ 0.77	4.64 $\pm$ 0.63*	0.75	3.99 $\pm$ 0.81	4.20 $\pm$ 0.74	0.27
Attitudes toward the program	6.40 $\pm$ 0.68	6.92 $\pm$ 0.23*	1.02	5.96 $\pm$ 1.02	6.34 $\pm$ 0.80	0.41
Intentions to exercise	6.21 $\pm$ 1.01	6.55 $\pm$ 0.73	0.39	5.77 $\pm$ 1.50	6.05 $\pm$ 1.17	0.21
Perceived control	5.66 $\pm$ 1.28	6.14 $\pm$ 1.02	0.41	5.09 $\pm$ 1.59	5.35 $\pm$ 1.67	0.16
Subjective norms	6.68 $\pm$ 0.57	6.75 $\pm$ 0.53	0.13	6.30 $\pm$ 1.03	6.5 $\pm$ 0.76	0.22
Self-esteem	42.60 $\pm$ 5.20	45.20 $\pm$ 3.74*	0.57	42.80 $\pm$ 4.96	43.80 $\pm$ 3.35	0.24
Self-efficacy	24.95 $\pm$ 7.56	29.70 $\pm$ 5.39*	0.72	23.85 $\pm$ 7.03	25.75 $\pm$ 7.25	0.27
Physical activity	43.10 $\pm$ 31.42	65.15 $\pm$ 22.24*	0.81	37.80 $\pm$ 24.35	43.00 $\pm$ 24.59	0.21

Physical activity classification: active (≥ 24), moderately active (14–23), insufficiently active (< 14).

* $p < 0.05$.

** $p < 0.01$.

intervention and control groups across pre- and post-intervention measurements. For BPN, no significant group-time interaction was found, but the intervention group scored significantly higher post-intervention compared to the control group [$F(1, 38) = 6.74$, $p = .050$] 95% CI [3.81,4.23], with significant pre-post improvement in the intervention group [$F(1, 38) = 8.19$, $p = .013$] 95% CI [4.28,4.78]. In Autonomy, Competence, and Relatedness, no significant group-time interactions were observed. Competence showed significant group differences at the second measurement [$F(1, 38) = 7.33$, $p = .010$], 95% CI [3.67,4.70] and significant pre-post improvement in the intervention group [$F(1, 38) = 4.46$, $p = .041$], 95% CI [pre: 3.65,4.35; post: 4.17,4.70]. Relatedness also improved significantly pre-post in the intervention group [$F(1, 38) = 8.41$, $p = .006$], 95% CI [pre: 3.76,4.47; post: 4.33,4.95]. Attitudes toward the program, as per the Theory of Planned Behavior, showed no group-time interaction but significant group differences post-intervention [$F(1, 38) = 9.81$, $p = .003$], 95% CI [6.44,6.81] and significant pre-post improvement in the intervention group [$F(1, 38) = 4.68$, $p = .037$] 95% CI [pre: 6.01,6.79; post: 6.65,7.18]. No significant differences were found in other TPB components. For self-efficacy and self-esteem, no significant group-time interactions were noted, but both showed significant pre-post improvement within the intervention group ($F(1, 38) = 5.50$, $p = .024$, 95% CI [pre: 21.68,28.25, post: 26.81,32.59] and $F(1, 38) = 4.35$, $p = .044$, 95% CI [pre: 40.30,44.90, post: 43.59,46.81], respectively). The means and SD are presented in Table 3.

3.5 Physical activity level

A two-way repeated measures ANOVA was performed to examine the differences in the variable physical activity between the intervention and control group for three measurements (pre-,

post-, and one month after the intervention). The results revealed that there was no statistically significant group-time interaction, $F(1,38) = 1.65$, $p = .20$. However, there were statistically significant differences between the post-intervention $F(1,38) = 8.93$, $p = .005$, 95% CI [54.54, 75.76] and follow-up $F(1,38) = 9.50$, $p = .004$, 95% CI [46.88, 68.42] scores between the two groups, with the intervention group having a mean 57.65, SD = 19.58, and the control group 34.45, SD = 27.37. Finally, there were statistically significant differences between the pre-intervention and post-intervention scores of the physical activity variable within the intervention group, $F(1,38) = 3.66$, $p = .035$, 95% CI [pre: 30.38, 55.82, post: 54.54, 75.76], with the post-intervention scores being higher than the pre-intervention scores. There were no differences between post-intervention and follow-up scores in ($p = .88$) and no differences in the physical activity scores within the control group, $F(1,38) = .74$, $p = .48$. The means and SD are presented in Table 3.

3.6 Attitudes towards exercise & interest/enjoyment

An independent samples t -test was conducted to examine the differences in interest/enjoyment and attitudes towards exercise between the intervention and control groups. The analysis revealed significant differences in both variables, with the intervention group scoring significantly higher than the control group. For interest/enjoyment, the t -test results were $t(38) = 4.247$, $p < .001$, with the intervention group having a mean of 4.99, SD = 0.45 compared to the control group's mean of 4.08, SD = 0.96. Similarly, for attitudes towards exercise, the t -test results were $t(38) = 3.477$, $p < .001$, with the intervention group scoring a mean of 5.95, SD = 0.99 compared to the control group's mean of 5.37, SD = 0.74. These findings suggest that the

VR exercise had a positive impact on both interest/enjoyment and attitudes towards exercise.

3.7 Perceived enjoyment, intended future use, usability, equipment

The descriptive statistics analysis revealed that participants expressed high levels of perceived enjoyment, intention for future use, usability, and positive perceptions of using the VR system. The maximum score for perceived enjoyment, intention for future use, and equipment was 5, while for usability it was 100. The mean and SD for each variable were as follows: perceived enjoyment had a mean of 4.93, SD = 0.12, intention for future use had a mean of 4.90, SD = 0.25, usability had a mean of 92.50, SD = 7.95, and equipment had a mean of 4.82, SD = 0.27. These results indicate that participants found the VR system highly enjoyable, intended to use it in the future, found it highly usable, and had positive perceptions of the equipment.

3.8 Semi-structured interview

A thematic analysis of the semi-structured interviews was conducted to explore participants' perceptions of the intervention for both groups. The results revealed that the intervention group consistently described the VR-based exercise as highly engaging, motivating, and beneficial for their psychological well-being, while the control group emphasized the positive impact of counseling on behavior change and goal-setting. The participants' responses are summarized in [Table 4](#). Frequencies of the responses in the semi-structured interview are presented in [Supplementary Material 8, 9](#).

4 Discussion

The primary aim of this study was to evaluate the impact of a VR-based exercise intervention combined with SDT-based counseling on key physiological and psychological outcomes in individuals with overweight and obesity. Specifically, the study compared changes in BMI, body fat mass, basic psychological needs, attitudes towards the program, self-esteem, self-efficacy, and physical activity engagement between participants performing VR-based exercise and those engaging in traditional, self-selected exercise paired with SDT-based counseling. The secondary aim was to assess participants' attitudes, interest, and enjoyment regarding each exercise modality, as well as the acceptance, usability, and overall enjoyment of the VR exercise platform. The results demonstrated significant improvements in physical, psychological, and behavioral factors for the intervention group compared to the control group. It was also observed increased engagement in physical activity, attitudes towards exercise, and interest/enjoyment in the intervention group compared to the control group. Finally, high scores of perceived enjoyment, intention for future use, usability and VR

equipment satisfaction were reported. The results of the semi-structured interview about their experience were also encouraging.

4.1 Physical aspects

The study's findings indicate that the intervention significantly impacted BMI, body fat mass and hip circumference. Participants in the intervention group showed a notable reduction in BMI, body fat mass and hip circumference from pre-intervention to post-intervention measurements. While the control group also experienced decreases in these measurements, the changes were limited and not statistically significant. Many studies have examined the effects of exercise on weight loss in individuals with obesity. However, only recent studies examine the effects of VR exercise on the BMI of this population. A recent study, after an 8-week intervention with VR-based exercise, showed that the BMI was significantly decreased compared with the baseline measures and compared with traditional exercise (40). Additionally, other studies have demonstrated similar positive outcomes with innovative exercise methods. For instance, Smith et al. (60) found that combining traditional exercise with technology-based interventions, such as mobile apps and wearable devices, significantly enhanced weight loss and adherence to exercise programs compared to traditional methods alone.

4.2 Psychological aspects

For the BPN in general, the results revealed no statistically significant interaction between measurements and the two groups, suggesting that the overall trend in BPN in general scores did not differ significantly between the intervention and control groups across the study period. However, a closer examination showed that post-intervention, the intervention group scored significantly higher on BPN in general than the control group. Additionally, within the intervention group, there were significant increases in BPN in general scores from pre- to post-intervention, highlighting that the intervention enhanced the participants' psychological well-being. Moreover, the analysis showed a large effect size indicating that the VR-based intervention had a substantial impact on participants' BPN in general, and more specifically in competence. These results are consistent with previous studies that have shown the positive impact of structured physical activity on psychological well-being (61). Regarding the BPN components -Autonomy, Competence, and Relatedness- the results provided further insights. For autonomy, there were no statistically significant changes, neither between nor within groups, suggesting that the intervention did not have a significant impact on participants' sense of autonomy. This could imply that while the intervention was beneficial overall, it did not specifically address or enhance the participants' feelings of autonomy. The autonomy support techniques used in this study such as eliciting participants' perspectives and sources of motivation toward participation in exercise, non-controlling

TABLE 4 Results of the semi-structured interview.

Theme	Intervention group responses	Theme	Control group responses
Overall experience	- Innovative, highly entertaining, motivating, interesting, pleasant, comfortable, easy, accessible, and attractive.-It positively impacted their psychological well-being and they highlighted the importance of the support and guidance they received	Overall experience	- Positive, efficient, pleasant, and interesting experience, which significantly helped them achieve their goals. Their participation in the program helped them change their behavior through the goal-setting process, the guidance they received, and learning more about exercise and nutrition. - Positive sentiments towards counseling, deeming it effective, enjoyable, and instrumental in achieving personal goals. - They attributed their behavioral changes to the goal-setting process, personalized guidance, and increased knowledge about exercise and nutrition.
Counseling experience	- Enhanced consistency in the exercise regimen - Altered their perspective on exercise and nutrition - Improved their psychological state - Helped them deal with obstacles and underscored the importance of determination and concentration on their goals - Goal-setting was particularly beneficial, helping them learn how to set goals correctly, assess their needs, and use goal-setting forms effectively. This allowed them to evaluate their progress weekly and set new, more challenging goals, with advice from the exercise specialist. - Self-monitoring forms were useful for better progress evaluation and mistake monitoring. - Counseling helped them learn important information and realize the importance of psychological support and motivation for achieving their goals	Counseling experience	- The goal-setting process helped them learn to set goals correctly using the SMART method and to properly assess their needs. - Weekly evaluations and goal-setting forms facilitated progress tracking and encouraged participants to set increasingly challenging goals. - Self-monitoring forms were useful for evaluating progress, focusing on goals, and easily monitoring mistakes.
Communication, support & digital booklet	- They valued the support and guidance provided, particularly through online communication, as it helped them stay focused on their goals - The booklet was useful and interesting, providing valuable advice on managing stress and anxiety through exercise, emphasizing dedication to the program and patience, and offering tips for an active lifestyle through daily choices	Communication, support & digital booklet	- Digital booklet was deemed very useful, as they found interesting advice and tips for exercise, overeating, nutrition, and behavior change ideas. - They appreciated support and guidance, noting that online communication helped them remember their incentive and feel that there was always an expert to advise them without being time-consuming
Psychological outcomes & self-efficacy	- Increased levels of self-efficacy. - Positive changes in their mood, feeling more optimistic, motivated, self-confident, full of energy and vitality, and experiencing a sense of wellness, joy, relaxation, and reduced anxiety and stress. - Positive shift in body image, deciding to take better care of their bodies. - Increased self-confidence, reduced dropout rates, improved focus on their goals, and a feeling of being “in control.	Psychological outcomes & self-efficacy	- Heightened levels of self-efficacy. - Some of them did not experience the same increase in self-efficacy. - Being in a better mood, feeling optimistic, and having a sense of wellness - A few felt some pressure not to deviate from the program - Body image improved for half of the participants, while others always had a positive body image and wanted to take care of their bodies.
Barriers & challenges	- Challenges participants faced were time constraints and lack of energy - Communication and support combined with composure and persistence towards their goals and the digital booklet, helped them manage obstacles and challenges.	Barriers & challenges	- Challenges were lack of free time, numerous obligations, motivation, inability to access public sports facilities all day long and the need for closer monitoring and guidance by exercise and nutrition experts - Communication with the exercise specialist, optimism, persistence in their incentive, composure, self-restraint, and discipline helped them manage obstacles and challenges.
Future intentions	- Desire to continue exercising with the same or increased frequency, though time constraints remained a significant inhibitor. - Intentions to utilize behavior change techniques were high, but more likely they would use them if they had motivation and guidance, participated in a community with similar goals, or had an application that could provide feedback and encouragement	Future intentions	- They would exercise with the same or greater frequency, though time constraints were an inhibitor. - Their intention to use behavior change techniques was similar, with most participants scoring highly
VR-Based exercise	- Scored highly on its contribution to their increased levels of physical activity, noting that being able to choose the duration and intensity of their exercise reduced the stress of failure and allowed them to control the exercise program - One participant mentioned needing more challenging goals from an external source - Intended to continue exercising with the VR system and increase exercise frequency and intensity		

language, free choice of exercise intensity and duration, experimenting, and self-initiation of the behavior may not have been sufficient to bring about changes in the satisfaction of this need, even though they were effective in previous studies. For instance, in another study, it was observed that autonomy levels were higher in self-selected exercise conditions (62). In terms of competence, the intervention group showed significant improvements post-intervention compared to the control group, and within the intervention group itself, pre- to post-intervention scores also increased. This suggests that the intervention was particularly effective in enhancing participants' sense of competence, likely by addressing potential barriers to behavior change, setting realistic expectations, providing education on goal-setting and adjustments during counseling sessions, as well as through the use of self-monitoring forms and the educational booklet. These findings align with studies by Ntoumanis and Standage (63), who found that competence is a key predictor of motivation and engagement in physical activities. Moreover, according to Vlachopoulos & Neikou (64), the need for competence is the main predictor of exercise adherence/dropout and levels of exercise attendance and according to Baneriski et al. (65) a sense of competence enhances well-being during VR exercise. The increased sense of competence may be influenced by the self-selected intensity and duration of exercise, while according to Rose and Parfitt (62), self-selected intensity and duration of exercise may positively influence the sense of autonomy and competence. For relatedness, similar to competence, the intervention group reported significantly higher post-intervention scores compared to pre-intervention, indicating that the relatedness support techniques such as expressing interest in participants' thoughts, offering empathy, support, and motivation, allowing them to ask questions and express themselves freely, and providing positive reinforcement regardless of the outcome, were highly effective. Following our results, Reer et al. (66) revealed that VR technology can increase the satisfaction of BPN, and more specifically the needs of autonomy and competence, compared with non-VR intervention. Overall, it is clear that the intervention group showed better outcomes in two of the three components of the BPN compared to the control group. Given that the type of exercise was the only distinguishing factor between the two groups, it can be assumed that this may have contributed to the observed differences.

In this study, within the intervention group, participants exhibited significant improvements in both self-efficacy and self-esteem from pre- to post-intervention measurements. The importance of self-efficacy and self-esteem in obesity is particularly evident in the context of physical activity. Studies have shown that higher levels of self-efficacy are associated with greater participation in physical activities, which is critical for weight management and overall health (67). Additionally, improvements in self-esteem can help individuals with obesity overcome psychological barriers to engaging in physical activity, leading to more sustainable lifestyle changes (68). It was supported that regular exercise can lead to improved levels of self-efficacy, self-esteem, and body awareness (69). More specifically, according to a meta-analysis, interventions that

provide feedback on participants' performance, or vicarious experience can lead to the highest increases in self-efficacy (70). Additionally, McAuley et al. (71) demonstrated that physical activity interventions could significantly improve self-esteem, further supporting the findings of our study. Aerobic exercise has been shown to significantly enhance body self-esteem among college students, and particularly in students with overweight or obesity (72). Similar positive effects from VR exercise have been observed in both stroke patients, where self-efficacy was enhanced (73), and older adults, where self-esteem showed significant improvements (74). Additionally, college students reported higher levels of self-efficacy and enjoyment after VR biking compared to traditional biking (75, 76). Furthermore, according to the present results, there was a strong positive correlation between personal innovativeness and self-efficacy. Similarly, a study conducted on employees found that personal innovativeness was significantly correlated with participants' self-efficacy (77). This finding means that individuals who were more innovative and open to new technology tended to have greater levels of self-efficacy. The self-esteem and self-efficacy of participants in both groups were positively affected, with the intervention group showing statistically significant differences. This indicates that VR exercise played a key role in this change, compared with traditional exercise.

There is also a small positive correlation between general mental distress and body image suggesting that individuals experiencing higher levels of health-related distress might also report concerns or dissatisfaction with their body image. As body image is closely related to psychological well-being, negative body image can affect negatively psychological well-being (78). Additionally, body image dissatisfaction is related with poor quality of life and self-esteem, depression and psychological distress (79).

4.3 Behavioral aspects

The results of the present study revealed changes in attitudes toward the program between the intervention and control groups post-intervention. The findings indicate that participants in the intervention group exhibited higher scores in attitudes toward the program compared to those in the control group. Moreover, the analysis showed a large effect size indicating that the VR-based intervention had a substantial impact on participants' attitudes towards the program. These results suggest that engaging in VR exercise, as it was the only difference between the two groups, can enhance participants' attitudes toward the program. Interestingly, while the attitudes toward the program were significantly improved within the intervention group from pre- to post-intervention, it did not have the same effect on perceived control, intentions to exercise, and subjective norms. This aligns with research by Hardeman et al. (80), who found that interventions often need to address multiple components of TPB to achieve comprehensive behavior change. Further, research by Rhodes et al. (81) supports the idea that perceived behavioral control is a crucial determinant of behavior change and may require targeted strategies to enhance an individual's

confidence in their ability to perform the desired behavior. Moreover, studies such as those by Plotnikoff et al. (82) highlight the importance of social support and environmental factors in shaping behavioral intentions and actions, indicating that future interventions might benefit from incorporating these elements more robustly. Our study underscores the complexity of behavior change and the necessity for multifaceted interventions that address attitudes toward the program, and other psychological and social factors. The significant improvements in attitudes toward the program and intentions to exercise within the intervention group suggest that VR-based exercise interventions have promising potential but also highlight the need for longer-term and more comprehensive strategies to translate these changes into sustained behavior.

4.4 Physical activity, attitudes toward exercise and interest/enjoyment

According to our results, the intervention group demonstrated significantly higher physical activity levels post-intervention and in follow-up comparing to the control group. This suggests that engaging in VR exercise effectively increased physical activity levels immediately after the intervention and maintained these levels one month later, highlighting its lasting effect. In contrast, the control group did not exhibit any significant changes in physical activity levels throughout the study period, suggesting that the VR-based exercise option was crucial for promoting and maintaining increased physical activity. It is important to mention that the analysis showed a large effect size, which indicates a substantial difference between the physical activity levels of the intervention and control groups and not only statistical significance but also practical relevance in real-world applications. These findings are consistent with previous research indicating the effectiveness of technology-based interventions in promoting physical activity. For instance, a study by Larsen et al. (83) found that digital interventions, including VR, significantly increased physical activity levels and maintained these changes over time. Similarly, Maturo and Cunningham (84) highlighted that interactive and engaging interventions like VR can be more effective in sustaining long-term physical activity compared to traditional methods. Research suggests that VR-based exercise has the potential to enhance adherence and motivation by creating engaging and enjoyable environments (85). The ability to provide pleasurable and performance-enhancing virtual spaces makes exercise more attractive. It is also supported that while a relaxing VR environment may not promote high-intensity activity, it maximizes enjoyment, which could encourage prolonged engagement (86). Additionally, researchers highlight that active VR games can elicit various levels of physical activity intensity, with those perceived as the most enjoyable and least effortful further supporting long-term participation in physical activity (87). Moreover, there was also found a moderate positive correlation between the follow-up physical activity levels and personal innovativeness. This relationship could suggest who are more open to new technology, may also be more likely to

maintain participating in VR exercise programs. There was a small positive correlation between the follow-up physical activity levels and body image. This may indicate that individuals with a more positive body image are slightly more likely to maintain or increase levels of physical activity. Following our results, Sabiston et al. (88) support that individuals with a negative perception of their body image were less likely to engage in physical activity and sports, as it was often seen as an obstacle to participation. In contrast, those with a positive body image were more inclined to be active and involved in sports.

Furthermore, results indicated that participants in the intervention group reported significantly higher levels of interest/enjoyment in exercise compared to the control group. As happened in Seo's et al. (40) study in which the levels of exercise enjoyment and immersion were significantly higher in the virtual reality exercise group compared with the other groups. This heightened interest/enjoyment could be a key factor contributing to the sustained increase in physical activity levels observed in the intervention group. According to (89), this is an important determinant for higher levels of physical activity. Moreover, research by Johnson et al. (90) suggested that interactive and immersive VR exercises could increase motivation and engagement, leading to more consistent and prolonged exercise habits among participants. There was also a moderate positive correlation between personal innovativeness and interest/enjoyment, indicating that individuals with high levels of personal innovativeness may experience more interest/enjoyment during exercise in VR environment.

Additionally, the intervention group demonstrated more positive attitudes toward exercise than the control group, further supporting the notion that engaging in VR exercise not only enhanced physical activity levels but also positively influenced participants' perceptions and attitudes toward exercise. That is also supported by other researchers, that VR training can improve participants' positive feelings and attitudes toward physical effort (65).

4.5 Exercise and counseling perceptions

According to our results, the participants of the intervention group scored highly in perceived enjoyment, intention for future use, and usability, and expressed positive perceptions of using the VR system. Following our results, VR-based physical activities can reduce anxiety and improve overall mental health, which can be particularly beneficial for individuals struggling with obesity. These findings suggest that incorporating VR technology in exercise regimens could address both physical and psychological barriers to weight loss (91).

The results from the semi-structured interviews indicated distinct differences and similarities emerged between the groups. Participants in the intervention group, who engaged in both counseling and VR exercise, consistently described the intervention as innovative and highly motivating. Significant improvements were reported in psychological well-being, consistency in their exercise regimen, and positive changes in mood and body image.

The VR exercise was particularly praised for its entertainment value and ease of use, contributing to increased self-efficacy and sustained physical activity. Despite facing challenges like time constraints, the Intervention group participants expressed a strong intention to continue using the VR system and behavior change techniques, underscoring the importance of support and goal-setting in their progress. Regarding control group, which received only counseling, found the sessions positive and effective, helping them set and achieve goals related to exercise and nutrition. While most participants reported improved self-efficacy and mood, the degree of these improvements varied, with some not experiencing significant changes. Similar to the Intervention group, time constraints were a notable challenge. The digital booklet and goal-setting process were also valued in control group, aiding in progress tracking and behavioral changes. Both groups appreciated the support and guidance provided, particularly through online communication, which helped maintain focus and motivation. Overall, while both interventions were deemed effective, the addition of VR exercise in the Intervention group provided an extra layer of engagement and motivation, leading to more pronounced improvements in psychological well-being and self-efficacy compared to counseling alone in control group.

4.6 Limitations

Despite the encouraging results, this study has several limitations that should be mentioned. Although we conducted a power analysis to determine the appropriate sample size, and the 40 participants meet this requirement, the findings should be generalized with caution. A larger sample size could enhance the generalizability of the results. Additionally, the novelty effect of VR could have temporarily enhanced participants' motivation and adherence to exercise. Initial enthusiasm for VR-based interventions may diminish over time as users become more familiar with this technology. Future studies could explore the long-term sustainability of VR-based exercise beyond the four-week period and assess whether the observed benefits persist over time. Investigating its effectiveness in different populations and examining the psychological mechanisms that contribute to increased enjoyment and motivation would provide deeper insights. Additionally, research should focus on the impact of VR exercise on psychological factors such as anxiety, stress, and mental well-being. Furthermore, future research could examine the cost-effectiveness of VR interventions to determine their feasibility for widespread implementation in clinical and real-world settings. Comparative studies with other emerging exercise technologies, such as AI-powered fitness platforms, could help identify the most effective tools for enhancing exercise adherence and outcomes.

4.7 Practical implications

Integrating VR-based exercise into obesity interventions offers a promising approach for enhancing engagement and adherence to physical activity. Fitness professionals can use VR technology to

create immersive, interactive workouts tailored to individual needs and preferences. Structured VR exercise programs, such as guided virtual training sessions, can be implemented in gyms, rehabilitation centers, or even home-based settings to provide accessible and enjoyable exercise experiences. Additionally, VR can be used to simulate real-world environments that may not be feasible due to cost, safety concerns, or weather conditions, enabling individuals with obesity to engage in diverse activities within a controlled and motivating setting. Personalization features, such as adaptive difficulty levels and real-time feedback, can further enhance motivation by ensuring that workouts remain both challenging and achievable. Finally, combining VR-based exercise with behavioral counseling and SDT-based strategies may maximize long-term adherence and support sustainable lifestyle changes.

4.8 Conclusion

The present study highlights the potential physical, psychological, and behavioral benefits of VR-based exercise combined with SDT-based counseling for individuals with overweight and obesity, compared to traditional exercise with SDT-based counseling. Significant improvements were observed in BMI and body fat mass, alongside enhanced psychological outcomes including increased competence, relatedness, self-efficacy, and self-esteem. These positive changes were not observed to the same extent in the control group. Additionally, VR-based exercise proved to be effective in sustaining physical activity levels, likely due to high levels of enjoyment, positive attitudes toward exercise, great psychological needs satisfaction, usability, and satisfaction with the VR equipment.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of University of Thessaly (Approval No. 1829, 13 October 2021). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ET: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. MH: Conceptualization, Methodology, Visualization, Writing – review & editing. EG: Conceptualization, Visualization, Writing – review & editing. GP:

Investigation, Writing – review & editing. CK: Formal analysis, Writing – review & editing. MG: Conceptualization, Validation, Visualization, Writing – review & editing. YT: Conceptualization, Methodology, Project administration, Supervision, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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The study of the association between exercise motivation and cardiorespiratory fitness in young students: a systematic review and meta-analysis

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Background: In recent years, many studies have shown that exercise motivation is essential for encouraging students to engage in physical activities. Cardiorespiratory function, which is closely related to cardiorespiratory fitness, plays a crucial supportive role in sports, and its level is usually reflected by cardiorespiratory fitness measurements. This study aims to explore the correlation between exercise motivation and cardiorespiratory fitness in young students, analyze the impact of exercise motivation on cardiorespiratory fitness, and investigate the role of cardiorespiratory fitness in the formation of exercise motivation.

Methods: Following the PRISMA statement, a comprehensive literature search was carried out in six electronic databases from July 1, 2000, to December 1, 2024. The selected studies were strictly quality-assessed, and relevant data were extracted using a standardized form. Then, a meta-analysis was conducted with Stata18 software, along with heterogeneity testing and publication bias assessment.

Results: After screening, 11 studies were included. Eight directly explored the correlation between cardiorespiratory fitness and exercise motivation, while the other four investigated the link between physical activity and exercise motivation, suggesting an association between cardiorespiratory fitness and exercise motivation during physical activity. Pearson correlation analysis (11 studies) and multiple regression analysis (7 studies) were used. By combining effect sizes with a random-effects model, the average correlation coefficient was 0.24 ($p < 0.001$). The average standardized coefficient of exercise motivation on promoting cardiorespiratory fitness was 0.16 ($p < 0.001$), and that of cardiorespiratory fitness on enhancing exercise motivation was 0.18 ($p < 0.001$).

Discussion: The results show a significant positive correlation between exercise motivation and cardiorespiratory fitness in young students, with a moderate positive effect on each other. This provides a theoretical basis for improving young students' cardiorespiratory fitness and exercise motivation. Future research could explore more effective assessment methods to better understand the underlying mechanisms.

KEYWORDS

young students, physical activity, exercise motivation, physical fitness, intervention strategies

Introduction

In recent years, the issue of students' physical fitness has garnered increasing attention from society. Particularly, the significant decline in cardiorespiratory fitness has raised high alert in the field of public health (Yin, 2017). As one of the important indicators of physical health, cardiorespiratory fitness is not only related to an individual's daily activity capacity and quality of life but is also a key factor in preventing chronic diseases such as cardiovascular diseases (Wu and Wang, 2023). However, among the current student population, the level of cardiorespiratory fitness is generally low, which is directly related to the insufficient participation of students in sports. The World Health Organization (WHO) recommends that adolescents engage in at least 60 min of moderate to vigorous-intensity physical activity daily (Zhang et al., 2021; British Nutrition Foundation, 2004; National Association for Sport and Physical Education, 2005; Guo and Rao, 2021) to promote the improvement of cardiorespiratory fitness. However, actual surveys have found that the number of students who meet this physical activity standard is very few (Jing and Mu, 2020). This current situation indicates a significant lack of motivation for students to participate in sports, and exploring the underlying determinants is of great practical significance for improving students' cardiorespiratory fitness.

In recent years, scholars have made positive progress in methods to promote exercise behavior. Numerous studies, based on various theoretical frameworks related to exercise motivation such as self-determination theory, planned behavior theory, and the health action process approach, have thoroughly investigated possible pathways to enhance students' cardiorespiratory fitness. These theories provide a multi-dimensional perspective for understanding and enhancing students' motivation to exercise. Research shows that motivation theories play a crucial role in explaining and promoting participation in physical activity. For example, self-determination theory emphasizes the importance of individuals' autonomy, competence, and relatedness in exercise motivation, pointing out that when students feel they have the autonomy to choose to participate in sports, possess the ability to complete sports tasks (Liu et al., 2013; Zhu and Yin, 2017; Xue, 2010), and receive support and recognition from others during sports, their intrinsic motivation for exercise will be significantly enhanced. After the enhancement of exercise motivation, students are more likely to actively participate in sports, and regular exercise has a positive impact on cardiorespiratory function. The planned behavior theory analyzes students' intention to participate in sports from three dimensions: attitude, subjective norm, and perceived behavioral control, suggesting that a positive attitude, social support, and a high level of perceived behavioral control are important prerequisites for students' participation in sports (Polet et al., 2020; Wang et al., 2011). Active participation in sports is a key factor affecting cardiorespiratory function. The Health Action Process Approach focuses on the cognitive, emotional, and behavioral factors of individuals during the process of health behavior change, emphasizing the promotion of cardiorespiratory fitness through enhancing students' health awareness, stimulating positive emotions, and cultivating good exercise habits. This theory provides theoretical support from the perspective of health behavior change for researching the relationship between the two, revealing the mechanism by which exercise motivation affects cardiorespiratory function through influencing the health behavior process (Zhang and Li, 2023; Wang

and Zheng, 2020; Chang, 2013). These three theories, each with a different focus, elaborate on the relationship between individual internal psychological needs, external environment, individual cognition, the process of health behavior change, and exercise motivation. Exercise motivation, in turn, directly or indirectly influences sports participation and cardiorespiratory function, providing a comprehensive and in-depth theoretical foundation for researching the relationship between cardiorespiratory function and exercise motivation. This helps to reveal the complex intrinsic connections and mechanisms of action between the two. Cardiorespiratory functions refer to the ability of the human heart to pump blood and the lungs to absorb oxygen, playing a fundamental and comprehensive key role in physical health (Franklin et al., 2022; Gordan et al., 2015). Higher cardiorespiratory fitness enables individuals to endure greater exercise intensity and longer duration during physical activity, reducing fatigue (Wang et al., 2022). When individuals can easily handle a certain level of physical activity during exercise, they are more likely to persist, and this persistence in exercise is closely related to exercise motivation, as continuous exercise experiences can influence an individual's perception and attitude toward exercise (Diehl et al., 2018), thereby affecting subsequent motivation to exercise.

In the past academic research field, there has been a lack of comprehensive and systematic review studies on the correlation between young students' sports motivation and cardiorespiratory endurance. Numerous literatures involving cardiorespiratory endurance and sports motivation merely mention the connection between the two, and the discussion is somewhat superficial. Some scholars have reviewed the correlation between physical activity and sports motivation; however, they have not conducted in-depth and targeted research on cardiorespiratory endurance, a key indicator. For example, in the study "Exercise, Physical Activity, and Self-Determination Theory: A Systematic Review" published by Teixeira et al. (2012) although a positive association between more autonomous forms of motivation and exercise behavior was clearly identified, the importance of cardiorespiratory endurance as a key indicator of physical health was overlooked. Some scholars have also conducted research from the perspective of cardiorespiratory endurance and physical literacy. For instance, Jiang et al. (2024) study systematically reviewed and summarized the relationship between cardiorespiratory endurance and physical literacy. The results showed a significant positive correlation between the sub-factors of physical literacy—motivation and confidence—and cardiorespiratory endurance. This finding further reinforces the notion of a close connection between cardiorespiratory endurance and motivation. However, it is worth noting that the study only revealed the correlation between the two and did not delve into the deeper mechanisms of their mutual influence. In addition, some research has focused on the relationship between physical activity and sports motivation in populations with health conditions. For example, Hutzler and Korsensky (2010) publication, "A Systematic Literature Review of the Motivation for Physical Activity in People with Intellectual Disabilities," revealed the correlation between the motivation for individuals with intellectual disabilities to engage in sports, recreation, or health-related physical activities. Veldhuijzen Van Zanten et al. (2015) publication, "Perceived Barriers, Facilitators, and Benefits of Regular Physical Activity and Exercise in Patients with Rheumatoid Arthritis: A Literature Review," demonstrated the relationship between physical activity barriers and

lack of motivation in patients with rheumatoid arthritis. However, given the physiological and psychological differences between populations with health conditions and the general population, these research findings are not entirely applicable to the general population.

Although numerous studies have mentioned the association between cardiorespiratory endurance and sports motivation in their articles, there is a noticeable absence of meta-analyses specifically focusing on the in-depth relationship between cardiorespiratory endurance and sports motivation in general young students. Furthermore, previous meta-analyses have not comprehensively integrated multiple dimensions of sports motivation. In light of this, the present study aims to delve into this research gap, with the intention of providing new perspectives and insights for the field, and exploring the intrinsic psychological mechanisms underlying young students' participation in physical activities from the perspective of psychological motivation. Through the review and analysis of relevant literature, the study seeks to reveal the impact mechanisms of different motivational factors on cardiorespiratory endurance, as well as the specific application and effectiveness of different theoretical frameworks in promoting students' sports participation. The research objective is to provide scientific evidence for the development of targeted behavioral intervention strategies, offering customized recommendations for educational practice, with the aim of effectively enhancing young students' cardiorespiratory endurance, thereby increasing their level of physical activity, ultimately improving the overall health status of adolescents, and laying a solid health foundation for their comprehensive development.

Methods

Literature search strategy

According to the standards specified in the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)” (Moher et al., 2009) statement, a structured electronic literature search was conducted. The search was performed by the first author on October 1, 2024, using computerized methods and included six electronic databases: Web of Science, PubMed, ProQuest, Scopus, ScienceDirect, and EBSCO. The search strategy was as follows: “[Title/Abstract] = (‘cardiorespiratory fitness’ OR ‘Aerobic fitness’ OR ‘cardiorespiratory fitness’ OR VO2max (Maximum Oxygen Uptake)) AND [Title/Abstract] = (‘Exercise motivation’ OR ‘Physical activity motivation’ OR ‘Fitness motivation’) AND [Title/Abstract] = (‘college students’ OR ‘university students’ OR ‘young’ OR ‘adolescents’).” Only peer-reviewed articles published in Chinese and English journals were included in this study. The search covered a time span from July 1, 2000, to December 1, 2024. We will exclude unpublished reports, conference abstracts, theses, and other forms of grey/gray literature from this systematic review.

Inclusion and exclusion criteria

Inclusion criteria: ① Participants were middle school to university students with an average age of 11 years or older; ② Included assessment of exercise motivation; ③ Included assessment of cardiorespiratory fitness; ④ Quantitatively analyzed the relationship

between exercise motivation and cardiorespiratory fitness; ⑤ Cross-sectional, longitudinal, or long-term study design; ⑥ Published in English.

Exclusion criteria: ① Studies focusing on special populations, such as those with cardiovascular disease, diabetes, etc.; ② Literature not published in peer-reviewed journals; ③ Study samples of less than 50 participants; ④ Did not provide data on the relationship between exercise motivation and cardiorespiratory fitness; ⑤ Review articles ⑥ non - English language.

After deduplicating the retrieved literature, two researchers independently screened the studies based on the inclusion and exclusion criteria. Initially, they conducted a preliminary screening of the article titles and abstracts to identify potentially relevant literature for full-text review. In addition, while including the studies confirmed through full-text review, we also meticulously checked the reference lists of the retrieved full-text articles and other systematic reviews to ensure that no additional eligible studies were missed. Finally, the included literature was determined through a joint check by the two researchers. If there were any discrepancies in the screening results, a third researcher was consulted to make the final decision.

Data extraction

The data were extracted by two authors according to the inclusion criteria, and any disagreements were resolved through discussion. The extracted information included: (1) authors and year of publication; (2) study location; (3) type of study; (4) methods for assessing exercise motivation; (5) methods for assessing cardiorespiratory fitness; (6) statistical methods; (7) association indicators (correlation coefficients, standardized coefficients); (8) study results.

Quality assessment of literature

The quality of the literature was assessed using the Quality Assessment Tool for Quantitative Studies (QualSyst) derived from criteria for primary research papers in different fields (Jing and Mu, 2020). QualSyst is a 14-item tool that allows for the evaluation of methodology and bias in both quantitative and qualitative studies with different research designs. Due to the observational design of the studies included in this review, items 5 (random allocation), 6 (investigator blinding), and 7 (participant blinding) were removed from QualSyst. Each item on the QualSyst was scored from 0 to 2 points to indicate whether the study met a criterion (0 = no, 1 = partial, 2 = yes). All scores were summed to create a total score. The total score was then converted into a percentage (i.e., the total study score divided by 22), and ratings were assigned as “excellent” (>80%), “good” (70–79%), “adequate” (55–69%), and “low” (<55%) (Liu et al., 2013; Zhu and Yin, 2017). Two researchers independently assessed the quality, and any discrepancies were resolved through discussion until a consensus was reached.

Statistical analysis

Each included study provided data on the association between exercise motivation indicators and cardiorespiratory fitness in

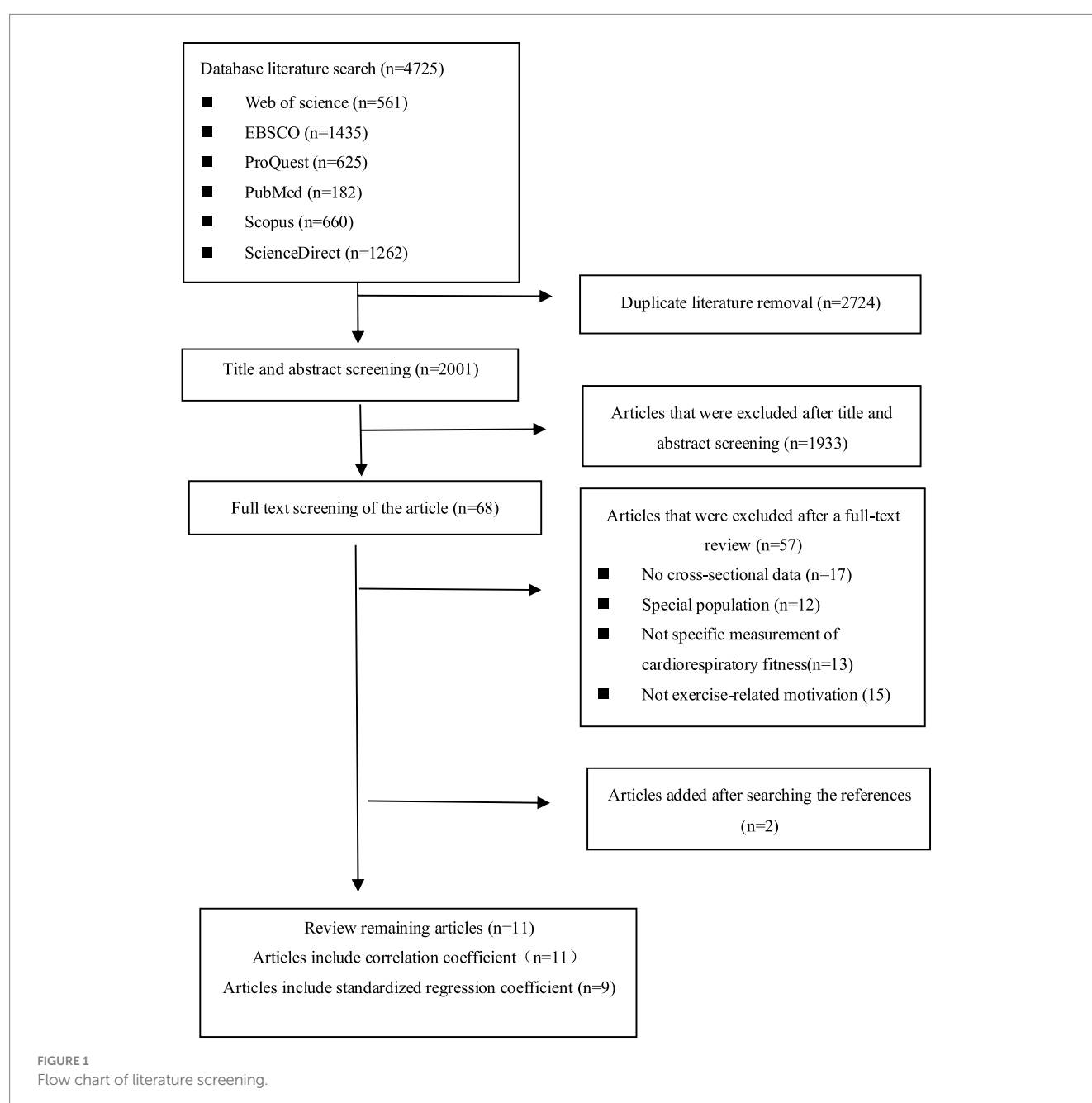
young students, as well as the sample size of the study. For longitudinal studies included the association data at baseline were selected for analysis; for studies that used multiple instruments for assessment, the association data were combined using meta-analysis. The transformed data were subjected to meta-analysis using Stata 18 software. Based on the results of the heterogeneity analysis, a fixed-effect model was adopted for the included literature when I^2 was less than 50% and P was greater than 0.05, or a random-effects model when I^2 was greater than or equal to 50% or P was less than 0.05. The level of heterogeneity was represented by the I^2 index, categorized as low ($I^2 \leq 25\%$), moderate ($25\% < I^2 \leq 50\%$), and high ($I^2 > 50\%$) (Liu et al., 2023; Higgins et al., 2003). Subgroup analysis was conducted in the presence of significant heterogeneity. To test for publication bias, funnel plots were calculated, and Egger's test

was performed, with the results of the analysis presented in forest plots.

Results

Study selection process

Figure 1 reports the study flow and reasons for excluding studies through the review process. A total of 4,725 potentially relevant articles were identified through database searches. After duplicates were removed, 2,001 unique articles entered the title and abstract screening, of which 1,933 were excluded. The full texts of the remaining 68 articles were reviewed according to the study selection



criteria. Among these, 57 articles were excluded. The reasons for exclusion included: 17 articles lacked original data, 12 studies focused on special groups (such as patients with diseases, police officers, etc.), 13 studies did not specifically measure cardiorespiratory fitness, and 15 did not address exercise-related motivation. Ultimately, 11 articles met the inclusion criteria, spanning from July 2000 to October 2024.

Basic characteristics of the included studies

Table 1 summarizes the basic information of the 11 included studies. All studies were published after the year 2000, with 8 cross-sectional studies and 3 longitudinal studies, all having relevant cross-sectional data. The study regions included countries such as China, the United Kingdom, Norway, and Canada, and the number of study participants ranged from 82 to 961 individuals. Among these studies, 11 included correlation analysis and correlation coefficients (r), and 8 studies employed multiple regression analysis and standardized coefficient (β). Detailed information is provided in **Table 1**.

Quality assessment of the included studies

The quality of the 11 included articles was assessed using the “Quality Assessment Tool for Primary Research Papers from Different Areas.” The scores of the 11 studies ranged from 68.2 to 100%, with an average score of 87.18%. Of these, 8 studies (72.73%) were rated as excellent quality, 2 study (18.18%) was rated as good quality, 1 study (9.09%) were rated as sufficient, as shown in **Table 2**.

Assessment tools for evaluating cardiorespiratory fitness in young students

This study included literature that employed four methods to assess the cardiorespiratory fitness of young students. Among them, six studies used the 20-meter shuttle run PACER (Progressive Aerobic Cardiovascular Endurance Run) (Kaj et al., 2015), a test method designed to evaluate an individual's cardiorespiratory fitness. The test is conducted on a 20-meter straight track, and with each completed lap (i.e., 40 meters), the speed increases, typically controlled by specific music rhythms. Participants are required to keep up with the pace for as long as possible until they are unable to complete a lap within the specified time. Additionally, three studies adopted the 800-meter and 1,000-meter endurance tests from the Chinese National Physical Fitness Test (Shen and Xu, 2008). Furthermore, two studies used different methods, one of which employed the YMCA Sub maximal Cycle Ergometer test with two stage extrapolations while wearing a heart rate monitor. An estimate of maximal oxygen consumption was produced using the multistage model technique (Wilson et al., 2020). Another study used a ramp-type progressive bicycle ergometer exercise test to measure the maximum oxygen uptake (Schneider, 2018). These studies, utilizing various assessment tools, provide a multi-dimensional perspective on the evaluation of cardiorespiratory fitness in young students. The tools encompass both field and laboratory tests, as well as methods ranging from simple to complex, thereby ensuring the reliability and validity of the assessment results.

Assessment tools for evaluating exercise motivation

In the literature included, seven main tools were used to assess the motivation of adolescents participating in sports. Among them, the “Behavioral Regulation in Exercise Questionnaire” (BREQ) was used in three studies. Based on self-determination theory, it assesses the types of motivation in individuals' sports behavior, including intrinsic motivation and various forms of extrinsic motivation. Additionally, two studies employed the “Motives for Physical Activity Measure–Revised” (MPAM-R), a questionnaire designed to evaluate the intensity of motivation for individuals to engage in physical activities. This questionnaire, also based on self-determination theory, measures the motivation for participating in activities such as weightlifting, aerobics, or various team sports. Furthermore, four studies used self-created scales, including a questionnaire developed by the Hungarian School Sports Federation (HSSF) using standardized procedures to measure exercise motivation, and a questionnaire from Ryan and Connell (1989) in the United States to assess children's motivation in the achievement and prosocial domains. These questionnaires evaluate four types of behavioral self-regulation derived from self-determination theory: external regulation, introjected regulation, identified regulation, and intrinsic motivation. Another questionnaire, adapted from previous research (Xiang et al., 2003, 2004) in the United States, measures exercise motivation subfactors (expectancy, importance, usefulness, interest) by posing relevant questions. Furthermore, one study used the “Exercise Motivations Inventory-2” (EMI-2), a scale designed to assess the motivation of individuals to participate in sports. The EMI-2 is suitable for both athletes and non-athletes, and it reflects how an individual's exercise motivation affects their level of sports participation and potential sports choices. Additionally, one study used the “Subjective Changes in Physical Activity Questionnaire,” where participants were asked to compare their current level of physical activity with their level during high school and their freshman year to evaluate how easy or difficult they found it to engage in sports during their freshman year. Challenges (i.e., limitations) faced during the freshman year, such as time management, lack of knowledge about how to exercise within the campus, having someone to exercise with, lack of motivation, and discomfort in using exercise facilities, were rated.

Finally, two studies used the “Physical Literacy Awareness Tool” (PLAT), which assesses an individual's mastery of basic knowledge, skills, and attitudes toward physical activity. By improving physical literacy, more people can be encouraged to participate in sports activities, thereby promoting the healthy development of society. The other tool used was the “Achievement Motivation in Physical Education Questionnaire” (AMPEQ), which is designed to evaluate students' achievement motivation in the field of physical education (Cadenas-sanchez et al., 2021).

Research progress

This study is the first to systematically and comprehensively review the relationship between exercise motivation and cardiorespiratory fitness in young students. After rigorous searching and screening, 11 high-quality literature articles were selected, and methods such as correlation analysis, multiple regression analysis, and

TABLE 1 Summary of the included literature.

Number	Author, year	Study design	Country	Sample Size	Age (years)mean (SD) [range]	Percentage girls (%)	Instruments used (CRF)	Instruments used (EM)	Analysis	Association indicators	Conclusion
1	Kaj et al. (2015)	LS	Hung	961	12-20	70.09%	PACER	SCS	Multiple regression analyses	$\beta = 0.249$	Results suggest that boys and girls have different behavior characteristics and attitudes toward PE. Our study also suggests that different attitude components were associated with the aerobic capacity level in boys and girls
2	Shen and Xu (2008)	CS	CN	208	18–23 (20.1)	49.52%	800/1000	EMI-2	Bivariate correlations, Multiple regression analyses	$r = 0.026$ $\beta = 0.081$	Overall, a positive correlation was found between CF and self-efficacy for both men and women, he regression analyses. For men, CF was the only significant predictor for psychological motives when the contribution of BMI and self-efficacy was not significant. The model predicted 16% of the variance in psychological motives. However, for women, self-efficacy was the only significant
3	Zhang et al. (2022)	CS	CN	390	19.2 ± 1.2	51.13%	800/1000	PL	Bivariate correlations	$r = 0.167$	Furthermore, the PF domains of muscular strength and aerobic fitness were significantly and positively correlated with the PL attributes of confidence and physical competence in both men and women, while the PF domains of vital capacity and aerobic fitness were significantly and positively correlated with the PL attribute of motivation in men
4	Wilson et al. (2020)	LS	US	572	21.06 ± 1.07	39.6%	YMCA	SCS	Multiple regression analyses	$\beta = 0.122$	Findings suggest that, upon reflection, upperclassmen consider a lack of motivation as the greatest constraint to physical activity as a freshman.
5	Schneider (2018)	LS	US	142	11.04	52%	ramp-type progressive cycle-ergometer	BREQ	Multiple regression analyses	$\beta = 0.081$	Consistent with general trends, boys in this study were more active and had higher cardiorespiratory fitness as compared to girls. Boys also preferred higher-intensity exercise as compared to girls.

(Continued)

TABLE 1 (Continued)

Number	Author, year	Study design	Country	Sample Size	Age (years)mean (SD) [range]	Percentage girls (%)	Instruments used (CRF)	Instruments used (EM)	Analysis	Association indicators	Conclusion
6	Power et al. (2011)	CS	US	82	12–14	51%	PACER	SCS	bivariate correlations	$r = 0.102$	intrinsic motivation was correlated with cardiovascular fitness, cardiovascular fitness was correlated with weight status
7	Li et al. (2022)	CS	CN	641	20.72 ± 1.41	50.55%	800/1000	MPAM-R	Bivariate correlations Multiple regression bootstrap	$r = 0.336$ $\beta = 0.324$	The physical exercise behavior of college students partially mediates the relationship between exercise motivation and cardiovascular fitness. Therefore, the educational concept of “Health First” should be promoted in college sports. Internal motivation of exercise can be transformed into external motivation to improve students’ exercise behavior and cardiovascular fitness through enhancing their cardiopulmonary capacity.
8	Riiser et al. (2014)	CS	NO	120	13.73	60.83%	PACER	BREQ-2	Multistage regression	$\beta = 0.240$	The physical exercise behavior of college students partially mediates the relationship between exercise motivation and cardiovascular fitness. Therefore, the educational concept of “Health First” should be promoted in college sports. Internal motivation of exercise can be transformed into external motivation to improve students’ exercise behavior and cardiovascular fitness through enhancing their cardiopulmonary capacity.
9	Gao et al. (2009)	CS	US	252	12–15	53.17%	PACER	SCS	Bivariate correlations, Multiple regression analyses	$r = 0.226$ $\beta = 0.041$	Correlation analysis yielded significantly positive relationships between ability beliefs and incentives. Regression results revealed that ability beliefs, importance, interest, and usefulness significantly predicted intention for future participation. Ability beliefs also emerged as significant predictors of PACER test scores.

(Continued)

TABLE 1 (Continued)

Number	Author, year	Study design	Country	Sample Size	Age (years)mean (SD) [range]	Percentage girls (%)	Instruments used (CRF)	Instruments used (EM)	Analysis	Association indicators	Conclusion
10	Sibley et al. (2013)	CS	US	194	18–31	63.92%	PACER	MPAM-R	Bivariate correlations, Multiple regression analyses	$r = 0.242$ $\beta = 0.081$	MPAM-R and BreQ-2 subscales were regressed onto two fitness measures. MPAM-R, stronger competence and fitness motives predicted better fitness and stronger appearance motives predicted worse fitness. For the BREQ-2, higher intrinsic motivation predicted better aerobic fitness, and stronger, introjected regulation predicted higher body fat composition.
11	Cadenas-sanchez et al. (2021)	CS	ES	341	12–18	52.2%	PACER	AEQ-PE	Multiple regression analyses	$\beta = 0.304$	Boys presented with higher levels of cardiorespiratory fitness and motivation than girls. In addition, cardiorespiratory fitness was associated with higher motivation

CS, Cross sectional study; LS, Longitudinal I study; CRF, cardiorespiratory fitness; EM, Exercise motivation; SCS, Self-Created Scale; PL, Physical literacy; PACER, Physical Activity and Cardiovascular Endurance Run; BREQ, Behavioral Regulation in Exercise Questionnaire; EMI-2, Exercise Motivations Inventory version; MPAM, Motives for physical activities measure.

Meta-analysis were employed for in-depth research. The results indicate a significant positive correlation between the two, with a bidirectional association and mutual influence. The study exploring the impact of exercise motivation on cardiorespiratory fitness shows that exercise motivation has a predictive effect on cardiorespiratory fitness. Conversely, when investigating the impact of cardiorespiratory fitness on exercise motivation, the results reveal that students with higher cardiorespiratory fitness also have higher exercise motivation. Additionally, factors such as gender, psychological cognition, and sports knowledge affect this relationship. Males generally have higher cardiorespiratory fitness and exercise motivation than females; stronger psychological cognitive abilities and beliefs are associated with higher exercise motivation and cardiorespiratory fitness; and individuals with a rich reserve of sports knowledge place greater importance on sports and have higher levels of cardiorespiratory health. In summary, the two factors mutually enhance each other, forming a virtuous cycle. This study provides theoretical support for promoting the development of cardiorespiratory fitness in young students, suggesting that intervention measures should aim to enhance exercise motivation and encourage student participation in sports.

Meta-analysis

All 11 included studies provided data on the association between cardiorespiratory fitness and exercise motivation in young students. Among them, 6 studies directly provided correlation data between cardiorespiratory fitness and exercise motivation in young students. The remaining studies provided standardized beta coefficients, which were converted into correlation coefficients r using a formula for meta-analysis. The Pearson correlation coefficient r in the literature, combined with the Pearson coefficient and sample size, was converted into Fisher's Z score, standard error (SE), and 95% confidence interval (CI) (Borenstein et al., 2011; Szczuka et al., 2021). A meta-analysis was conducted using a random-effects model for the correlation coefficient ρ and the 95% confidence interval (CI). Before performing the calculations, the standardized coefficient β was converted to an r value using the formula $r = \beta \times 0.98 + 0.05\lambda$ (when $-0.5 < \beta < 0$, $\lambda = -1$; when $0 < \beta < 0.5$, $\lambda = 1$) (Peterson and Brown, 2005). The results showed that the pooled effect size was 0.24, with a 95% confidence interval ranging from 0.19 to 0.30, indicating a significant overall effect among the studies. The heterogeneity test revealed a chi-square value of 35.50 with 11 degrees of freedom, and a p -value less than 0.0001, suggesting significant heterogeneity among the studies. The I-squared value was 72.45%, indicating that 72.45% of the variance in the effect size could be attributed to the heterogeneity between studies. In addition, the z -value for the Test of ES = 0 was 8.49, with a p -value less than 0.0001, further confirming the statistical significance of the study results.

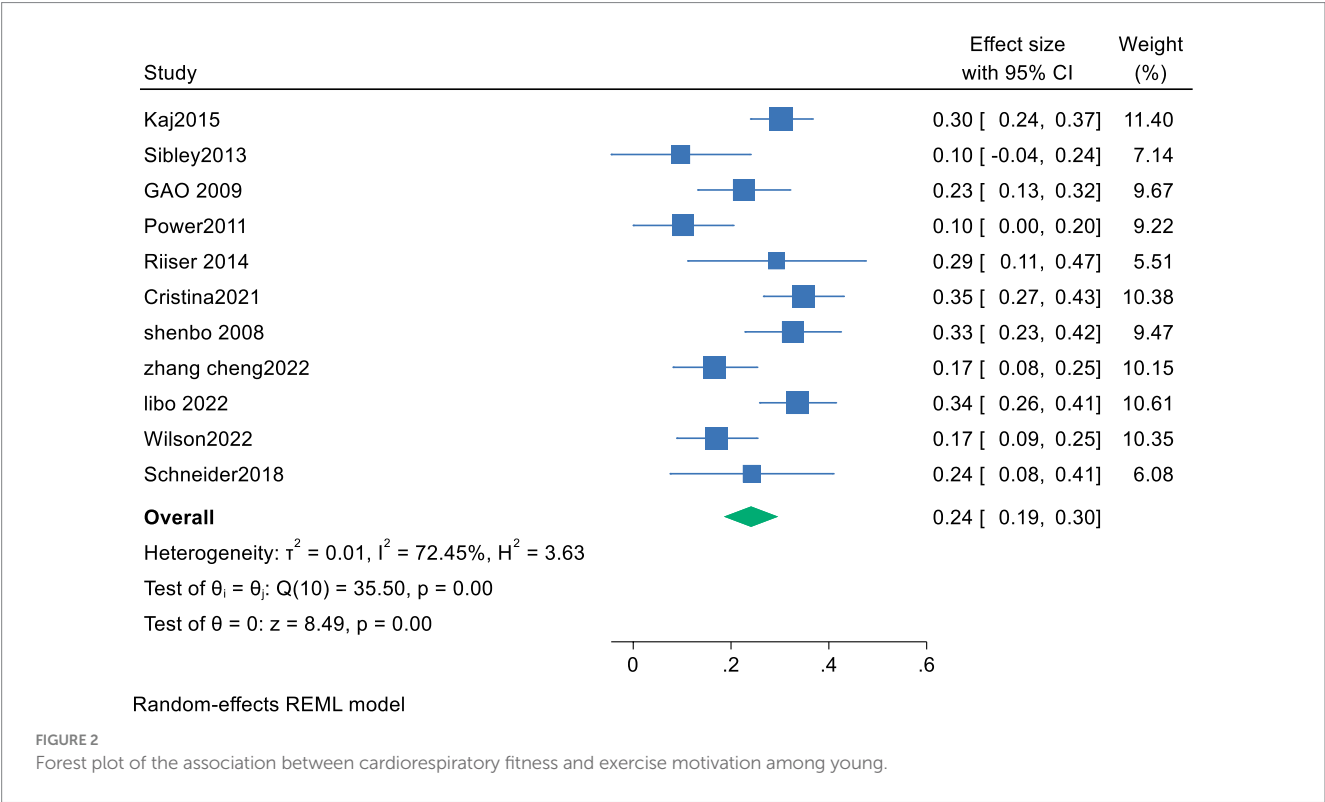
The pooled Fisher's z score and 95% CI were converted back to the correlation coefficient r , resulting in an r of 0.235 with a 95% CI. The lower limit of the 95% confidence interval was approximately 0.187, and the upper limit was approximately 0.291. This means that the analysis yielded an average correlation coefficient of 0.235 between cardiorespiratory fitness and exercise motivation in young students, with a 95% confidence interval ranging from 0.187 to 0.291 (Figure 2).

Of the 11 included studies, 4 conducted regression analyses with exercise motivation as the independent variable and cardiorespiratory

TABLE 2 Results of the quality assessment of the studies included in the systematic review (N = 11).

Author and year	1. Research question	2. Studydesign	3. Subject and variable selection	4. Subject characteristics	8. Exposures and outcome	9. Sample size	10. Analytic methods	11. Estimate of variance	12. Confounding	13. Results in sufficient detail	14. Conclusions supporting results	Sums	Weights	Rank #
Kaj et al. (2015)	2	2	2	2	2	2	2	2	1	2	2	21	95.5%	Excellent
Gao et al. (2009)	2	2	2	2	2	2	2	2	2	2	2	22	100.0%	Excellent
Shen and Xu (2008)	2	1	2	1	2	2	2	1	1	1	2	17	77.3%	Good
Zhang et al. (2022)	2	1	2	2	2	2	2	2	2	2	2	21	95.5%	Excellent
Wilson et al. (2020)	2	2	1	2	2	2	2	1	1	2	2	19	86.4%	Excellent
Schneider (2018)	1	2	1	2	1	2	2	2	1	1	1	16	72.7%	Good
Power et al. (2011)	2	1	2	2	2	2	2	2	2	2	2	21	95.5%	Excellent
Li et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	22	100.0%	Excellent
Riiser et al. (2014)	2	1	2	2	2	2	1	1	2	2	2	19	86.4%	Excellent
Cadenas-sanchez et al. (2021)	2	1	2	2	2	2	2	2	2	2	2	21	95.5%	Excellent
Sibley et al. (2013)	2	2	1	1	1	2	1	1	0	2	2	15	68.2%	Adequate

Each item was scored depending on to what degree the criterion was met: yes = 2 points, partial = 1 point, no = 0; t study total sum score divided by the total possible score of 22; # A percentage score of > 80, 70–80%, 55–69, and < 55% was rated as “excellent,” “good,” adequate and “low,” respectively.



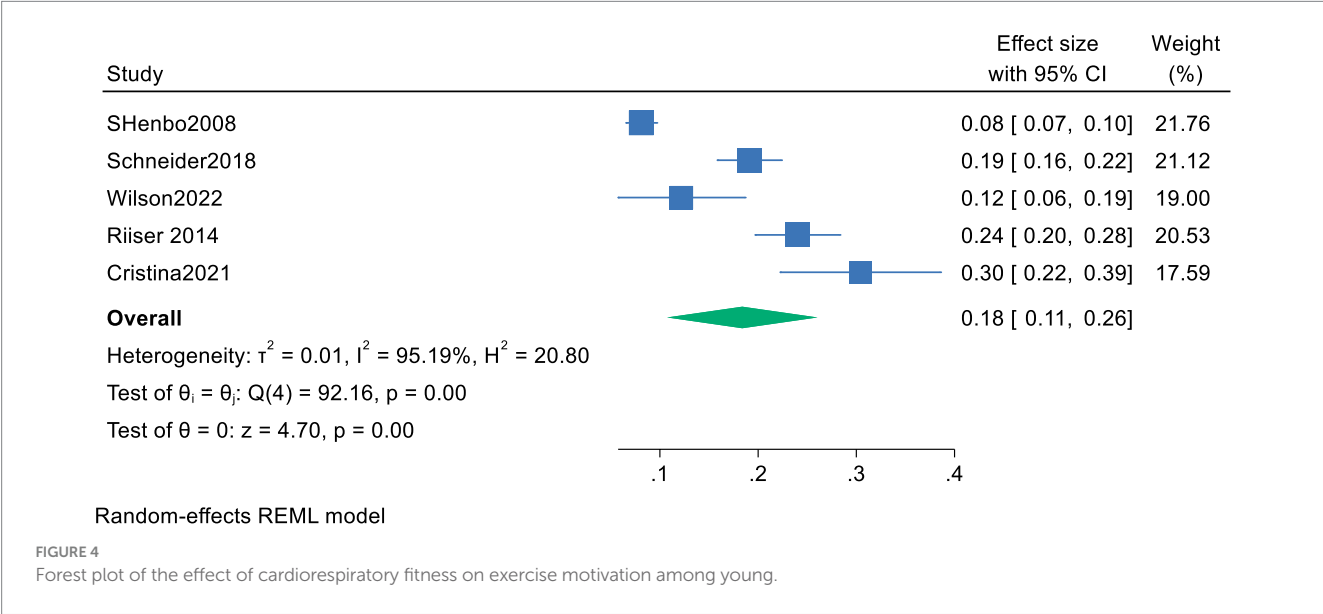
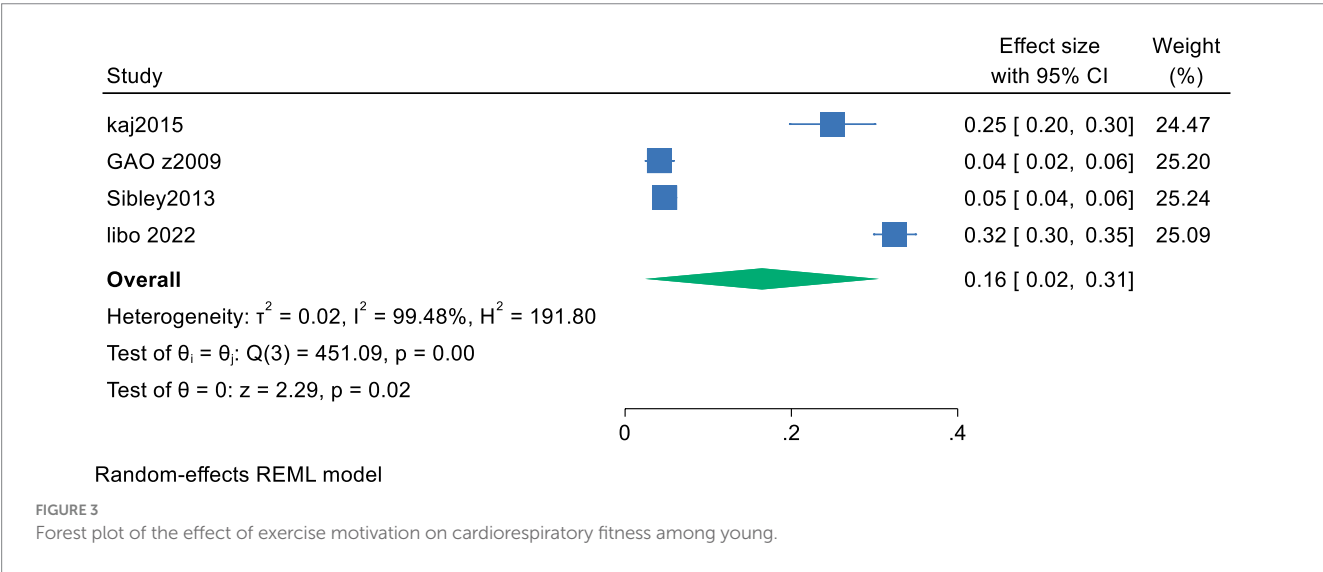
fitness as the dependent variable, providing effect sizes (standardized coefficients) for the prediction of future cardiorespiratory fitness in adolescents based on exercise motivation. The 95% confidence intervals (CI) were calculated using the formula ($CI = \beta \pm 1.96 \times SE$) based on the standardized coefficient β and the standard error (SE). A meta-analysis was performed using a random-effects model for the standardized coefficient β and the 95% CI. The results showed a pooled effect size of 0.16, with a 95% confidence interval ranging from 0.02 to 0.31, indicating a significant overall effect among the studies. The heterogeneity test revealed a chi-square value of 451.09 with 3 degrees of freedom, and a p -value less than 0.0001, suggesting significant heterogeneity among the studies. The I-squared value was 99.48%, indicating that 99.48% of the variance in the effect size could be attributed to heterogeneity among the studies. Additionally, the z -value for the test of $ES = 0$ was 2.29, with a p -value less than 0.05, further confirming the statistical significance of the results (Figure 3). The overall results suggest that exercise motivation has a moderate predictive effect on the future level of cardiorespiratory fitness in young students, with a standardized coefficient of 0.16. This means that for everyone standard deviation unit increase in exercise motivation, the probability of an increase in the future level of cardiorespiratory fitness in young students averages an increase of 0.16 standard deviation units.

Of the 11 included studies, 5 conducted regression analyses with cardiorespiratory fitness as the independent variable and exercise motivation as the dependent variable, providing effect sizes (standardized coefficients) for the impact of cardiorespiratory fitness on adolescents' exercise motivation. The 95% confidence intervals were calculated using the formula (confidence interval = $\beta \pm 1.96 \times SE$) based on the standardized coefficient β and the standard error SE. A meta-analysis was performed using a random-effects model for the

standardized coefficient β and the 95% CI. The results showed a pooled effect size of 0.18, with a 95% confidence interval ranging from 0.11 to 0.26, indicating a significant overall effect among the studies. The heterogeneity test revealed a chi-square value of 92.16 with 4 degrees of freedom, and a p -value less than 0.0001, suggesting significant heterogeneity among the studies. The I-squared value was 95.19%, indicating that 95.19% of the variance in the effect sizes could be attributed to heterogeneity among the studies. Additionally, the z -value for the Test of $ES = 0$ was 4.70, with a p -value less than 0.0001, further confirming the statistical significance of the results (Figure 4). The overall results showed that cardiorespiratory fitness has a moderate effect on the exercise motivation of young students, with a standardized coefficient of 0.18. This means that for everyone standard deviation unit increase in cardiorespiratory fitness, the exercise motivation of young students increases by an average of 0.18 standard deviation units.

Subgroup analysis

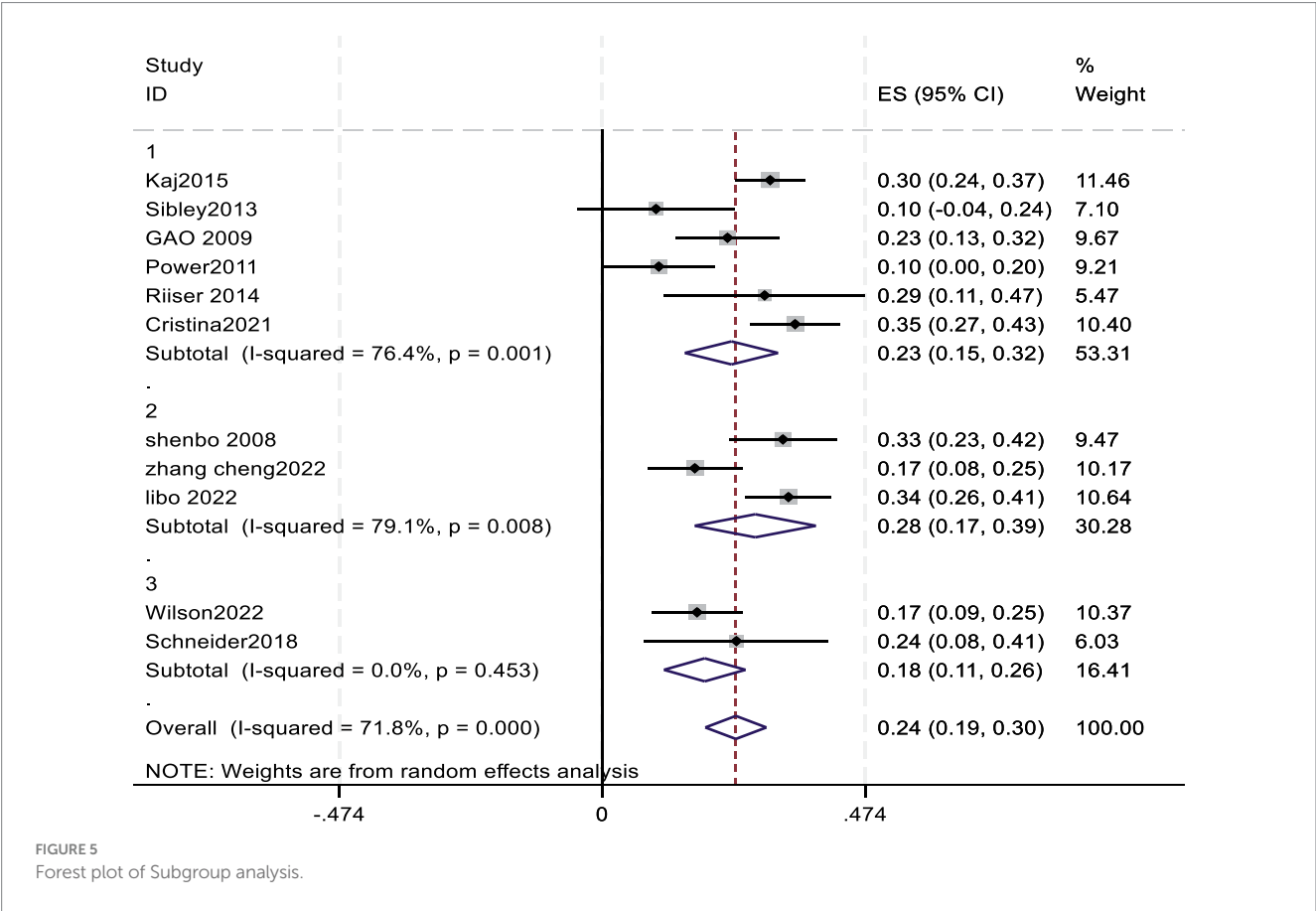
A subgroup analysis was conducted based on different cardiorespiratory fitness assessment tools. Specifically, the data were divided into three subgroups using the 20-meter shuttle run PACER, the 800/1000-meter run, and other assessment tools. The subgroup analysis was performed based on the cardiorespiratory fitness assessment tools (PACER, 7 studies; 800/1000-meter run, 3 studies; other tools such as the YMCA heart rate monitor and ramp-type progressive bicycle ergometer, 2 studies) to examine the association between adolescent cardiorespiratory fitness and exercise motivation. The results showed that the pooled effect size for PACER was 0.23, with a 95% confidence interval of 0.15 to 0.32; for the



800/1000-meter run, the pooled effect size was 0.28, with a 95% confidence interval of 0.17 to 0.39; and for other assessment tools, the pooled effect size was 0.18, with a 95% confidence interval of 0.11 to 0.26. The p -values for all three subgroups were less than 0.05, indicating a significant overall effect among the studies (Figure 5). This suggests that there is a significant association between adolescent cardiorespiratory fitness and exercise motivation overall, regardless of the different cardiorespiratory fitness assessment tools used, meaning that cardiorespiratory fitness has a notable impact on exercise motivation. The heterogeneity test results showed that the I-squared value for the subgroup using PACER was 76.4%, and for the subgroup using the 800/1000-meter run, it was 79.1%, both indicating a high degree of heterogeneity among the studies within these two subgroups. This heterogeneity may be due to significant differences in study subjects, research methods, interventions, and other factors across the studies. Meanwhile, the subgroup using other assessment tools had an I-squared value of 0.0%, suggesting low

heterogeneity and more consistent results within this subgroup. However, this subgroup only included two studies with a small sample size, so its reliability needs further validation. The differences in results obtained from different assessment tools suggest that caution is needed when selecting cardiorespiratory fitness assessment tools. The choice should be made based on a comprehensive consideration of the research objectives, study subjects, and other factors to select the most appropriate assessment tool. Additionally, further research is needed to develop more accurate and effective cardiorespiratory fitness assessment tools to better investigate the relationship between cardiorespiratory fitness and exercise motivation.

Based on the above-mentioned research data, subgroup analyses were carried out to further explore the sources of heterogeneity. According to the educational stages, the included studies were divided into three different subgroups: primary school, middle school, and university, with 2 studies in the primary - school subgroup, 4 studies in



the middle - school subgroup, and 5 studies in the university subgroup, respectively. The results of the subgroup analyses revealed a significant positive correlation between cardio - respiratory fitness and exercise motivation across different educational levels. Specifically, the pooled effect size of the primary - school subgroup was 0.16, with a 95% confidence interval ranging from 0.02 to 0.29. The pooled effect size of the middle - school subgroup was 0.30, with a 95% confidence interval from 0.25 to 0.35. The pooled effect size of the university subgroup was 0.23, with a 95% confidence interval from 0.14 to 0.31. The p - values of all three subgroups were less than 0.05, indicating a significant overall effect statistically, thus demonstrating that cardio - respiratory fitness has a significant impact on exercise motivation. Regarding the heterogeneity assessment, the I^2 statistic of the primary - school subgroup was 49.4% and that of the middle - school subgroup was 19.5%. Both indicated low heterogeneity. This indicates that the correlation between cardiopulmonary endurance and exercise motivation plays a significant role in both primary and secondary school stages, demonstrating a certain degree of consistency in the research findings. In contrast, the university subgroup showed high heterogeneity, with an I^2 value of 78.1%. This might be attributed to the wider age range within this group. This observation emphasizes the need for greater caution when interpreting the research findings of the university subgroup and the consideration of other variables that may affect the results (Figure 6).

Overall, although there are differences in the degree of association between cardio - respiratory fitness and exercise motivation among students at different educational stages, a significant positive

correlation was consistently observed. This finding highlights the importance of improving students' cardio - respiratory fitness to enhance their exercise motivation. In addition, the results of this study emphasize the necessity of considering heterogeneity when choosing research tools and interpreting research conclusions. Finally, we conducted a sensitivity analysis on this outcome, indicating the stability of the results (Figure 7).

Publication bias assessment and sensitivity analysis

The funnel plot exhibits symmetry, indicating that the effect sizes are uniformly distributed around the overall effect size on both sides. The blue dots are symmetrically distributed within the grey lines, and the majority of them fall within the grey lines, suggesting minimal publication bias. In conjunction with the Egger's regression test, which yielded a p -value of 0.317 for the intercept across various data types, we conclude that there is no evidence of publication bias in the statistical correlation data (r) (Figure 8A).

The funnel plot displayed exhibits symmetry, yet the distribution of blue dots beyond the confines of the grey lines suggests the potential presence of publication bias. In light of the Egger's regression test outcomes, which returned a p -value of 0.285 for the intercept across various data types, it is inferred that an acceptable magnitude of bias is present within the standardized coefficient beta (Figure 8B).

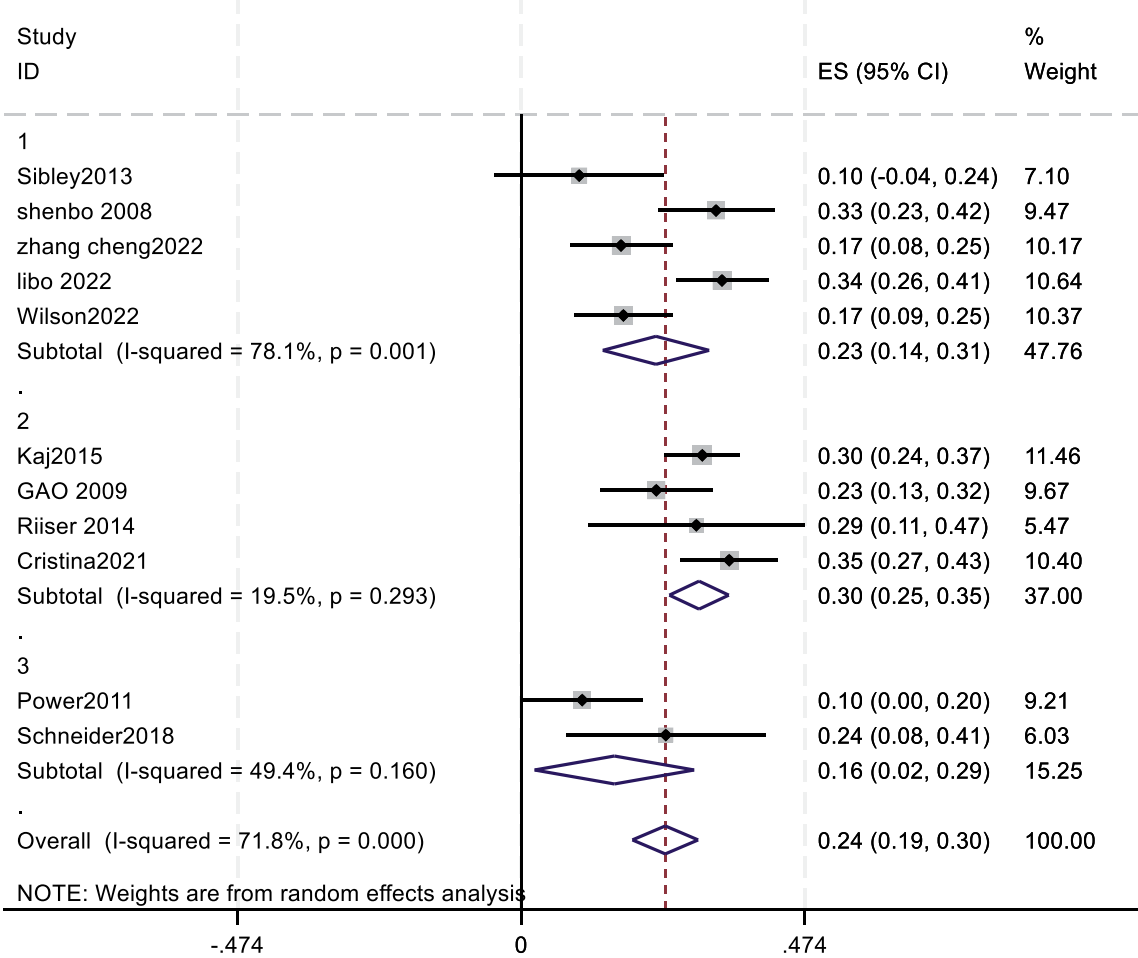


FIGURE 6
Forest plot of Subgroup analysis.

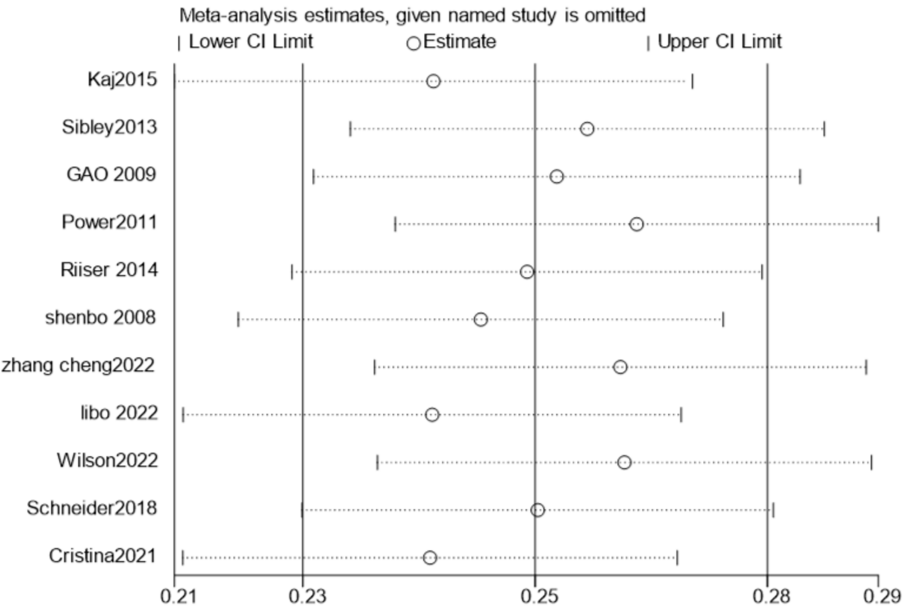


FIGURE 7
The results of the sensitivity analysis for the included studies.

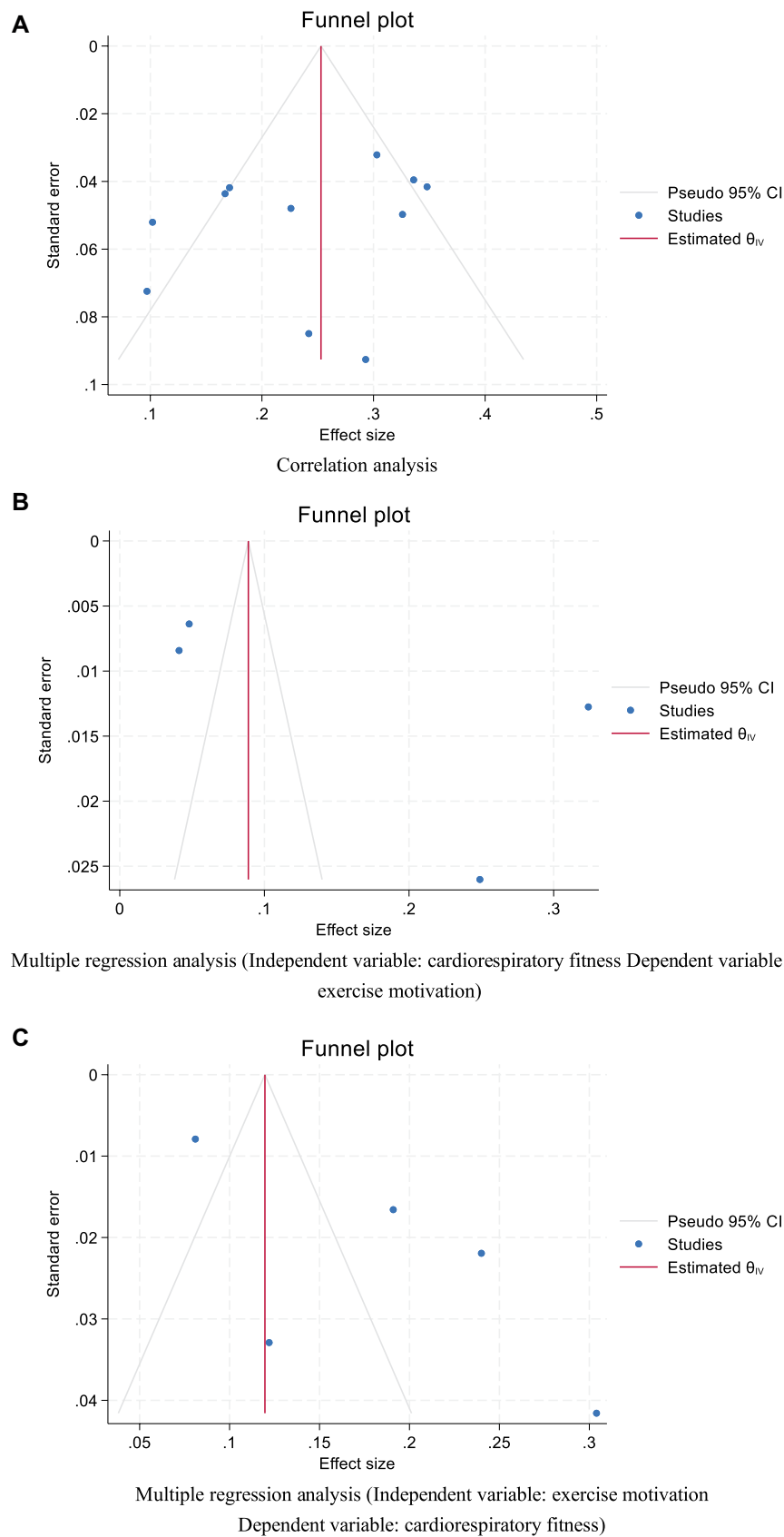


FIGURE 8

Funnel plot analyzing the association between cardiorespiratory fitness and exercise motivation among young. (A) Correlation analysis. (B) Multiple regression analysis (Independent variable: cardiorespiratory fitness Dependent variable: exercise motivation). (C) Multiple regression analysis (Independent variable: exercise motivation Dependent variable: cardiorespiratory fitness).

TABLE 3 Results of publication bias test.

Date type	P-value of slope	P-value of bias	Is there publication bias
Correlation data r	$p = 0.005$	$p = 0.317$	No
Standardized β	$p = 0.626$	$p = 0.285$	No
Standardized β	$p = 0.391$	$p = 0.093$	No

The funnel plot illustrated demonstrates a certain degree of symmetry, indicating that the effect sizes are uniformly distributed around the estimated overall effect size. However, the presence of several blue dots outside the grey lines may suggest the potential for publication bias. Considering the results of Egger's regression test, which yielded a p -value of 0.093 for the intercept across various data types, we infer that there is an acceptable level of bias in the standardized coefficient β . This finding still helps to strengthen our confidence in the overall integrity and reliability of the data under consideration (Figure 8C).

The funnel plots and Egger's test were employed to assess the publication bias of the included studies. By examining the symmetry of the funnel plots, in conjunction with the p -values of the interception coefficients for various data types from Egger's test (0.317, 0.287, and 0.093), we conclude that there is no evidence of publication bias in the statistical correlation data r . Furthermore, regarding the standardized coefficient β , there is insufficient evidence to indicate the presence of small-study effects or publication bias (Table 3).

The sensitivity analysis indicated that there was no substantial change in the positive association when each study was omitted one by one (Figure 7).

Discussion

This study comprehensively and systematically reviews the relationship between exercise motivation and cardiorespiratory fitness among young students for the first time. Through systematic database searches, 11 research articles were successfully selected, covering cross-sectional and longitudinal studies, all of which are of high quality. During the research process, correlation analysis and multiple regression analysis were mainly used. After standardizing similar correlation data, a Meta-analysis was carried out. The results show that there is a significant statistical association between exercise motivation and cardiorespiratory fitness among young students. In addition, the Meta-analysis of multiple regression reveals that the influence between cardiorespiratory endurance and exercise motivation is bidirectional. Individuals with strong cardiorespiratory endurance also have stronger exercise motivation, and the level of exercise motivation can predict the future level of cardiorespiratory endurance.

The results of the Meta-analysis of correlation coefficients indicate that there is a moderate positive impact between cardiorespiratory endurance and physical activity among young students, with a significant positive correlation (the average correlation coefficient $r = 0.24$, $p < 0.001$). This means that students with stronger cardiorespiratory endurance typically have higher exercise motivation. A systematic review on the sports motivation of Chinese college students (Deng et al., 2023) shows that the influencing factors include

the sports level. The study reveals that individuals with a lower sports level also have weaker exercise motivation. In addition, another Meta-analysis study on the impact of motivational physical activity interventions on the aerobic fitness (CRF) of healthy adults further confirms the association between exercise motivation and cardiorespiratory endurance (Chase and Conn, 2013). Motivational physical activity (PA) interventions have a significant effect on improving the aerobic fitness of healthy adults, indicating an association between stronger exercise motivation and stronger cardiorespiratory endurance. In the study by Galan-lopez et al. (2022), the researchers explored the potential links between cardiorespiratory fitness (CRF) and different subfactors of exercise motivation. The results show that when CRF levels increase, boys scores on exercise motivation subfactors such as revitalization and enjoyment, competition, strength and endurance, and challenge also increase. For female participants, when CRF levels rise, there is an increase in scores on exercise motivation subfactors like recovery and enjoyment, strength and endurance, and challenge. This indicates that individuals with higher cardiorespiratory fitness feel more relaxed during exercise and are less prone to fatigue, thereby being more willing to participate in physical activities, which in turn strengthens their exercise motivation. There is a mutual influence and interaction between exercise motivation and cardiorespiratory fitness. Another study explored the correlation between exercise motivation and cardiorespiratory fitness from a different perspective. Raghuvveer et al. (2020) research suggests that the results of cardiorespiratory fitness tests are also influenced by motivation levels. In summary, there is a moderate correlation between exercise motivation and cardiorespiratory fitness.

To further explore the correlation between cardiorespiratory fitness and exercise motivation in adolescents, this study conducted a subgroup analysis of the relevant data. Specifically, we divided the analysis into three categories based on different cardiorespiratory fitness assessment tools: the 20-meter Pacer test, the 800/1000-meter run test, and other assessment tools. The analysis results showed that in all three subgroups using these assessment tools, there was a significant positive correlation between adolescents' cardiorespiratory fitness and exercise motivation. This finding indicates that the selected assessment tools have a certain degree of validity in measuring the association between cardiorespiratory fitness and exercise motivation.

In addition, the results of the Meta-analysis of multivariate/regression data further confirm this point. In the Meta-analysis with exercise motivation as the independent variable and cardiorespiratory fitness as the dependent variable, the average standardized coefficient β was 0.16 ($p < 0.001$). The study indicates that students with stronger exercise motivation typically have higher levels of cardiorespiratory fitness; conversely, students with weaker exercise motivation, due to a lack of sufficient motivation, have lower enthusiasm for participating in sports, resulting in relatively weaker cardiorespiratory fitness. Therefore, exercise motivation has a predictive effect on cardiorespiratory fitness. This conclusion is highly consistent with the research findings presented in the article "Research on the Relationship between Physical Activity Constraints among College Freshmen and Current Health, Behavior, and Outcomes among Upperclassmen" by Wilson et al. (2020). In this study, differences in freshmen's physical activity constraints, current physical activity levels, predicted aerobic fitness, and obesity based on subjective changes in physical activity were explored through one-way ANOVA of subjective physical activity changes. The research found that compared

to their high school years, students who reported a decrease in physical activity indicated that they were more limited by motivation during their freshman year, and the difficulty in exercising significantly increased. This indicates that a decrease in exercise motivation makes students less willing to participate in physical activity, which in turn leads to a gradual decline in cardiorespiratory fitness levels. Thus, it can be seen that exercise motivation is an important factor in predicting future cardiorespiratory fitness.

However, in terms of the impact of sub-factors of exercise motivation on future cardiorespiratory health, [Kaj et al. \(2015\)](#) further confirmed the predictive role of exercise motivation in cardiorespiratory endurance in their longitudinal study, while also finding significant gender differences. Using multiple regression analysis, the study found that various sub-factors of exercise motivation, including health orientation in physical education (C1), avoidance of failure (C2), success orientation (C3), attitude toward physical activity (C4), and cooperation and social experience (C5), were all significantly related to cardiorespiratory health ($p < 0.05$). Specifically, for boys, the statistically significant predictors included C1, C2, C3, and C4, while for girls, they were C2 and C4. This indicates that there are significant differences between male and female students in terms of motivational factors predicting future cardiorespiratory health.

Additionally, in the Meta-analysis where cardiorespiratory fitness was the independent variable and exercise motivation was the dependent variable, the effect size was 0.18 ($p < 0.001$). The research results indicate that students with stronger cardiorespiratory fitness typically have stronger exercise motivation, further clarifying the association between cardiorespiratory fitness and exercise motivation. The study by [Riiser et al. \(2014\)](#) also supports this viewpoint; when conducting a regression analysis of self-determined motivation on cardiorespiratory fitness, a statistically significant relationship was found, with a regression coefficient $B = 2.08$, 95% CI [0.53–3.63], $p < 0.01$, suggesting that healthier adolescents tend to have stronger exercise motivation.

In addition, we conducted a publication bias test on the included literature. Through the funnel plot and Eggers test, we did not find publication bias in the correlation data r and standardized coefficient β , which enhances the reliability of the results of this study. These findings provide an important empirical basis for further exploring the relationship between exercise motivation and cardiorespiratory fitness and offer references for future research directions and methodologies.

Overall, the relationship between cardiorespiratory fitness and exercise motivation in young students manifests as a positive feedback loop. Students with stronger cardiorespiratory fitness typically have higher exercise motivation, and those with stronger exercise motivation are likely to develop greater cardiorespiratory fitness in the future, with the two factors mutually reinforcing each other to create a virtuous cycle. This bidirectional relationship suggests that in interventions aimed at enhancing cardiorespiratory fitness in young students, it is important not only to focus on increasing exercise motivation but also to encourage active participation in physical activities to strengthen cardiorespiratory fitness. These studies provide important theoretical support for the development of cardiorespiratory fitness in young students.

When delving into other factors that affect the correlation between cardiorespiratory fitness and exercise motivation, it becomes evident that the relationship between the two is influenced by numerous external factors. Among these, gender, psychological cognition, and educational level are particularly crucial. In the comprehensive analysis

of the 11 studies, 6 of them pointed out that males generally have higher levels of cardiorespiratory fitness and exercise motivation than females. For instance, [Schneider \(2018\)](#) study showed that, consistent with the overall trend, boys in the study were more active than girls, had higher levels of cardiorespiratory fitness, and were more inclined to participate in high-intensity sports. Furthermore, [Wilson et al. \(2020\)](#) research indicated that females were less active than males, and among females, those with lower levels of aerobic fitness were more limited by comfort factors, facing greater difficulties during physical activity. Thus, gender differences play a significant role in the association between exercise motivation and cardiorespiratory fitness.

Secondly, from the perspective of psychological cognition, there is a significant association between an individual's beliefs in their cognitive abilities and both exercise motivation and cardiorespiratory fitness. [Gao et al. \(2009\)](#) study provides strong empirical support for this. Through correlation analysis, the study clearly indicated a significant positive relationship between ability beliefs and motivation. Further regression analysis results showed that factors such as ability beliefs, importance, interest, and usefulness significantly predict an individual's intention to participate in related activities in the future. Particularly noteworthy is that ability beliefs are a key predictor of scores on the PACER 20-meter shuttle run test. This fully demonstrates that the stronger an individual's beliefs in their cognitive abilities, the more intense their exercise motivation and the higher their level of cardiorespiratory fitness.

In addition, the study by [Shen et al. \(2009\)](#) found that the reserve of sports knowledge also plays a significant role in the relationship between exercise motivation and cardiorespiratory fitness. The research indicates that individuals with a richer reserve of sports knowledge tend to place greater importance on sports and are inclined to engage in physical activities to promote their health. Specifically, the study showed that students in the mastery-oriented group differed significantly from those in other groups in terms of effort in classroom learning, knowledge acquisition, and cardiorespiratory health levels. Compared to students in the performance-oriented rich group and the low motivation group, the mastery-oriented students not only possessed more knowledge but also had a more proactive attitude toward physical education (as evidenced by interest and perceived autonomy) and demonstrated higher levels of cardiorespiratory health. Furthermore, some data were not included in the meta-analysis due to a lack of necessary quantitative data, but their perspectives are of great value. For instance, [Faiide-Garrido et al. \(2022\)](#) divided students into physically active and inactive groups based on their cardiorespiratory fitness levels and physical activity questionnaire scores. They used the BREQ questionnaire to assess the exercise motivation of the active and inactive groups, and the results showed that the active group had significantly higher exercise motivation than the inactive group. Additionally, the study concluded that educational level had an impact on physical activity, with higher-educated individuals engaging in more sports activities and exercising more ([Corder et al., 2009](#)), while those with lower educational levels had a higher prevalence of lack of physical activity and overweight ([Devaux and Sassi, 2013](#)).

Although this study provides important insights into the correlation between exercise motivation and cardiorespiratory fitness in young students, it also has several limitations. First, the predominantly cross-sectional design of this study implies a lack of

exploration of the causal relationship between cardiopulmonary endurance and exercise motivation. Second, subgroup analyses conducted to assess school levels, measurement tools, and confounding factors help reduce heterogeneity, indicating their importance as sources of heterogeneity. However, there may be other unmeasured factors that influence this association, such as insufficient sample representativeness, large differences in sample size, few longitudinal studies, inconsistent assessment tools, lack of consideration for other potential factors and their interactions, high heterogeneity in the Meta-analysis, potential publication bias, challenges in interpreting results and applying them in practice, and a limited scope of research. To address these issues, in future experimental research, it is essential to deeply explore the influencing mechanisms of gender, psychological awareness, sports knowledge, and educational levels, conduct long-term tracking research using diverse methods, and evaluate the intervention effects, so as to optimize the strategies for improving exercise motivation and cardiorespiratory endurance. In the subsequent teaching practice, personalized exercise programs should be designed by taking gender differences into account. It is necessary to focus on enhancing psychological awareness and popularizing sports knowledge. Attention should also be paid to differences in educational levels, and comprehensive intervention measures should be adopted.

Conclusion

This study has confirmed a significant positive correlation between exercise motivation and cardiorespiratory fitness in young students, with the positive influence of exercise motivation on cardiorespiratory fitness being moderate, and conversely, cardiorespiratory fitness also having a positive effect on exercise motivation. This finding provides a theoretical basis for enhancing cardiorespiratory fitness and strengthening exercise motivation in young students. Future research could also explore more effective assessment methods to gain a more comprehensive and in-depth understanding of the association mechanism between exercise motivation and cardiorespiratory fitness.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

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FZ: Conceptualization, Data curation, Investigation, Writing – original draft. WW: Writing – review & editing, Formal analysis, Methodology. YN: Writing – review & editing, Investigation, Software. CS: Writing – review & editing, Conceptualization, Data curation, Resources. WM: Writing – review & editing, Funding acquisition, Investigation, Software. WQ: Funding acquisition, Resources, Supervision, Writing – review & editing. GQ: Writing – review & editing, Methodology, Conceptualization. JG: Data curation, Formal analysis, Methodology, Project administration, Writing – review & editing. CL: Conceptualization, Data curation, Project administration, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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High-groove music boosts self-selected running speed and positive mood in female university students

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Introduction: Approximately 27.5% of adults worldwide fail to meet the recommended 150 min per week of moderate-to-vigorous physical activity. Music is a powerful tool that enhances positive affective responses and exercise adherence. However, little is known regarding which types of music are most effective in enhancing these benefits. Groove, which induces a sensation of “wanting to move to the music” and is associated with positive affective responses, may help make self-paced exercise more active and pleasant. Therefore, in this study, we examined the effects of high-groove (HG) music on self-paced exercise and mood responses.

Methods: Thirty-eight university students (18 males) participated in this randomized crossover study under two experimental conditions. The participants ran on a treadmill for 10 min at a self-selected comfortable speed while listening to HG and low-groove (LG) music playlists.

Results: The HG playlist received higher groove ratings than the LG playlist. Self-selected running speed and positive mood responses (vitality and arousal) were greater under the HG condition only in women. Exercise intensity measured using heart rate and the rate of perceived exertion was comparable between the conditions. The groove ratings for the HG playlist positively correlated with speed (HG-LG) and vitality changes under the HG condition (post-pre).

Conclusion: These results suggest that HG music promotes a positive mood response and exercise adherence, particularly in female students. Moreover, the observed sex difference suggests that individual differences in music perception may also influence exercise behavior. Focusing on groove, a musical characteristic distinct from tempo and volume, our study provides a more comprehensive understanding of music that is compatible with exercise, while also examining potential sex differences in its effects on self-paced exercise and mood responses. These findings contribute to health promotion by encouraging active living via physical exercise.

KEYWORDS

groove, physical exercise, exercise adherence, heart rate, affect, self-paced exercise, tempo, sex differences

1 Introduction

The WHO guidelines for physical activity and sedentary behavior state that physical activity has a positive effect on mental and cognitive health across the human life span and recommend 150 min of moderate-to-vigorous physical activity per week (1). Nonetheless, approximately 27.5% of adults worldwide do not meet this

recommendation (2). Previous studies regarding the promotion of exercise adherence have indicated that affective response to physical exercise has been identified as a key factor for enhancing motivation towards exercise and physical activity (3–7). A systematic review of actual surveys concluded that positive affective responses during and after exercise reliably correlated with affective judgments on future physical activity (8). In addition to exercise adherence, positive mood responses to exercise can predict the effects of exercise on mental health (9, 10).

For a more sustainable exercise experience, individualized self-paced exercise prescriptions based on emotional state, rather than at a specific prescribed intensity, have been proposed (11). In affect-based, self-paced exercise, exercise intensity is self-regulated to “feel good” based on affective responses (11, 12). Affect-based exercise not only enhances affective responses but also improves exercise adherence—measured by exercise behavior—particularly in individuals with low physical activity levels and cardiorespiratory fitness (13–15). In addition to the benefits of exercise adherence, exercise training at an affect-regulated intensity also improves aerobic fitness (16). These exercise prescription strategies are also advantageous from the perspective of self-determination theory (17).

Music is one of the most powerful and compatible environmental factors for improving exercise performance and positive mood responses (18, 19). Few studies in the health-promotion literature have examined the effect of music on self-paced exercise at the submaximal level. Edworthy and Waring (20) reported that fast, loud music enhanced exercise intensity and positive mood during treadmill running (20). Hutchinson et al. (21) showed that exercise with self-selected music promoted a greater exercise intensity during 20 min of affect-regulated running, exercise compared to without music while maintaining a “good” feeling (21). Almeida et al. (22) also indicated that fast tempo (140 beats per minute [bpm]) music enhances self-selected walking pace in women (22). Although these studies have shown that listening to music increases exercise intensity and positive mood in self-paced exercise, it is unclear whether any musical characteristics other than tempo and volume are effective in enhancing positive affect and exercise behavior.

The groove sensation may be a promising musical feature that enhances affect and exercise behavior (23, 24). A common feature of groove across cultures is “the pleasurable sensation of wanting to move one’s body to music” (25–27). Groovy music evokes arousal and pleasant feelings (27, 28). In addition to positive mood responses, groove influences movement. Groove not only affects dance-like movements (29) but also facilitates repetitive and cyclic movements, such as gait and cycling performance. High-groove (HG) music facilitates faster and less variable movements than those performed with low-groove (LG) music (30, 31). Rhythmic entrainment, a fundamental mechanism by which listeners’ bodily rhythms adapt to the periodicities of music, may underlie the mechanisms through which groove facilitates movement and elicits a positive mood (32, 33). The coactivation of emotional and motivational brain systems, including the dopaminergic reward pathway, along with the activation of several other areas outside the emotional system, including

motor-, attention-, and memory-related regions, is thought to underlie this neural basis (34, 35).

Individual experiences towards groove music are influenced by listener characteristics such as music familiarity (26, 36, 37). Particularly, sex-based differences are known. The tempo at which groove is easily experienced is faster in men than in women (38). In addition, women prefer pop music more (39) and can better identify emotional expressions in music than men (40, 41). These findings suggest sex differences exist in groove sensation, even while listening to the same music.

Taken together, the present study aimed to clarify the effects of groove on self-selected exercise speed and affective response in men and women. We hypothesized that higher groove music would increase self-selected running pace and positive mood compared to lower groove music with a compatible tempo. Furthermore, given that women are generally more sensitive to musical stimuli than men, we anticipated that the observed effects would be more pronounced in women. Our study extends previous research by focusing on groove, a musical characteristic distinct from tempo and volume, while also examining potential sex differences in its effects on self-paced exercise and mood responses.

2 Materials and methods

2.1 Participants

A priori power analysis was performed using G-power software (42). An optimal total sample size of $N=20$ for each sex was calculated, with a partial η^2 effect size of 0.17, power of 0.8, and alpha of 0.05, based on our previous acute exercise intervention studies (43, 44).

Forty healthy university students (aged 18–21 years; 20 male participants) from the Faculty of Health and Sports Sciences of Ryutsu Keizai University participated. Those majoring in sports and health sciences were likely more engaged in exercise and had higher physical activity levels than students in non-sports-related fields. Two male participants were excluded because of unaccomplished experiments or missing data, resulting in data from only 38 students (18 male participants) being collected and analyzed. Participants’ demographic characteristics are presented in Table 1.

Written informed consent was obtained from all participants before starting the experiment. Ethical approval for this study was obtained from the Ethics Committee of Ryutsu Keizai University (approval number: 45). This study complied with

TABLE 1 Participant demographic.

	All		Male		Female	
	Mean	SD	Mean	SD	Mean	SD
Sample size	38		18		20	
Age	19.4	0.8	19.5	0.7	19.4	0.9
Height	165.6	9.6	174.6	6.2	158.2	4.7
Weight	65.5	18.2	79.4	19.0	53.9	5.3
BMI	23.5	4.9	26.1	6.0	21.4	1.8

the ethical requirements of the latest version of the Declaration of Helsinki.

2.2 Procedures

The two experimental conditions, HG and LG conditions, were implemented using a within-subject crossover design in a randomized order. An outline of the experimental procedures is shown in Figure 1. At least 10 min after arrival, the participants performed the first exercise session. The second exercise session was conducted after a minimum of 15 min of seating rest, when the heart rate was confirmed to decrease to resting levels.

As part of the exercise session, the participants ran on the treadmill (PH-OST-2705, Life Fitness) for 10 min, including a 5 min warm-up. The participants were instructed to run, but not walk, for a total of 10 min at a speed that felt comfortable; they were allowed to adjust the treadmill speed by themselves at the beginning and 5 min after the start for 30 s each time. The slope of the treadmill was set to zero. The treadmill speed display was masked from the participants' viewpoint to minimize the impact of cognitive biases. Participants who had never run on a treadmill were allowed to run for 1–2 min before the experiment for familiarization. The first exercise session was then performed after confirming that the heart rate had returned to resting levels following a seated rest. The treadmill speed and heart rate (HR) were recorded continuously during the sessions. HR was measured using a wireless chest strap telemetry system (WHS-1, Union Tool Co., Tokyo, Japan). The rate of perceived exertion [RPE; (45)] was measured immediately after exercise.

2.3 Auditory stimuli

We used commercially available music to provide a natural listening experience for the participants (26). The music selection

process began with groove ratings for a pool of music tracks, from which a balanced set of high- and low-groove tracks was selected based on these ratings. Although various acoustic features contribute to the perception of groove (27), in this study, we relied on subjective groove evaluations for music selection. First, we selected music that is familiar to Japanese university students since familiarity with a song is known to affect groove (46). Altogether 138 music tracks from a variety of genres (pop, rock, hip-hop, jazz, etc.) were originally listed based on input from lab members from the same faculty as the experimental participants. Nine lab members (six women) rated the groove ratings after listening to music pieces and ranked them. Subsequently, three tracks were selected from the top and bottom of the list to create the HG and LG playlists (Table 2). To minimize the impact of a specific tempo on groove (47) and entrainment (48), music with a variety of tempos (slow, medium, and fast) was included in the playlists. Furthermore, the tempo of the music (bpm) was counterbalanced to be comparable across lists to control the effect of tempo on groove. The bpm were obtained from <https://tunebat.com>.

Music was played through loudspeakers, with the volume adjusted to be consistent across all tracks, ensuring it was neither too loud nor too quiet, so as to avoid interference with the sound of the ergometer. The order of the tracks to be listened to in the experiments was randomized across the participants.

2.4 Groove rating

We used the Japanese Version of the Experience of Groove Questionnaire (EGQ-JA) to measure the groove experience for each HG and LG music playlists (49, 50). The EGQ-JA consists of six items and evaluates the groove experience using two scales: the urge to move and pleasure. The participants were asked to indicate how they felt when they listened to a piece of music based on a seven-point Likert-type scale ranging from

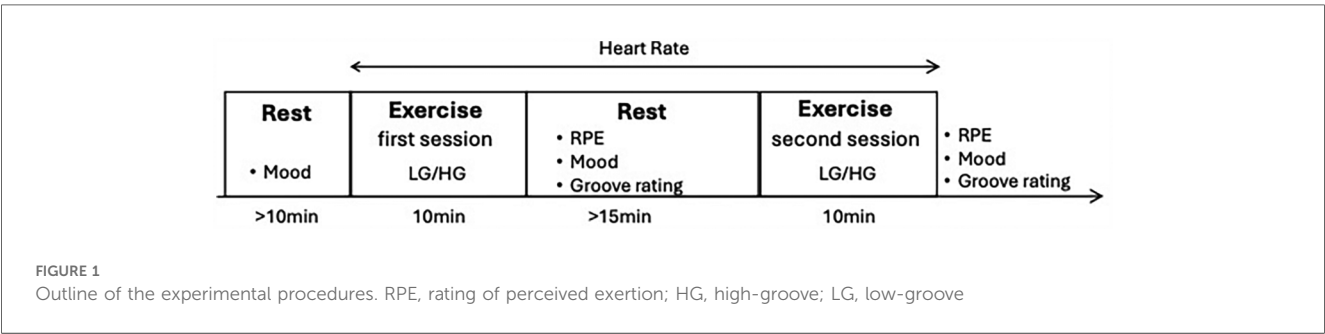


TABLE 2 Musical playlist.

No.	Low-groove				High-groove			
	Track	Artist	BPM	Time	Track	Artist	BPM	Time
1	The Sound of Silence	Disturbed	86	4:08	We Will Rock You	Queen	81	2:02
2	Someone You Loved (Lewis Capaldi)	Cynthia Colombo	110	3:14	Butter	BTS	110	2:44
3	Black Swan	BTS	147	3:18	Shake It Off	Taylor Swift	160	3:39

0 = “strongly disagree” to 6 = “strongly agree”. The total score for the six items was used as the groove rating.

The participants listened to the music tracks again after the exercise sessions and rated each track. The average rating of the three tracks was used as the groove rating for the HG and LG playlists.

2.5 Mood scale

The psychological mood state was measured using the Two-Dimensional Mood Scale (TDMS) before and after the exercise session (51). The TDMS is a psychometric scale comprising eight mood-expressing words that describe both pleasurable and arousal states (energetic, lively, lethargic, listless, relaxed, calm, irritated, and nervous). The participants were asked to indicate how they were feeling at the time according to a six-point Likert-type scale ranging from 0 = ‘not at all’ to 5 = ‘extremely’. Vitality level, which represents low arousal–displeasure to high arousal–pleasure (−10 to +10 points), and stability level, which represents high arousal–displeasure to low arousal–pleasure (−10 to +10 points), were measured. Based on these scores, pleasure (vitality + stability: −20 to +20 points) and arousal (vitality − stability: −20 to +20 points) levels were calculated.

2.6 Statistical analysis

First, we tested the significance of the differences according to sex and groove experience while listening to the HG and LG playlists. We performed a repeated-measures two-way analysis of variance (ANOVA) of groove ratings by sex and condition, followed by a Bonferroni’s *post hoc* test.

Second, we examined the effects of groove on running speed and exercise intensity (HR, RPE) with a paired *t*-test and mood changes with a repeated measures two-way ANOVA. To account for cases wherein groove ratings differed between men and women, an analysis was performed for each sex.

Finally, when there were significant differences in exercise intensity and mood changes between conditions, we examined their relationship with groove experiences.

3 Results

3.1 Groove ratings

The groove ratings measured using the EGQ-JP are presented in Table 3. A repeated-measures two-way ANOVA by sex (male/female) × music condition (HG/LG) revealed a significant interaction [$F(1, 36) = 4.75, p = 0.04$, partial $\eta^2 = 0.12$]. A series of *post hoc* comparisons using a Bonferroni test revealed that groove ratings for the HG playlist were significantly greater than those for the LG playlist in both men [$F(1, 17) = 36.25, p < 0.001, d = 1.80$] and women [$F(1, 19) = 90.60, p < 0.001, d = 2.82$]. However, the groove ratings for the HG playlist were significantly higher in women than in men [$F(1, 36) = 10.37, p = 0.003, d = 1.01$]. The results indicating higher groove ratings for HG than those for LG for both men and women confirmed the validity of each playlist. In addition, the groove ratings for the HG playlist in women indicated that women were more appreciative of HG.

3.2 Running speed and exercise intensity

The results of running speed and exercise intensity (HR and RPE) are presented in Table 3. A paired *t*-test revealed that running speed (6–10 min) was faster when listening to HG music than LG music in women [$t(19) = 2.09, p = 0.04997, d = 0.21$]; however, no significant differences were observed in men [$t(17) = 0.64, p = 0.53, d = 0.06$]. In contrast, running speed at warm-up, RPE, and HR did not differ between the conditions in either men or women (Table 3).

3.3 Mood changes

The psychological mood states (vitality, stability, arousal, and pleasure) measured using the TDMS are shown in Figure 2. In women, a repeated measures two-way ANOVA with experimental condition (LG/HG) and time (pre/post) revealed a significant interaction for vitality [$F(1, 19) = 4.69, p = 0.04$, partial $\eta^2 = 0.20$] and arousal levels [$F(1, 19) = 6.02, p = 0.02$, partial $\eta^2 = 0.24$]. A *post hoc* comparison using a Bonferroni test

TABLE 3 The results of groove ratings, running speed, and exercise intensity.

	Male					Female				
	LG		HG		P-value	LG		HG		P-value
	mean	SE	mean	SE		mean	SE	mean	SE	
Groove ratings	19.7	1.1	29.0	1.3	<0.001	20.1	1.3	34.0	0.9	<0.001
Running speed 1–5 min (warm-up)	5.0	0.6	5.0	0.5	0.80	5.8	0.6	6.3	0.5	0.14
Running speed 6–10 min	5.9	0.6	6.0	0.6	0.53	6.9	0.7	7.5	0.6	0.05
Heart rate 1–5 min (warm-up)	112.1	4.8	109.6	4.4	0.33	117.2	4.6	119.9	4.2	0.50
Heart rate 6–10 min	121.1	6.4	121.3	5.5	0.94	132.2	6.0	134.4	5.3	0.43
RPE	12.1	0.6	12.7	0.5	0.23	11.0	0.5	11.4	0.4	0.32

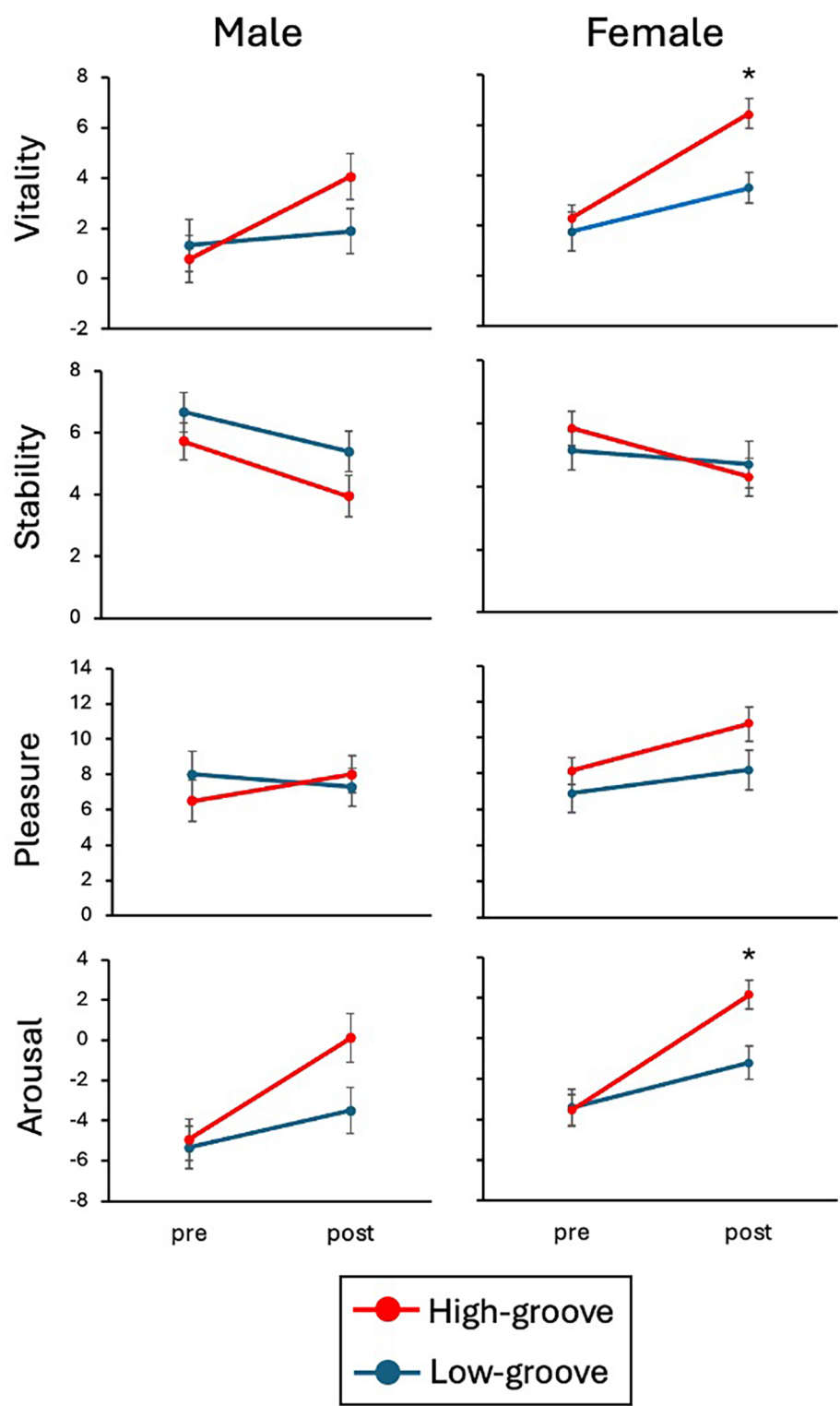


FIGURE 2
Psychological mood state (vitality, stability, pleasure, arousal) for high- and low-groove conditions in pre- and post-exercise sessions in men and women. Post-exercise vitality and arousal levels were significantly higher under the high-groove condition than under the low-groove condition. * indicates $p < 0.01$ versus low-groove condition after Bonferroni correction.

revealed that the vitality [$F(1, 19) = 14.44$, $p = 0.001$, $d = 1.67$] and arousal levels [$F(1, 19) = 11.51$, $p = 0.003$, $d = 1.72$] in the post-exercise session for the HG condition were greater than those in the LG condition. There were no interactions for stability levels [$F(1, 19) = 2.42$, $p = 0.14$, partial $\eta^2 = 0.11$] and pleasure levels [$F(1, 19) = 1.19$, $p = 0.29$, partial $\eta^2 = 0.06$].

In men, there were no significant interactions for validity [$F(1, 17) = 2.85$, $p = 0.11$, partial $\eta^2 = 0.11$], stability [$F(1, 17) = 0.32$, $p = 0.58$, partial $\eta^2 = 0.02$], pleasure [$F(1, 17) = 1.67$, $p = 0.21$, partial $\eta^2 = 0.09$], and arousal [$F(1, 17) = 2.72$, $p = 0.12$, partial $\eta^2 = 0.14$].

3.4 Relationship of groove rating to running speed and mood changes

The results of the correlation analyses are shown in Figure 3. In women, the Pearson correlation analysis revealed positive correlations between groove rating in the HG and running speed (HG-LG) ($r = 0.46$, $p = 0.04$) and vitality (post-pre) ($r = 0.47$, $p = 0.04$). There was no significant correlation between the groove rating and arousal ($r = 0.24$, $p = 0.30$). In men, there were no significant correlations between groove ratings and running speed or mood changes.

4 Discussion

This study aimed to clarify the effects of HG music on self-selected comfortable running pace and mood responses in male and female university students. The findings in this study revealed that running while listening to HG music induced a higher running speed and more positive mood than that induced by LG music in female students. Furthermore, among female students, the enhanced running speed and vitality levels in the HG condition positively correlated with individual groove ratings for HG music tracks. These findings support our hypothesis, at least in female students, that HG music can make self-paced exercise more active and pleasant and suggest that individual differences in groove experiences may moderate these effects.

Among female students, HG music accelerated running speed and improved positive mood compared to LG music, and these effects were greater in those with higher groove ratings for HG music. These results indicate that groove is involved in the effects of music on running speed and mood, in addition to the previously identified factors such as tempo and volume of music (20, 22). Listening to HG music elicits a faster gait in short-distance measurements (30, 52). The results of this study show that similar effects can be obtained for continuous running. Furthermore, the increased positive mood with HG music is

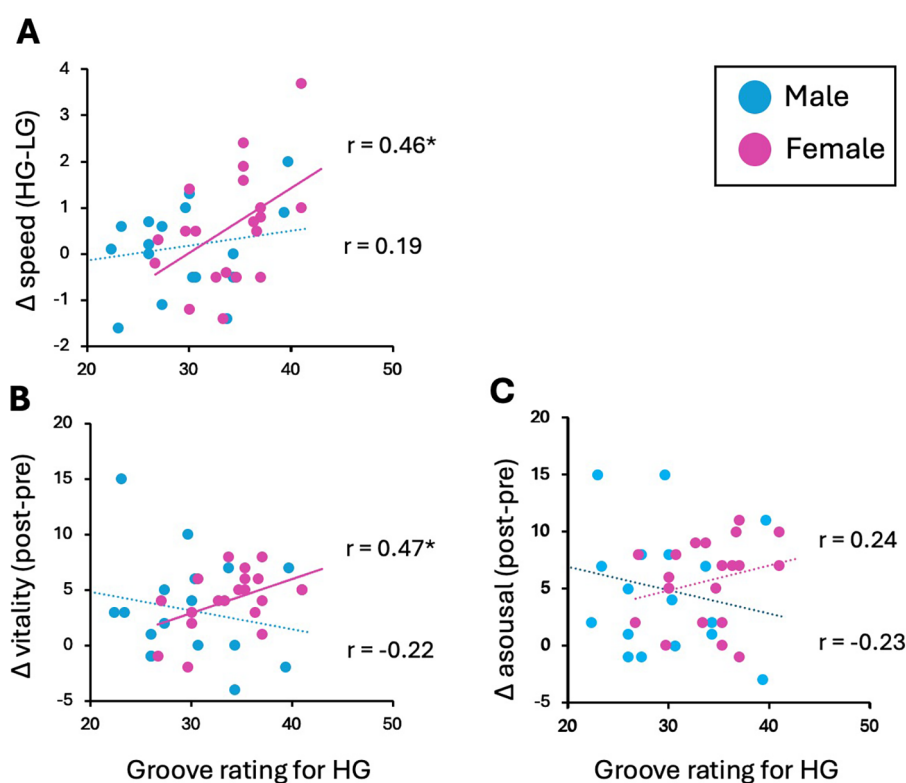


FIGURE 3

Relationships between groove rating for the high-groove playlist and (A) speed change (HG-LG), (B) vitality change (post-pre), (C) arousal change (post-pre), separately for men and women. Positive correlations were found between groove ratings and both faster running speed and increased vitality in women. r represents Pearson's product-moment correlation coefficient. * indicates $p < 0.05$.

consistent with findings from previous studies which showed that pedaling while listening to HG drum breaks had positive effects on participants' psychological states, including "excited" and "having fun" (53).

Despite the increased running speed in women, exercise intensity (as measured by HR and RPE) remained unchanged. The potential effect of increased exercise intensity due to a higher running speed may have been cancelled out by the effects of HG music on HR and RPE. A previous study has shown that listening to music during exercise can reduce RPE (18). In addition, some reports have indicated that music reduces HR (54, 55). This suggests that, although increased running speed in women may have led to an increase in exercise intensity, the accompanying effects of music on reducing HR and RPE could have counteracted this increase, resulting in no overall change in the perceived exercise intensity.

In the present study, HG music did not affect running speed or mood responses in male participants. There may be two possible explanations for this finding. First, women may be more sensitive to groove than men, and the HG playlist may not have elicited sufficient groove sensations in men. Previous studies suggest that women are more sensitive to the emotional aspects of music than men (40, 41). Additionally, women's affective responses (happy-sad) to music are more influenced by tempo and mode compared to men (56). Since groove is associated with pleasant feelings, women are thought to be more sensitive to groove sensation. Our results, showing that women rated the HG playlist higher than men, support this idea. The biological and neuroscientific mechanisms underlying sex differences remain largely unexplored, thus many aspects are still unclear (57). Second, the contribution of groove as a determinant of running speed and mood responses was less among men. The results of the correlation analysis confirmed that groove rating did not predict the effect on speed and mood in men. Other determinants such as tempo and volume may have a greater impact on men.

This study has some limitations. First, the effect of the synchronization of music and movement is unclear. Since this study did not focus on whether the running steps were synchronized with the music tempo, the running pitch was not recorded. However, the music used in this study ranged between 81 and 159 bpm, whereas the typical running pitch is approximately within 160–200 bpm, suggesting that the music tempo and movement were not synchronized. Music synchronized with movement patterns may further enhance the effect (58). This is a topic for future study. Second, since the participants comprised university students who belonged to the Faculty of Health and Sports Sciences, many were likely familiar with exercise. Additional verification is needed, targeting those with no or fewer exercise habits to promote physically active lifestyles. Third, this study revealed sex differences in the effects of groove on exercise. A more detailed investigation is necessary to determine the factors leading to these individual differences. Applying these findings in practice, considering sex differences is essential to optimize the use of groove music in exercise programs. Fourth, individual differences, including

physiological and musical background, as well as music perception, may have influenced the results. Addressing these potential confounding factors in future research could contribute to the development of personalized exercise interventions that account for individual variability. Fifth, the neural basis underlying the observed effects remains unclear. Future studies utilizing neuroimaging methods could provide new insights into the mechanisms through which groove influences exercise performance, as the dopamine reward system and other pathways are likely involved (34, 35).

In conclusion, the present study demonstrated that HG music increased self-selected running speed and positive mood responses compared to LG music, and these effects were greater in female students with higher groove ratings for HG music. These results suggest that HG music promotes a positive mood and exercise adherence, contributing to health promotion through a physically active lifestyle. Coaches and fitness instructors can leverage these benefits by incorporating HG music into exercise programs to enhance motivation and performance. Additionally, integrating HG music into rehabilitation and health promotion programs may help sustain long-term exercise participation.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by The Ethics Committee of Ryutsu Keizai University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. SK: Conceptualization, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that this study was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

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Development and preliminary validation of a Chinese Physical Activity Parenting Practices Scale (3–6 years)

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Background: This study aimed to develop a scale to assess the physical activity (PA)-related parenting practices of Chinese parents of children aged 3–6 years based on general parenting theory.

Methods: A pool of scale items (123 items) was constructed based on a literature review and in-depth personal interviews. The pretest scale (60 items) was developed using Delphi correspondence and a presurvey. After two rounds of item screening of the pretest scale using exploratory factor analysis (EFA) and analysis of variance, we deleted 30 items. We ultimately developed a formal version of the Chinese Physical Activity Parenting Practices Scale (CPAPPS) using the remaining 30 items. We examined the structure of the scale using factor analysis and evaluated its reliability, validity, and discriminant ability using data from 899 parents of children aged 3–6 years.

Results: The CPAPPS includes 30 items in 6 dimensions scored on a 5-point Likert scale. The 6 dimensions are education, autonomy promotion, modeling, demands, expectations, and rewards. Both exploratory and confirmatory factor analyses confirmed the construct validity of the scale. Furthermore, the scale had adequate internal consistency, split-half reliability, test–retest reliability, and concurrent validity. Parents younger than 30 scored significantly lower on the demand dimension than parents aged 40–50 ($p < 0.05$). The differences in rewards and expectations between parents of different ethnicities were statistically significant ($p < 0.05$). Compared with married parents, parents who were currently single had lower scores for education, rewards, modeling, and autonomy promotion ($p < 0.05$). There was a significant difference in scores across all dimensions between parents with different places of residence ($p < 0.05$).

Conclusion: The CPAPPS satisfies the conditions for reliability and validity in accordance with psychometric requirements. The scale can be employed to evaluate the characteristics of Chinese parents' physical activity-related parenting practices and to design family-based PA interventions.

KEYWORDS

physical activity, validity, reliability, measurement, parents, children

Background

Insufficient physical activity (PA) is now a global public health problem. The World Health Organization (WHO) reported that more than 80% of children and adolescents globally do not meet the WHO's recommendation of completing at least 60 min of moderate- to vigorous-intensity PA daily (Bull et al., 2020). Although globally comparable data for younger children are not available (Willumsen and Bull, 2020), in China, a national report revealed that the rate of physical inactivity among children and adolescents was 84.3% (Zhang and Wang, 2012). It is well known that physical inactivity is a significant risk factor for many chronic diseases (Hansford et al., 2022). A survey on the nutritional status and chronic disease status of Chinese residents revealed that in 2020, the overweight and obesity rates for children and adolescents aged 6–17 years and under 6 years in China were 19 and 10.4%, respectively; the incidence of single behavioral abnormalities in children ranged from 10 to 20%; the prevalence of hyperactivity disorders, autism, learning disabilities, and behavioral disorders among children increased; and unhealthy lifestyles were prevalent (Yu and Zou, 2023). Chronic diseases such as hypertension, diabetes mellitus, dyslipidemia, and fatty liver, which typically appear only in adulthood, now appear in overweight and obese children and adolescents and indicate a trend toward chronic diseases at a younger age (Ding et al., 2016).

Parents are comparators and constructors of children and adolescents. Both multigenerational transmission theory and social-ecological systems theory suggest that, in contrast to other distal factors, parents exert a direct, enduring, and distinctive influence on the lifelong behaviors and attitudes of children and adolescents about PA (Eisenberg et al., 2014; Hu et al., 2021; Kennedy et al., 2021). In the context of parenting, parents influence children's PA through multifaceted behavioral strategies. Researchers reported that parental encouragement continued to increase children's PA 5 years later (Bauer et al., 2008). A systematic review also revealed that even when parent–child closeness is low, parents can still impact individual children's behavior by supporting organized PA (Petersen et al., 2020). Logistical support, such as transporting children to and from PA and purchasing relevant equipment and gear, also facilitates the PA of children and adolescents (Laird et al., 2016).

Furthermore, regular parental exercise behaviors play a significant role in modeling PA in children and adolescents. Predictions of children's participation in moderate to vigorous PA increase from 67 to 74% when parents increase the number of moderate to vigorous PA sessions per week from 0 to 3 (Isgor et al., 2013). Research reported that parental modeling led to a perceived increase in children's sense of security and that the initial parental gift of a sense of participation influenced children's enjoyment of PA (Xu and Gao, 2018). It has been suggested that parental control, restrictions, and supervision are associated with children's PA, but in some cases, the results are contradictory (Trost et al., 2013; Hutchens and Lee, 2018). In a pre-conference session at the 2012 International Society for Behavioral Nutrition and Physical Activity (ISBNA) annual conference, experts from several countries defined physical activity parenting practices (PAPP) as the behavioral strategies used by parents to socialize their children's PA (Mâsse et al., 2017). The early identification of problems with PAPP and the subsequent planning and development of parent-level interventions to create a supportive environment for children is vital for the development of PA habits in children. Developing a tool that can help identify problems with PAPP and objectively assess the severity of these problems is critical.

Since the 1990s, several instruments have been developed to assess PAPP. However, early studies were characterized by the inconsistent or non-existent adoption of theory in the construction of conceptual frameworks and a lack of agreed-upon measures, resulting in many incoherent and inconsistent measurement constructs between scales as well as measurements that are difficult to compare (Sleddens et al., 2012; Davison et al., 2013). In response to this issue, a pre-conference session at the 2012 annual meeting of the ISBNA recommended that follow-up research should integrate parenting dimensions from the general parenting literature into the conceptualization of PA parenting to promote the standardization of PAPP measures (Davison et al., 2013).

Three main approaches characterize the general parenting domain: (1) responsive, which refers to the extent to which parents help children develop individuality and self-assertion through the use of warmth, support for autonomy, and rational communication; (2) controlling or demanding, which refers to the extent to which parents exert an influence on children through directive, restrictive, and punitive parenting to force the child to satisfy parental demands; and (3) structural, which refers to parents' organization of the child's social and physical environment to promote the development of competence (Slater and Power, 1987; Conger, 2009; Power, 2013).

Based on this framework, Vaughn et al. (2013) developed the Physical Activity Parenting Practices Scales (PAPPS) (ages 2–5); O'Connor et al. (2014) compiled the Preschoolers' Physical Activity Parenting Practices (PPAPP) (ages 3–6); Suen et al. (2017) developed the Physical Activity Parenting Practices for Preschoolers-Hong Kong questionnaire (PAPPP-HK); and in 2020, scholars from six countries—Australia, Canada, England, Scotland, the Netherlands, and the United States—developed the Physical Activity Parenting Practices item bank (PAPP-IB) (5–12 years) (Mâsse et al., 2020). Since parenting practices are deeply influenced by traditional culture and social conditions, these practices have inherited cultural characteristics. Therefore, the items in these scales may not be cross-culturally universal and may easily overlook phenomena and behavioral traits that are considered meaningful in Chinese culture. For example, although Hong Kong is a city in China, it is located on the coast and has a more developed economy. Many of the items in the PAPPP-HK, such as “How often do you take your child to the beach?” and “How often do you encourage your child to take the stairs instead of the elevator?” do not apply to inland Chinese cities.

In recent years, the topic of PAPP has attracted the attention of experts and parents in mainland China. Still, there is a general lack of theoretical foundations and qualitative formative research. To our knowledge, there is no widely accepted questionnaire for assessing PAPP in mainland China. In mainland China, the amount of time parents spend with their children is significantly reduced after children start school due to academic pressure or the nature of the school (e.g., boarding school). Therefore, this study aimed to develop and validate a questionnaire to assess the PAPP of parents of children aged 3–6 in mainland China.

Methods

Stage I: primary instrument development

Step one: determining the scale structure

A literature review was conducted to select three domains of general parenting theory as the basis for the scale structure.

Dimensions and items from questionnaires or scales borrowed from related studies were identified. Subsequently, 12 parents were selected for semi-structured interviews. When choosing the sample, we considered maximum variability in gender, age, ethnicity, education level, marital status, and total monthly household income. After the interviewer explained the purpose of this study and obtained informed consent from the interviewee, the interview was started and recorded. The outline was as follows: (1) Have you been the primary caregiver for your child for the past year? (2) Do you understand the role of physical activity in children's development? (3) Do you think there are ways to promote physical activity in your child? (4) What specific methods do you use to get your child moving? (5) Is there any relevant event that impresses you? After analyzing the data using Colaizzi's 7-step analysis method, three verbal strategies were extracted: criticism, mockery, and gossip, which we categorized into the persuasion dimension. This step established a Chinese item pool with 10 dimensions (Table 1) and 123 candidate items.

Step two: Delphi surveys

We organized two rounds of Delphi surveys and invited 15 experts (5 pediatric nurses, 5 pediatricians, 1 sports medicine physician, 2 educators, and 2 statisticians) to evaluate the item pool. The experts' mean working experience was 25.08 ± 9.23 years, and their collective experience and knowledge ensured the robustness and relevance of the scale items. The experts were asked to evaluate the importance of the dimensions and items using a 5-point Likert scale ranging from 1 (very unimportant) to 5 (very important) and to self-assess their familiarity with the indicators and the basis for their judgments. Dimensions and items with mean scores >3.5 and coefficients of variation (CV) <0.25 were retained. The experts were also asked to assess the accuracy and clarity of each dimension and item and to suggest specific deletions or modifications. We paid consulting fees to all of the experts.

The authority coefficient was 0.896, and all experts proposed amendments in the two rounds of correspondence. In the first round of correspondence, Kendall's W values for the dimensions and items were 0.609 ($p < 0.05$) and 0.149 ($p < 0.05$), respectively. The experts identified "permissive" as the behavior opposite of "demands" and suggested deleting it. Furthermore, they identified the meanings of "empowerment" and "education" as overlapping and recommended merging these dimensions. In the second round of correspondence, the Kendall's W values for the dimensions and items were 0.666 ($p < 0.05$) and 0.156 ($p < 0.05$), respectively. After the Delphi surveys, 52 items were deleted, 14 items were merged, 19 items were modified, and 3 new items were added, resulting in an item pool of 8 dimensions and 60 items.

Step three: pilot testing

To further assess the scale items' clarity, comprehensibility, and feasibility, we conducted a pretest with 25 parents in the child healthcare department of a hospital in Xi'an using convenience sampling. The inclusion criteria were as follows: (1) the child's father or mother, (2) the child's primary caregiver (the leading participant who is responsible for the child's daily living, such as eating, sleeping, and activities), (3) currently having at least one child aged 3–6 years, (4) the ability to read and understand Chinese, and (5) volunteering to participate in this study. The exclusion criteria were (1) children aged 3–6 years who had

a disease or disability that limited participation in PA or (2) parents who had a disease or disability that limited participation in PA.

We recorded items that the respondents had questions about during the field survey. Each item on the scale measured the frequency of behaviors or strategies for parents in the past month. The response format for each item included five levels: 1 = never, 2 = seldom, 3 = sometimes, 4 = often, and 5 = always. The mean score was calculated as the sum of the items divided by the number of items answered in each dimension to calculate the PAPP scores. Twenty-five parents completed the questionnaire in 8–15 min. Based on participant feedback, the 2-item formulation was fine-tuned, and the informed consent form was refined, resulting in a CPAPPS I version that contained 8 dimensions and 60 items.

Stage II: final instrument development

A cross-sectional research design was used for the item analysis and the reliability and validity tests. Five trained investigators collected the data for all three samples reported in this study from August 2022 to May 2023. The inclusion and exclusion criteria were the same as those for the pilot test. There was no data crossover between any of the three samples. According to the Kendall criterion, the number of respondents is roughly 5–10 times the number of scale items (Tang et al., 2023). The number of scale items used in the three surveys was 60, 40, and 30 in that order, and the minimum sample size should be 315, 210, and 175 cases, respectively, considering the 5% inefficiency rate.

Step one: item analysis

Item analysis determines whether each item should be eliminated or retained quantitatively. In this study, an item was removed if it met one or more of the following criteria: (1) the selection rate of an option for an item was $>80\%$; (2) the critical ratio (CR) of the item was found to be insignificant; (3) the CV of the item was $>15\%$; (4) the item total correlation coefficient was not significant, or the coefficient was <0.3 ; (5) the factor loading value of an item within each factor was <0.4 or the number of items contained in a factor was <3 . The dimensions and items were deleted depending on the situation (Cao et al., 2019).

Sample 1 comprised 316 parents sampled randomly from three urban and two suburban kindergartens in Xi'an with the same inclusion and exclusion criteria used for pilot testing. The parents completed the CPAPPS-I under the guidance of the investigators. The response rate was 92%. After the analysis excluded the ceiling and floor data, 284 questionnaires were included (effective rate 90%). The mean age of the subjects was 35.94 ± 4.07 years. This sample was used to screen items for the CPAPPS-I. Twenty items that did not meet the above criteria were deleted. During factor analysis, the remaining items in the persuasion dimension were categorized into the education dimension. It is reasonable because persuasion is usually considered an educational tool in China. After this screening round, the CPAPPS-II comprised 40 items in 7 dimensions.

Sample 2 consisted of 412 parents randomly selected from 5 kindergartens in 3 cities (Xi'an, Yulin, and Yan'an) in Shaanxi Province. Online and on-site surveys were used for data collection. The response rate was 94%. After data cleaning, 388 questionnaires were included in the analysis (effective rate 94%). The mean age of the subjects was 35.85 ± 5.89 years. This sample was used for item screening of the CPAPPS-II. 10 items removed in this screening round. Six common

TABLE 1 Initial conceptual framework and operational definitions.

Domain	Initial dimension	Number of items	Definition	Source of items
Control	Demands	11	Parents motivate children to participate in PA by applying pressure or prescribing appropriate punishments.	Larios et al. (2009) Mâsse et al. (2020) Timperio et al. (2008) O'Connor et al. (2014)
	Restriction	11	Parents discipline behaviors detrimental to their children's PA by establishing rules.	Davison et al. (2011) Larios et al. (2009) Timperio et al. (2008) Vaughn et al. (2013)
	Permissive	6	Behavior in which the parent lacks demand (allowing the child to decide) on the children's PA.	Mâsse et al. (2020)
Responsiveness	Education	10	Parents use strategies or behaviors that directly or indirectly (training) promote their children's knowledge, understanding, and skills for PA.	Mâsse et al. (2020) O'Connor et al. (2014) McMinn et al. (2009) Vaughn et al. (2013)
	Empowerment	6	Parents improve their children's physical activity or increase their opportunities for physical activity by providing human, material, financial, and transportation resources.	Davison et al. (2011) Mâsse et al. (2020) Vaughn et al. (2013)
	Persuasion	19	Parents use verbal strategies to elicit positive or negative feelings in their children, promoting action or reducing sedentary behavior.	Anderson and Coleman (2008) Brustad (1996) O'Connor et al. (2014) Vaughn et al. (2013) Parents interviews
	Autonomy promotion	16	Parents promote their children's independent decision-making regarding PA by providing choices for or consulting with their children.	Mâsse et al. (2020) Suen et al. (2017)
	Motivation	12	Parents motivate their children to be rewarded and self-improvement by prescribing rewards and expressing expectations (related to physical activity).	Gubbels et al. (2011) Vaughn et al. (2013) Timperio et al. (2008)
Structure	Environmental support	13	Parents change residential and social environments to influence their children's PA behaviors.	Vaughn et al. (2013) Suen et al. (2017) Parents interviews
	Modeling	19	Parents demonstrate positive behaviors related to PA for their children.	Larios et al. (2009) McMinn et al. (2009) Suen et al. (2017) Davison et al. (2011)

factors were extracted after factor analysis. The education, autonomy promotion, demands, and modeling dimensions were retained. The restriction of all items with factor loadings that were too low was removed. It may be that the preset items involved multiple independent factors, such as social rules, risk perception, and environmental adaptation, rather than a single “limiting behavior.” Items in the environmental support dimension (e.g., supervision, planned activities) may belong to different behavior types, resulting in a loose factor structure. Items related to planned activities (e.g., I will schedule family activities related to physical activity) were categorized in the role modeling dimension. Items related to safety (e.g., before my child is physically active, I will check with him/her to ensure that the environment or site is safe) were categorized into autonomy promotion. The motivation dimension was split into the reward and expectation dimensions. This process resulted in a formalized version of the CPAPPS with 30 entries in 6 dimensions.

Step two: preliminary validation of the final scale

Sample 3 included 945 parents of young children in 10 kindergartens in Xi'an, Shaanxi Province, Harbin, Heilongjiang Province, and Nanning, Guangxi Province, which are located in the central, northern, and southern regions of China, respectively. The survey was conducted using the final version of the CPAPPS, and the same data collection method was used for Sample 2. A total of 933 questionnaires were returned (response rate 98%), and 899 were included in the analysis (effective rate 93%). This sample was used to explore the structure and to evaluate the validity and reliability of the final CPAPPS. Fifty parents out of the 899 selected subjects randomly repeated the questionnaire after 1 month. There were no differences in the distribution of gender or age between those who completed the second questionnaire and those who did not.

The data were analyzed using SPSS 26.0 and AMOS 25.0 in this step. Descriptive statistics were used for demographic variables and overall and individual scores. A t-test or one-way ANOVA was used

to compare the CPAPPS scores of different groups, and a difference of $p < 0.05$ was considered statistically significant.

Validity analysis

Construct validity

The data from 899 cases were divided into two groups based on the principle of odd and even columns. Of these, 450 cases were subjected to EFA to extract the factor structure using principal component analysis and maximum variance rotation. The other 449 samples were subjected to validation factor analysis (CFA) to verify whether the preset theoretical factor model was suitable for the actual data. Before EFA was conducted, the Kaiser–Meyer–Olkin (KMO) test and Bartlett's sphere test were used to measure the suitability of the sample for factor analysis. The data were suitable for EFA because the KMO value was >0.6 , and Bartlett's ball-point test result was $p < 0.05$.

The eigenvalues and the scree plot determined the number of factors. The maximum factor that should be extracted is the first point at which Cattell's scree plot begins to flatten. Items were retained if they met the following criteria: (1) factor loadings >0.4 and no cross-factors, and (2) items were conceptually consistent with their corresponding factors. CFA was subsequently performed. Since some observed variables were non-normally distributed, the general least squares (GLS) method was used to estimate the model parameters.

The CMIN/DF, goodness of fit index (GFI), adjusted goodness of fit index (AGFI), Tucker–Lewis index (TLI), normed fit index (NFI), and root mean square error of approximation (RMSEA) were calculated to assess how well the model fits the data, with CMIN/DF < 3 , GFI, AGFI, TLI, NFI > 0.90 , and RMSEA < 0.08 indicating good model fit. In addition, the average variance extracted (AVE), construct reliability (CR), and correlation coefficients between factors were calculated to validate the discriminant and convergent validity of the subfactors of the tool. AVE > 0.7 and CR > 0.5 indicated good convergent validity, and the square root of the AVE was larger than the correlation coefficient between factors, indicating good discriminant validity (Fazhan et al., 2023).

Concurrent validity

Research (Zhou et al., 2023) shows significant differences in parenting behaviors with different parenting motives, and early parenting behaviors that parents with misaligned parenting motives adopt are inappropriate. Parenting motivation and parenting behavior are correlated; parenting motivation is an upstream variable of parenting behavior. Because PA parenting is an aspect of parenting behavior, this study used PA parenting motivation as an index to evaluate validity. Chinese scholars developed the Self-Regulation Questionnaire (SRQ), to measure the degree of internalization of parenting motivation, which was used to assess validity (CMIN/DF = 3.89, CFI = 0.90, IFI = 0.90, GFI = 0.88, NFI = 0.88, RMSEA = 0.07, Cronbach's $\alpha = 0.90$) (Zhou et al., 2023). The degree of internalization of parenting motivation was measured by the relative autonomy index (RAI), with higher RAI scores indicating more autonomous parenting motivation and lower RAI scores indicating more controlled parenting motivation. Concurrent validity was assessed by Spearman correlation coefficients between the two scale scores and factor scores.

Reliability analysis

Reliability was assessed by Cronbach's alpha coefficient, the split-half reliability coefficient, and the test–retest reliability coefficient. Reliability coefficients >0.70 were considered satisfactory (Cao et al., 2019).

Data collection and quality control

To conduct the survey, we first contacted the director of the kindergarten. After we obtained the director's consent, the director informed the classroom teachers of each classroom and asked them to cooperate with the researcher in conducting the survey. The data for Sample 1, Sample 2, and Sample 3 in the Xi'an area were collected via field surveys. The parents of the children selected from each class were organized in one classroom. After the investigator explained the purpose and requirements of the study in detail, the parents completed the questionnaire, which the investigator subsequently collected. Data for Sample 2 and Sample 3 were collected outside of Xi'an using an electronic questionnaire, and quality control was achieved through the following steps. (1) The first page was an informed consent page that explained the content and purpose of the study. The scale could be completed after this page was read. (2) A hint was presented for missing answers, and the survey could not be submitted without them. (3) Important content was highlighted in bold and in eye-catching colors. (4) Large font was used to visually present the scoring options to make them easier to complete. (5) The classroom teacher distributed Detailed explanations and unified guidelines to the parents who completed the survey. (6) The app screened and cleaned the data, checked the answers, and eliminated random answers or answers with a response time of less than 4 min to ensure the accuracy and completeness of the information entered.

Two people entered the data collected from the field survey into a database using EpiData3.1. The data were checked for logic, and incomplete questionnaires were eliminated.

Results

Demographic characteristics of the sample

The demographic characteristics of Samples 1, 2, and 3 are shown in Table 2. Differences in demographic characteristics such as gender, age, education, ethnicity, marital status, place of residence, and monthly household income were not statistically significant for parents in the EFA and CFA samples.

Assessing the psychometric properties of the scale

Construct validity by EFA

The EFA was performed on the data of 450 cases from Sample 3. The Kaiser–Meyer–Olkin coefficient of sampling adequacy was 0.863, the approximate chi-square value of Bartlett's test of sphericity was 8405.11, and the probability was lower than 0.05. The results indicated that the sample size was sufficient and suitable for factor analysis.

The scale was explored by extracting common factors with an eigenvalue more significant than one and limiting the number of

TABLE 2 Demographic characteristics of participants.

Characteristics	Sample1 (n = 284)	Sample2 (n = 388)	Sample3 (n = 899)	EFA (n = 450)	CFA (n = 449)	χ^2/Z	P
Gender							
Male (father)	76	83	347	173	174	0.009	0.924
Female (mother)	208	305	552	277	275		
Age (M ± SD)	35.94 ± 4.07	35.85 ± 5.89	35.09 ± 6.06	34.83 ± 5.93	35.37 ± 6.19	−1.310	0.191
Ethnic groups						1.343	0.246
Han people	272	369	771	392	379		
Minority people	12	19	128	58	70		
Marital status						1.488	0.475
Single	3	18	35	20	15		
Married	281	370	864	430	434		
Education						−0.135	0.892
Junior high school and below	1	62	178	93	85		
High School/Junior College	15	59	162	77	85		
College	27	70	217	111	106		
Undergraduate	158	154	296	142	154		
Master and above	83	43	46	27	19		
Residence						−1.245	0.210
City	262	274	576	279	297		
Suburbs/Town	22	43	212	89	83		
Rural	0	71	111	65	46		
Monthly household income						−1.277	0.202
<5,000	16	133	405	213	192		
5,000 ~ 10,000	52	102	200	96	104		
10,000 ~ 20,000	122	94	163	73	90		
>20,000	94	59	131	68	63		
Family structure						−1.686	0.093
Nuclear family	134	205	635	307	328		
Main family	145	162	175	92	83		
Single parent family	5	21	89	45	44		

factors to 6. The results revealed that the overall structure was favorable with a factor of 6, which was corroborated by the scree plot (Figure 1). These 6 factors explained 67.962% of the total variance. All items were maintained in the original dimensions of the formal version of the CPAPPS, and the factor loadings for all items were higher than 0.672 with no cross-loadings (Table 3).

Construct validity by CFA

The central path diagram of the model was plotted based on the EFA results, which revealed that CMIN/DF = 1.147, GFI = 0.938, AGFI = 0.927, TLI = 0.989, NFI = 0.926, and RMSEA = 0.018, indicating a satisfactory model fit. The standardized factor loadings for each item were >0.40, which was statistically significant. The parameter estimates for the CFA are shown in Figure 2. The AVE for the six factors was >0.5 (0.645, 0.747, 0.774, 0.758, 0.769, and 0.791, respectively). The CR of each factor was >0.7 (0.936, 0.713, 0.741, 0.627, 0.724, and 0.920, respectively). The square root of the AVE was

more significant than the correlation coefficients among the 6 factors, as shown in Table 4, indicating that the CPAPPS had good convergent and discriminant validity.

Overall, the results showed an acceptable model fit in a test sample of Chinese parents of children aged 3–6 years. The results of the EFA and CFA supported the structural validity of the CPAPPS.

Concurrent validity

The CPAPPS and SRQ scores were non-normally distributed. Spearman’s rank correlation analysis revealed a moderate positive correlation between the total CPAPPS and SRQ scores ($r = 0.541$, $p < 0.05$). There was a positive correlation between each CPAPPS dimension and the total score of the SRQ, with correlation coefficients ranging from 0.206 to 0.270; these were all low-degree correlations. This result reflects the independence of the scale. The highest correlation coefficient was found between parental autonomy motivation and modeling in the CPAPPS ($r = 0.322$, $p < 0.05$),

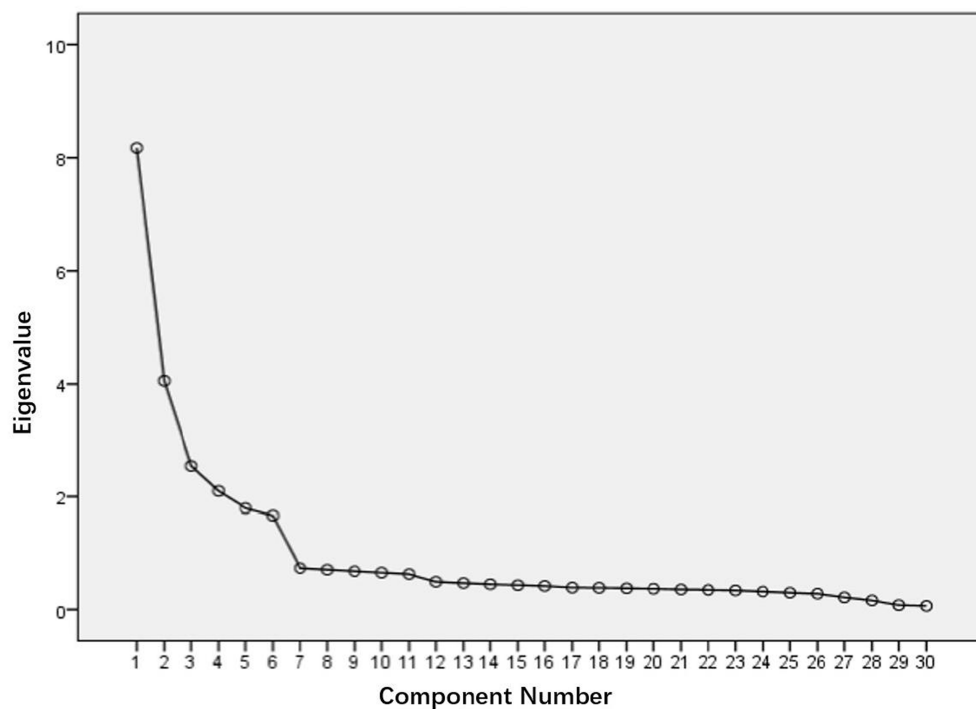


FIGURE 1
Scree plot of principal component factor analysis ($n = 450$).

indicating that the more autonomous a parent is, the greater the correlation between parenting motivation and parenting practices in terms of teaching by example. Except for a lack of correlation with the education dimension, parents' controlling motivation was negatively correlated at a low degree with all other dimensions of the CPAPPS, with correlation coefficients ranging from -0.167 to 0.060 ($p < 0.05$). Overall, the validity of the CPAPPS was acceptable, as shown in Table 5.

Reliability analysis

The Cronbach's alpha coefficient for the CPAPPS was 0.892, and the Cronbach's alpha coefficients for the dimensions ranged from 0.714 to 0.942. The split-half reliability coefficient for the CPAPPS was 0.658, and the dimensions ranged from 0.671 to 0.945. The retest reliability coefficient for the 50-subject subsample at four-week intervals was 0.844, ranging from 0.695 to 0.891 for all dimensions (Table 6).

Discriminant ability

Table 7 shows the CPAPPS scores of parents by gender, age, ethnicity, marital status, education, residence, and monthly family income. There was no difference between fathers' and mothers' scores on each dimension ($p < 0.05$). The demand dimension scores differed significantly ($p < 0.05$) between parents younger than 30 years old and parents 40–50 years old. Differences in parenting practices regarding rewards and expectations were statistically significant among parents of different ethnicities ($p < 0.05$). Compared with married parents, parents who were currently single (divorced, widowed, or unmarried) had lower scores for education, rewards, modeling, and autonomy support ($p < 0.05$). There were significant differences in parents' scores across different places of residence in all dimensions ($p < 0.05$). There were no

significant differences in the scores of parents with different monthly household incomes and family structures on each dimension ($p < 0.05$).

Discussion

In this study, we developed the Chinese Physical Activity Parenting Practices Scale using general parenting theories as a framework. The scale contains 30 items in 6 dimensions: education, autonomy support, rewards, expectations, modeling, and demands. The scale is reliable and valid and can be used to study Chinese parents' physical activity parenting practices of children aged 3–6.

In China, the government has attached great importance to the physical fitness of children and adolescents. In recent years, several policies have been introduced to promote improvements in children's and adolescents' PA levels. However, distal externalities have had little success in counteracting the dramatic effects of lifestyle changes, and children's and adolescents' PA levels continue to decline. Research confirms that children have a natural intrinsic interest in PA, and perceptions and habits of PA established in childhood tend to carry over into adulthood and impact adult health (Zeng et al., 2023). Meanwhile, the dynamic interaction that exists between physical activity parenting practices and children's physical activity levels has been confirmed by a variety of theories. Social cognitive theory emphasizes that parents shape children's activity patterns through behavioral modeling and reinforcement mechanisms. A study using accelerometers showed that children's moderate-vigorous activity (MVPA) attainment increased by 58% when parents engaged in family exercise ≥ 3 times per week (Trost et al., 2013). On the other hand,

TABLE 3 Results of the exploratory factorial analysis.

Dimension name and items	Factor loading	Communality
Factor 1: education (eigenvalue = 7.964, % of variance = 26.584%)		
A1 I teach my child new or different programs or games that will get him/her active	0.950	0.945
A2 I instruct children in PA (e.g., how to jump rope)	0.793	0.652
A3 I answer my child's questions about PA.	0.808	0.688
A4 I tell my child that he/she can make new friends through PA.	0.811	0.692
A5 I tell my child to choose PAs appropriate for his/her developmental level.	0.794	0.659
A6 I try to make PA more fun for my child so that he/she enjoys it more.	0.798	0.657
A7 I set goals to encourage my child to be more physically active.	0.805	0.687
A8 I encourage my child to play more active games.	0.844	0.743
Factor 2: autonomy promotion (eigenvalue = 4.16, % of variance = 13.865%)		
F1 I ask the child to name or list his/her favorite PA himself/herself	0.946	0.928
F2 I ask my child what PA he/she would like to do before the activity.	0.786	0.636
F3 I chose PA, which I can participate in with my child.	0.776	0.631
F4 In my free time, I let my child decide when to start the PA.	0.805	0.662
F5 When the whole family is physically active together, I will let my child choose exactly what to do	0.794	0.653
F6 I let my child choose the location or place for PA.	0.774	0.642
F7 I check with my child that the environment or site is safe before PAs.	0.81	0.671
F8 I regularly check and maintain my child's sports equipment or toys with him/her.	0.772	0.628
Factor 3: demands (eigenvalue = 2.659, % of variance = 8.864%)		
D1 I punish my child appropriately if he/she refuses to do PA.	0.891	0.843
D2 I will ask my child to go outdoors because I feel that only outside can my child be active.	0.727	0.538
D3 I enroll my child in a sports class because I feel that only this organized training can make my child active.	0.72	0.556
D4 I ask my child to be physically active to improve his/her physical fitness.	0.674	0.484
D5 I ask my child to train to be good at a particular sport.	0.672	0.489
Factor4: modeling (eigenvalue = 2.103, % of variance = 7.01%)		
E1 I am in the habit of regular PA.	0.908	0.888
E2 I show my child that I am physically active.	0.847	0.74
E3 I talk to my child about how much I enjoy being physically active	0.828	0.725
Factor5: expectations (eigenvalue = 1.762, % of variance = 5.873%)		
C1 I want my child to play outside if the weather is good.	0.845	0.788
C2 I want my child to be good at a particular PA.	0.771	0.607
C3 I hope my child to be physically active for 1 h or more every day.	0.789	0.64
Factor 6: rewards (eigenvalue = 1.741, % of variance = 5.802%)		
B1 I reward my child for being physically active (e.g., initiating PA, initiating participation in sports).	0.85	0.773
B2 I reward my child for progress/achievement in physical activity.	0.752	0.572
B3 I use outdoor activities to reward good behavior (e.g., telling my child I will take you to the park if you learn to brush your shoes).	0.729	0.573

ecological systems theory reveals synergies between family microsystems and extra-community systems. Studies have shown that structured parenting practices (e.g., shared exercise planning) increase children's MVPA attainment by 2.3-fold in safe community settings (Sleddens et al., 2012). Notably, self-determination theory proposes that autonomy-supportive parenting effectively promotes children's intrinsic motivation to exercise, leading to significant increases in exercise (Ntoumanis et al., 2021). Therefore, it is essential to rely on

parents as the key socialization agents to plant the “seeds of love for PA” early in parenting and to transform children's intrinsic interest in PA into an intrinsic motivation to engage in PA through specific parenting practices. Children between the ages of 3 and 6 have already acquired a certain level of physical mobility and understanding. They spend most of the day with their parents and maintain a close and dependent relationship. Therefore, Parents have a more significant influence on children at this stage.

The final structure of the CPAPPS was based on the CFA validation results. In contrast to the activity support scale for multiple groups (ASSMG) (Davison et al., 2011), our scale did not extract the logistical support dimension. This may be because our sample population came from different regions (e.g., urban, township, rural). Logistical support included items that reflect the family’s financial situation, such as enrolling a child in basketball classes, which requires parents to pay the appropriate fees. Some parents from townships and rural areas find it difficult to afford this cost. In addition, rural

education resources are limited, and parents may face a lack of access even if they are willing to spend money. We believe that emphasis should be placed on PA for parents and children from weaker economic backgrounds to develop recommendations for PA parenting practices that apply to a broad range of people. The restriction dimension was removed from the initial conceptual framework, which is inconsistent with the PAPP, APQ, and PARR scales. Most items in this dimension were safety-motivated restrictions, such as supervising children when playing outdoors. For children aged 3 to 6 years, Chinese parents believe that safety is a prerequisite for all activities. Moreover, since most residents of cities and townships in China live in apartment buildings without separate yards, children playing outdoors are inevitably accompanied by adults.

After we conducted CFA, the dimensions of education, empowerment, and persuasion were merged into a single structure because empowerment and persuasion are different ways of education. The motivation dimension was divided into rewards and expectations, which is consistent with the PAPP item bank. Conceptually, this split regrouped items that focused on material rewards. In contrast, although expectations are considered the most long-term approach to motivation (Shang et al., 2023), they focus on the psychological dimension and are a more substantial attribute of parenting strategies. These similarities and differences reflect the differences and commonalities of PA parenting practices in different countries and regions.

Differences in family roles assumed by people of different genders result in differences in the performance of parenting practices. Multiple studies have shown that fathers significantly influence role modeling more than mothers (Neshteruk et al., 2017; Sigmund et al., 2018). A survey of Irish parents revealed that mothers and fathers differed in their roles concerning PA and that fathers were more involved in parenting practices (Sohun et al., 2021). Our study did not observe a significant difference between fathers and mothers regarding parenting practices across PA. The difference in the demand dimension was significant ($p < 0.05$) between parents younger than 30 years old and parents aged 40–50 years old. This phenomenon may be because older parents are more emotionally stable, have a compensatory mentality for having children later in life, or have energy constraints that lead to a greater preference for non-controlling parenting practices (Fang et al., 2024). Such low requirements may weaken children’s sense of rules and resistance to frustration, which is not conducive to establishing good physical activity habits.

In the comparison of parenting practices among different ethnic groups, although there were significant differences only in the dimensions of rewards and expectations, we also observed that Han

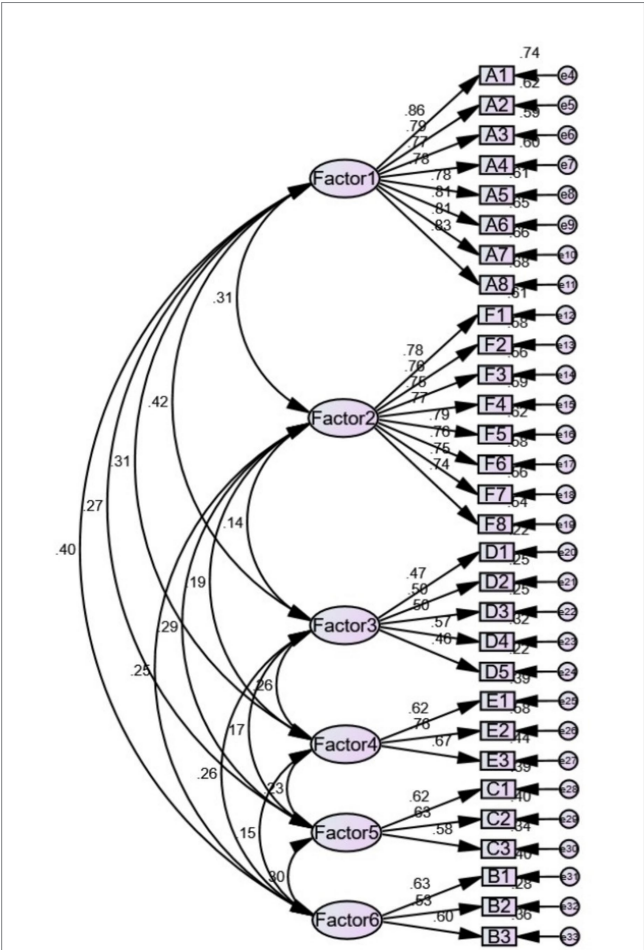


FIGURE 2 The standardized path diagram of the confirmatory factor analysis. A1 to F8 represent the items of CPAPPS, and Factor 1 to Factor 6 are the 6 factors of CPAPPS.

TABLE 4 Results of the confirmatory factorial analyses.

Factor	Education	Autonomy promotion	Demands	Modeling	Expectations	Rewards
Education (Factor 1)	0.803*					
Autonomy promotion (Factor 2)	0.298	0.589*				
Demands (Factor 3)	0.207	0.184	0.611*			
Modeling (Factor 4)	0.316	0.165	0.109	0.508*		
Expectations (Factor 5)	0.259	0.114	0.165	0.188	0.685*	
Rewards (Factor 6)	0.286	0.188	0.224	0.112	0.161	0.769*

* represents the square root of AVE of 6 factors; the others represent the correlation coefficients between 6 factors.

TABLE 5 The correlation between the scores of CPAPPS and SRQ.

SQR	CPAPPS						
	Education	Rewards	Expectations	Demands	Modeling	Autonomy promotion	Total score
Autonomy motivation	0.319**	0.261**	0.278**	0.297**	0.322**	0.312**	0.662**
Controlling motivation	−0.060	−0.106**	−0.137**	−0.137**	−0.167**	−0.139**	−0.307**
Total score	0.222**	0.206**	0.231**	0.244**	0.270**	0.251**	0.541**

** represents $p < 0.01$.

TABLE 6 Reliability of the CPAPPS.

Dimensions	N	Cronbach's α	Guttman split-half reliability	Test–retest reliability
Education	8	0.942	0.945	0.863
Rewards	3	0.714	0.671	0.695
Expectations	3	0.758	0.738	0.891
Demands	5	0.806	0.787	0.827
Modeling	3	0.858	0.827	0.797
Autonomy promotion	8	0.932	0.927	0.784
Total	30	0.892	0.658	0.844

parents scored higher than ethnic minority parents in the dimensions of education, rewards, and demands and lower than ethnic minority parents in the dimensions of expectations, modeling, and autonomy support. These results reflect the cultural differences between Han people and ethnic minorities. As ethnic minorities live in areas with more variable natural environments, such as mountainous regions and plateaus, their lifestyles and cultural traditions make them more active in their daily lives. Han culture is based on Confucianism, emphasizing ritual norms and ideological aspects. We also found that in our sample population, single fathers or mothers used parenting practices that focused on education, rewards, modeling, and autonomy support less frequently than married parents did. This finding is consistent with a recent study of parents in Hong Kong, China. It may be related to the support parents receive from their partners and the additional time and energy to devote to parenting activities (Suen et al., 2019).

Examining the relationship between parenting practices and children's motor behaviors requires considering the physical and social environments in which families live (Goncalves et al., 2020). Our study revealed that parents who lived in urban areas used all parenting practices significantly more often than those in rural areas. As mentioned earlier, parents from rural areas were not comparable to those who lived in urban areas regarding awareness, time, income, activity venues, and the accessibility of organized training. This finding also underscores the urgent need to develop effective parenting interventions for rural parents to enhance their PA-related parenting skills. These results support the good discriminant validity of our scale.

Although the dimensions were reduced from 10 to 6 compared with the initial conceptual framework, the scale still covers the three domains of general parenting theories and standard PA-related parenting practices of Chinese parents of 3- to 6-year-old children. In practical applications, CPAPPS can be used to design multi-tiered

strategies in conjunction with scenario characteristics. In school programs, CPAPPS can be used as a baseline assessment tool to identify parents' parenting practices in encouraging physical activity and setting an example. In turn, personalized feedback is provided through parent workshops to guide the development of a home exercise program synergistic with school sports activities. In public health campaigns, CPAPPS data can help locate weaknesses in community parenting practices. For example, family exercise kits can be distributed in areas where "structural environment creation" is inadequate, and media campaigns can be used to reshape social norms. For weight management of overweight/obese children, CPAPPS can effectively identify risk factors such as poor parenting practices. Clinical interventions can be designed with milestones based on the dimensions of the scale, such as cognitive restructuring to enhance parental autonomy, training in positive reinforcement skills, and integrating nutritional education to form a comprehensive program.

Limitations

Despite the rigorous methodology used in this study to assess reliability and validity, several limitations exist. First, some data in sample 3 were collected online, requiring parents to have a smartphone to access the survey. Some parents with low income who did not have a cell phone or who could not operate a cell phone may have been excluded, which may have affected the generalizability of the data. Second, parent-reported parenting practices are at risk of social desirability bias and difficulty recalling problems associated with specific behaviors. The answers may, therefore, overestimate PA parenting practices that are perceived as positive or good. Third, we conducted testing only in three

TABLE 7 Comparison of CPAPPS scores among different groups (*n* = 899).

Group	Education	Rewards	Expectation	Demands	Modeling	Autonomy promotion
Gender						
Male (father)	2.48 ± 0.84	2.88 ± 0.75	2.92 ± 0.83	2.88 ± 0.73	2.79 ± 0.88	2.65 ± 0.79
Female (mother)	2.38 ± 0.85	2.93 ± 0.81	2.88 ± 0.83	2.83 ± 0.70	2.78 ± 0.89	2.68 ± 0.76
Age (years)						
<30	2.45 ± 0.84	2.90 ± 0.77	2.95 ± 0.84	2.91 ± 0.72	2.77 ± 0.88	2.70 ± 0.79
30–40	2.42 ± 0.85	2.92 ± 0.79	2.86 ± 0.81	2.85 ± 0.71	2.82 ± 0.87	2.65 ± 0.78
40–50	2.37 ± 0.85	2.89 ± 0.80	2.89 ± 0.87	2.76 ± 2.69 ^a	2.73 ± 0.92	2.67 ± 0.73
Ethnic groups						
Han people	2.43 ± 0.85	2.93 ± 0.78	2.87 ± 0.83	2.85 ± 0.71	2.78 ± 0.88	2.66 ± 0.78
Minority people	2.37 ± 0.82	2.77 ± 0.81 ^b	3.05 ± 0.84 ^b	2.82 ± 0.73	2.85 ± 0.93	2.71 ± 0.71
Marital status						
Single	1.98 ± 0.56	2.46 ± 0.93	2.66 ± 0.84	2.66 ± 0.72	2.21 ± 0.90	2.42 ± 0.70
Married	2.43 ± 0.85 ^c	2.93 ± 0.77 ^c	2.90 ± 0.83	2.86 ± 0.71	2.81 ± 0.88 ^c	2.68 ± 0.77 ^c
Education						
Junior high school and below	2.36 ± 0.84	2.90 ± 0.79	2.96 ± 0.83	2.80 ± 0.72	2.74 ± 0.93	2.69 ± 0.78
High School/Junior College	2.42 ± 0.86	2.85 ± 0.84	2.87 ± 0.78	2.82 ± 0.72	2.69 ± 0.89	2.60 ± 0.77
College	2.36 ± 0.84	2.96 ± 0.76	2.89 ± 0.83	2.93 ± 0.66	2.80 ± 0.93	2.62 ± 0.78
Undergraduate	2.48 ± 0.85	2.90 ± 0.78	2.83 ± 0.87	2.84 ± 0.73	2.82 ± 0.81	2.71 ± 0.77
Master and above	2.46 ± 0.84	2.91 ± 0.79	3.13 ± 0.03 ^d	2.88 ± 0.71	3.01 ± 0.89 ^e	2.74 ± 0.77
Residence						
City	2.46 ± 0.85	2.94 ± 0.78	2.93 ± 0.84	2.90 ± 0.71	2.83 ± 0.90	2.70 ± 0.78
Suburbs/Town	2.40 ± 0.79	2.82 ± 0.82	2.87 ± 0.69	2.78 ± 0.70	2.74 ± 0.91	2.69 ± 0.73
Rural	2.29 ± 0.84 ^f	2.86 ± 0.77 ^f	2.82 ± 0.86 ^f	2.75 ± 0.71 ^f	2.68 ± 0.83 ^f	2.56 ± 0.77 ^f
Monthly income						
<5,000	2.42 ± 0.87	2.93 ± 0.81	2.92 ± 0.83	2.81 ± 0.73	2.83 ± 0.90	2.69 ± 0.77
5,000 ~ 10,000	2.44 ± 0.81	2.90 ± 0.74	2.82 ± 0.85	2.91 ± 0.72	2.76 ± 0.89	2.61 ± 0.81
10,000 ~ 20,000	2.42 ± 0.85	2.81 ± 0.81	2.91 ± 0.81	2.90 ± 0.64	2.77 ± 0.87	2.70 ± 0.75
>20,000	2.35 ± 0.82	2.96 ± 0.73	2.91 ± 0.84	2.80 ± 0.69	2.71 ± 0.87	2.64 ± 0.72
Family structure						
Nuclear family	2.42 ± 0.85	2.91 ± 0.77	2.91 ± 0.84	2.85 ± 0.71	2.79 ± 0.89	2.66 ± 0.78
Main family	2.38 ± 0.90	2.94 ± 0.86	2.87 ± 0.83	2.88 ± 0.69	2.83 ± 0.88	2.72 ± 0.75
Single parent family	2.48 ± 0.65	2.83 ± 0.72	2.82 ± 0.83	2.75 ± 0.77	2.63 ± 0.87	2.59 ± 0.73

a represents *p* < 0.05 vs. age lower than 30 years, b represents *p* < 0.05 vs. Han people, c represents *p* < 0.05 vs. Single, d represents *p* < 0.05 vs. Undergraduate, e represents *p* < 0.05 vs. High School/Junior College, f represents *p* < 0.05 vs. City.

regions in China; thus, in further studies, researchers can extend the samples to other areas of China or countries. Fourth, we only used Classical Testing Theory to confirm the validity and reliability of the tool. In subsequent studies, we hope to validate the scale using other methods and tests.

Conclusion

In this study, we present the Chinese Physical Activity Parenting Practices Scale. To our knowledge, this is the first questionnaire based

on general parenting theory developed to assess the PA parenting strategies and behaviors of parents of 3- to 6-year-old children in mainland China. The questionnaire satisfies all psychometric properties and can be used as a practical tool to assess PA parenting practices in mainland China.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Tangdu Hospital, Air Force Military Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

RN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. YL: Writing – original draft, Writing – review & editing. HZ: Formal analysis, Writing – original draft, Writing – review & editing. ZY: Writing – review & editing. NL: Writing – review & editing. WZ: Writing – review & editing. HT: Writing – review & editing. WY: Writing – review & editing. LZ: Writing – review & editing. XJ: Writing – original draft, Writing – review & editing. LS: Funding acquisition, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Effect of physical activity on mental toughness and quality of life in gender-specific participants: a cross-sectional examination

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Background and aims: Mental toughness is a psychological construct related to resilience and perseverance, and quality of life encompasses physical, emotional, and social wellbeing, which are critical indicators of overall health and wellbeing. This study aims to investigate the effects of different levels of physical activity on mental toughness and quality of life in both male and female participants.

Methods: This cross-sectional study consists of 220 participants with the age range of 18–31 years. The data were collected using the International Physical Activity Questionnaire, the Mental Toughness Questionnaire, and the World Health Organization Quality of Life. Gender specific differences were determined using an independent *t*-test (two-tailed). The effect of varying levels of physical activity in male and female participants was determined by analysis of variance.

Results: Significant differences were found between male and female participants for physical activity levels as high ($t = 4.21$, $p \leq 0.001$, $d = 871.80$), moderate ($t = 3.72$, $p \leq 0.001$, $d = 1309.59$), and low ($t = 3.21$, $p = 0.002$, $d = 520.91$) physical activity participants. Statistically significant differences were also found between gender for mental toughness parameters [handling pressure ($t = 17.96$, $p \leq 0.001$, $d = 1.25$), concentration ($t = 16.07$, $p \leq 0.001$, $d = 1.22$), mental rebounding ($t = 13.34$, $p \leq 0.001$, $d = 1.45$), winning attitude ($t = 12.01$, $p \leq 0.001$, $d = 1.17$)] and quality of life parameters [physical ($t = 13.16$, $p \leq 0.001$, $d = 1.58$), mental ($t = 6.17$, $p \leq 0.001$, $d = 1.69$), social ($t = 4.58$, $p \leq 0.001$, $d = 2.05$), environmental ($t = 8.35$, $p \leq 0.001$, $d = 4.95$)].

Conclusion: Statistically significant differences were found between genders in levels of physical activity, mental toughness, and quality of life. Future research should aim to unravel the complex interlink between physical activity, mental toughness, and quality of life, using longitudinal designs and diverse populations to validate the findings and explore the underlying mechanisms further.

KEYWORDS

physical activity, mental health, mental toughness, quality of life, sex differences

Introduction

Physical activity is generally described as any type of body movement that involves skeletal muscles and results in energy consumption due to skeletal muscle action, such as housework and participation in sports and fitness programs (Pucci et al., 2012). Regular physical activity is one of the most effective methods for preventing cardiometabolic risks such as high blood pressure, diabetes, stroke, obesity, osteoarthritis, and sleep apnea (Reiner et al., 2013). It is now globally recognized as a key component of a healthy lifestyle (Muaiddi and Ahsan, 2020). Physical activity offers numerous physical, psychological, social, and environmental benefits. In addition to its well-established effects on physical health, growing evidence indicates that physical activity can positively influence mental health and wellbeing (Biddle and Asare, 2011; Penedo and Dahn, 2005).

One area of mental health that has gained increasing interest in literature is mental toughness. Mental toughness represents a complex construct that encompasses an individual's ability to handle stress and challenges, maintain focus, and persevere in the face of adversity (Clough et al., 2002). Mental toughness is increasingly recognized as a key factor in achieving personal and athletic goals. Recent research has explored the correlation between physical activity and mental toughness, with studies involving both males and females indicating that individuals who consistently participate in physical activities, such as trail running, tend to develop higher levels of mental toughness (Gameiro et al., 2023). Individuals possess greater mental toughness and demonstrate higher resilience, better emotional regulation, and enhanced performance in various domains, including sports, academics and the workplace (Gerber et al., 2013; Gucciardi et al., 2015). Gender affects mental toughness, with males exhibiting greater mental toughness than female participants (Mohebi et al., 2018), particularly when it comes to controlling emotions, life management, and self-confidence (Nicholls et al., 2009). Male participants have greater power to overcome challenges in a competition than female participants (Kumar and Ahmed, 2013).

In addition to its potential effect on mental toughness, participation in physical activities has also been associated with an improved quality of life, encompassing a comprehensive view of an individual's wellbeing, including physical, mental, social, and environmental aspects (Pucci et al., 2012; Rejeski and Mihalko, 2001). Participating in consistent physical activities has been linked to higher levels of life satisfaction, better emotional and cognitive functioning, and enhanced social interactions (Bize et al., 2007). Early research suggests that gender-specific factors may influence the relationship between physical activity and various health outcomes (Eime et al., 2013). Rejeski and Mihalko demonstrated that individuals who engage in physical activity evaluate certain domains of quality of life as higher than those who are physically inactive (Rejeski and Mihalko, 2001). It seems that males might show a stronger inclination to engage in physical activities focused on improving both physical performance and mental toughness, while females may be more driven by the overall health and wellbeing benefits (Omorou et al., 2013). Lee et al. (2020) investigated gender-specific differences in quality of life. They concluded that males reported a higher quality of life than females across China, Ghana, India, Russia, and South Africa.

Prior research has explored the advantages of physical activity on mental toughness and quality of life. However, the potential differences

between male and female participants have not been extensively examined. Gender-specific differences and associations among physical activity, mental toughness, and quality of life can significantly influence the design and implementation of targeted interventions. This cross-sectional study aimed to determine the effects of physical activity on mental health and quality of life in both male and female participants.

Methods

Study design

This research employed a cross-sectional study design.

Ethical consideration

All participants submitted a written informed consent form, and the study received approval from the institutional review board at Imam Abdulrahman Bin Faisal University in Dammam.

Participants

For this comparative study, 220 participants (110 males, 110 females) aged 18–31 were recruited from Imam Abdulrahman Bin Faisal University.

Measures

Physical activity

The assessment of the participants' physical activity levels was conducted utilizing the International Physical Activity Questionnaire-Short Form (IPAQ-SF). The participants reported the days and times of physical activity during the last 7 days. The IPAQ evaluates the frequency and duration of physical activity across different domains. This study measured MET-min for each participant and classified them (high, moderate, and low) based on their total weekly MET-min according to the IPAQ-SF analysis guidelines (Booth, 2000; Craig et al., 2003). Participants additionally reported the number of hours spent on sedentary behavior each day.

Mental toughness

Mental toughness was assessed using a questionnaire developed by Goldberg A.S. in 1998. This questionnaire consists of four subscales: handling pressure, concentration, mental rebounding, and winning attitude. It contains 80 statements, each offering two potential responses: True or False (Goldberg, 1998).

Quality of life

The assessment of participants' quality of life was conducted using the World Health Organization Quality of Life-BREF (WHOQOL-BREF). The WHOQOL-BREF measures four domains of quality of life: physical health, mental health, social relationships, and environment (WHO, 2020).

Procedure

The data collection occurred in a classroom setting. Before data collection, all relevant information on the research and how to provide their best-fit responses on the physical activity, mental toughness, and quality of life questionnaires was conveyed to the participants. Participants took 15–20 min to complete all the questionnaires. The anthropometric or sociodemographic data, along with their responses on outcome measures, were transferred to Excel sheets from the questionnaires. All the data were imported into SPSS software for further analysis.

Statistical analysis

All the statistical analyses were carried out using the software known as IBM-Statistical Package for Social Sciences (IBM-SPSS), version 26.0, for Windows, Chicago, IL, United States. The data was analysed to identify any missing values or outliers. The normality assumption for the outcome measures was validated at a significance level of $p < 0.05$ using the Shapiro–Wilk test. Therefore, parametric tests were employed for further investigation. Gender-specific differences were assessed using an independent two-tailed t -test for physical activity, mental toughness, and quality of life. Cohen's d was considered as the effect-size measure. The interpretation of effect size used as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) based on benchmarks suggested by Cohen (1988). A one-way analysis of variance (ANOVA) was conducted to examine the differences in physical activity levels related to mental toughness and quality of life among male and female participants separately. Eta-squared served as the effect-size measure. The values of 0.01, 0.06, and 0.14 have been considered as benchmarks for small, medium, and large effects, respectively (Cohen, 1988). Due to multiple testing, all *post-hoc* comparisons were made with Bonferroni. The statistical significance level was set at 0.05.

Results

Table 1 shows that there are significant differences between male and female participants for physical activity levels as high physical active

participants ($t = 4.21, p \leq 0.001$), moderate physical active participants ($t = 3.72, p \leq 0.001$), and low physical active participants ($t = 3.21, p = 0.002$). Total scores of physically active participants ($t = 7.38, p \leq 0.001$), and sitting time ($t = 6.06, p \leq 0.001$). All the physical activity levels and the sitting time show a large effect size for both genders.

Table 2 shows that there are statistically significant differences between gender for mental toughness parameters [handling pressure ($t = 17.96, p \leq 0.001$), concentration ($t = 16.07, p \leq 0.001$), mental rebounding ($t = 13.34, p \leq 0.001$), winning attitude ($t = 12.01, p \leq 0.001$)] and quality of life parameters [physical ($t = 13.16, p \leq 0.001$), mental ($t = 6.17, p \leq 0.001$), social ($t = 4.58, p \leq 0.001$), environmental ($t = 8.35, p \leq 0.001$)]. All the parameters for mental toughness and quality of life show a large effect size for both genders.

Table 3 showed that there are statistically significant differences between physical activity levels for mental toughness [handling pressure ($F = 29.19, p \leq 0.001$), concentration ($F = 54.39, p \leq 0.001$), mental rebounding ($F = 63.72, p \leq 0.001$), winning attitude ($F = 26.61, p \leq 0.001$)] and quality of life [physical ($F = 7.83, p \leq 0.001$), mental ($F = 12.94, p \leq 0.001$), social ($F = 101.87, p \leq 0.001$), environmental ($F = 418.58, p \leq 0.001$)] in male participants. All the parameters for mental toughness and quality of life show large effect sizes between physical activity levels for male participants. Only the physical aspect of quality of life shows a moderate effect size.

Table 4 shows multiple comparisons of mental health and quality of life among male participants as per physical activity level classification. There are significant differences between physical activity levels for the parameters of mental toughness and quality of life, except between hyper and moderate physical activity level classification for quality of life's physical parameter for male participants.

Table 5 shows that there are statistically significant differences between physical activity levels for mental toughness parameters [handling pressure ($F = 40.95, p \leq 0.001$), concentration ($F = 44.63, p \leq 0.001$), mental rebounding ($F = 44.12, p \leq 0.001$), winning attitude ($F = 17.45, p \leq 0.001$)] and quality of life parameters [physical ($F = 17.23, p \leq 0.001$), mental ($F = 24.58, p \leq 0.001$), social ($F = 40.39, p \leq 0.001$), environmental ($F = 36.69, p \leq 0.001$)] in female participants. All the parameters for mental toughness and quality of life show large effect sizes between physical activity levels for female participants.

Table 6 presents multiple comparisons of mental health and quality of life among female participants based on physical activity level classification. Significant differences exist between physical

TABLE 1 Comparison between male and female participants for physical activity as per its levels.

PA level	Gender	N	Mean $\pm$ SD	t	Sig.	d
High	Male	57	5696.98 $\pm$ 861.37	4.21	<0.001	871.80
	Female	28	4850.50 $\pm$ 893.06			
Moderate	Male	37	3322.08 $\pm$ 1355.84	3.72	<0.001	1309.59
	Female	46	2246.89 $\pm$ 1271.37			
Low	Male	16	2398.3750 $\pm$ 535.08	3.21	0.002	520.91
	Female	36	1896.3056 $\pm$ 514.72			
Total scores	Male	110	4418.35 $\pm$ 1699.88	7.38	<0.001	1630.71
	Female	110	2794.89 $\pm$ 1558.47			
Sitting times	Male	110	440.00 $\pm$ 119.44	6.06	<0.001	117.33
	Female	110	344.21 $\pm$ 115.17			

TABLE 2 Comparison between male and female participants for mental toughness and quality of life's parameters.

Variables		Gender	N	Mean $\pm$ SD	t	Sig.	d
Mental toughness	Handling pressure	Male	110	16.53 $\pm$ 1.16	17.96	<0.001	1.25
		Female	110	13.49 $\pm$ 1.35			
	Concentration	Male	110	13.78 $\pm$ 1.16	16.07	<0.001	1.22
		Female	110	11.13 $\pm$ 1.29			
	Mental rebounding	Male	110	11.04 $\pm$ 1.39	13.34	<0.001	1.45
		Female	110	8.43 $\pm$ 1.51			
	Winning attitude	Male	110	6.25 $\pm$ 1.18	12.01	<0.001	1.17
		Female	110	4.34 $\pm$ 1.18			
Quality of life	Physical	Male	110	23.01 $\pm$ 1.34	13.16	<0.001	1.58
		Female	110	20.19 $\pm$ 1.80			
	Mental	Male	110	19.62 $\pm$ 1.59	6.17	<0.001	1.69
		Female	110	18.22 $\pm$ 1.77			
	Social	Male	110	16.78 $\pm$ 2.19	4.58	<0.001	2.05
		Female	110	15.52 $\pm$ 1.89			
	Environmental	Male	110	21.88 $\pm$ 5.41	8.35	<0.001	4.95
		Female	110	16.31 $\pm$ 4.44			

TABLE 3 Mental toughness and quality of life differences among male participants as per physical activity level classification.

Variables		PA level	N	Mean SD	F	Sig.	Eta-squared
Mental toughness	Handling pressure	High	57	17.11 $\pm$ 0.90	29.19	<0.001	0.353
		Moderate	37	16.22 $\pm$ 0.98			
		Low	16	15.19 $\pm$ 0.98			
	Concentration	High	57	14.53 $\pm$ 0.80	54.39	<0.001	0.504
		Moderate	37	13.24 $\pm$ 0.83			
		Low	16	12.38 $\pm$ 0.89			
	Mental rebounding	High	57	11.91 $\pm$ 0.95	63.73	<0.001	0.544
		Moderate	37	10.54 $\pm$ 1.02			
		Low	16	9.06 $\pm$ 0.77			
	Winning attitude	High	57	6.84 $\pm$ 0.94	29.61	<0.001	0.356
		Moderate	37	5.92 $\pm$ 1.01			
		Low	16	4.88 $\pm$ 0.89			
Quality of life	Physical	High	57	23.39 $\pm$ 1.42	7.83	<0.001	0.128
		Moderate	37	22.86 $\pm$ 1.13			
		Low	16	22.00 $\pm$ 0.89			
	Mental	High	57	20.26 $\pm$ 1.53	12.94	<0.001	0.195
		Moderate	37	19.11 $\pm$ 1.26			
		Low	16	18.50 $\pm$ 1.46			
	Social	High	57	16.00 $\pm$ 1.28	101.87	<0.001	0.656
		Moderate	37	19.11 $\pm$ 1.26			
		Low	16	14.19 $\pm$ 1.42			
	Environmental	High	57	25.84 $\pm$ 1.99	418.58	<0.001	0.887
		Moderate	37	14.81 $\pm$ 1.31			
		Low	16	24.13 $\pm$ 2.28			

TABLE 4 Multiple comparisons of mental toughness and quality of life differences among male participants as per physical activity level classification.

Dependent variable			Mean difference (I-J)	Std. error	Sig.	95% CI	
						Lower bound	Upper bound
Handling pressure	Hyper	Moderate	0.89*	0.20	0.000	0.41	1.37
		Low	1.92*	0.27	0.000	1.27	2.56
	Moderate	Hyper	−0.89*	0.20	0.000	−1.37	−0.41
		Low	1.03*	0.28	0.001	0.35	1.71
	Low	Hyper	−1.92*	0.27	0.000	−2.56	−1.27
		Moderate	−1.03*	0.28	0.001	−1.71	−0.35
Concentration	Hyper	Moderate	1.28*	0.17	0.000	0.86	1.71
		Low	2.15*	0.23	0.000	1.58	2.72
	Moderate	Hyper	−1.28*	0.17	0.000	−1.71	−0.86
		Low	0.87*	0.25	0.002	0.27	1.47
	Low	Hyper	−2.15*	0.23	0.000	−2.72	−1.58
		Moderate	−0.87*	0.25	0.002	−1.47	−0.27
Mental rebounding	Hyper	Moderate	1.37*	0.20	0.000	0.88	1.86
		Low	2.85*	0.27	0.000	2.20	3.50
	Moderate	Hyper	−1.37*	0.20	0.000	−1.86	−0.88
		Low	1.48*	0.28	0.000	0.79	2.17
	Low	Hyper	−2.85*	0.27	0.000	−3.50	−2.20
		Moderate	−1.48*	0.28	0.000	−2.17	−0.79
Winning attitude	Hyper	Moderate	0.92*	0.20	0.000	0.43	1.41
		Low	1.97*	0.27	0.000	1.31	2.63
	Moderate	Hyper	−0.92*	0.20	0.000	−1.41	−0.43
		Low	1.04*	0.29	0.001	0.35	1.74
	Low	Hyper	−1.97*	0.27	0.000	−2.63	−1.31
		Moderate	−1.04*	0.29	0.001	−1.74	−0.35
Physical	Hyper	Moderate	0.52	0.27	0.162	−0.13	1.17
		Low	1.38*	0.36	0.001	0.51	2.26
	Moderate	Hyper	−0.52	0.27	0.162	−1.17	0.13
		Low	0.86	0.38	0.074	−0.06	1.79
	Low	Hyper	−1.38*	0.36	0.001	−2.26	−0.51
		Moderate	−0.86	0.38	0.074	−1.79	0.06
Mental	Hyper	Moderate	1.16*	0.30	0.001	0.42	1.89
		Low	1.76*	0.41	0.000	0.78	2.75
	Moderate	Hyper	−1.15*	0.30	0.001	−1.89	−0.42
		Low	0.61	0.43	0.480	−0.44	1.65
	Low	Hyper	−1.76*	0.41	0.000	−2.75	−0.78
		Moderate	−0.61	0.43	0.480	−1.65	0.44
Social	Hyper	Moderate	−3.11*	0.27	0.000	−3.77	−2.44
		Low	1.81*	0.37	0.000	0.92	2.71
	Moderate	Hyper	3.11*	0.27	0.000	2.44	3.77
		Low	4.92*	0.39	0.000	3.98	5.86
	Low	Hyper	−1.81*	0.37	0.000	−2.71	−0.92
		Moderate	−4.92*	0.39	0.000	−5.86	−3.98

(Continued)

TABLE 4 (Continued)

Dependent variable			Mean difference (I-J)	Std. error	Sig.	95% CI	
						Lower bound	Upper bound
Environmental	Hyper	Moderate	11.03*	0.39	0.000	10.09	11.97
		Low	1.72*	0.52	0.004	0.45	2.98
	Moderate	Hyper	-11.03*	0.39	0.000	-11.97	-10.09
		Low	-9.31*	0.55	0.000	-10.65	-7.98
	Low	Hyper	-1.71*	0.52	0.004	-2.98	-0.45
		Moderate	9.31*	0.55	0.000	7.98	10.65

*The mean difference is significant at the 0.05 level.

TABLE 5 Mental toughness and quality of life differences among female participants as per physical activity level classification.

Variables		PA level	N	Mean SD	F	Sig.	Eta-Squared
Mental toughness	Handling pressure	High	28	14.89 ± 0.96	40.95	<0.001	0.434
		Moderate	46	13.35 ± 0.99			
		Low	36	12.58 ± 1.11			
	Concentration	High	28	12.54 ± 0.58	44.63	<0.001	0.455
		Moderate	46	10.91 ± 1.11			
		Low	36	10.31 ± 0.98			
	Mental rebounding	High	28	9.96 ± 0.92	44.12	<0.001	0.452
		Moderate	46	8.37 ± 1.24			
		Low	36	7.31 ± 1.12			
	Winning attitude	High	28	4.82 ± 0.86	19.45	<0.001	0.267
		Moderate	46	4.72 ± 1.05			
		Low	36	3.47 ± 1.08			
Quality of life	Physical	High	28	21.68 ± 1.52	17.23	<0.001	0.244
		Moderate	46	19.85 ± 1.58			
		Low	36	19.47 ± 1.63			
	Mental	High	28	19.82 ± 1.25	24.58	<0.001	0.315
		Moderate	46	18.00 ± 1.53			
		Low	36	17.25 ± 1.57			
	Social	High	28	15.07 ± 1.41	40.39	<0.001	0.430
		Moderate	46	14.43 ± 1.34			
		Low	36	17.25 ± 1.57			
	Environmental	High	28	23.32 ± 2.25	36.69	<0.001	0.871
		Moderate	46	14.43 ± 1.34			
		Low	36	13.25 ± 1.32			

activity levels concerning mental toughness and quality of life parameters, except for the comparison between hyper and moderate physical activity classifications regarding winning attitude and between moderate and low physical activity classifications regarding the physical and mental aspects of quality of life in female participants.

Discussion

This research aimed to investigate the effect of physical activity on mental toughness and quality of life among male and female

participants. To achieve the research objective, data were collected using distinct questionnaires, including the IPAQ, Mental Toughness Scale, and WHOQOL-BREF. The findings revealed significant differences in physical activity levels among male and female participants: high ($t = 4.21, p \leq 0.001$), moderate ($t = 3.72, p \leq 0.001$), and low ($t = 3.21, p = 0.002$). Moreover, statistically significant differences between genders also existed for mental toughness parameters: handling pressure ($t = 17.96, p \leq 0.001$), concentration ($t = 16.07, p \leq 0.001$), mental rebounding ($t = 13.34, p \leq 0.001$), and winning attitude ($t = 12.01, p \leq 0.001$), as well as for quality of life parameters: physical ($t = 13.16, p \leq 0.001$), mental ($t = 6.17,$

TABLE 6 Multiple comparisons of mental toughness and quality of life differences among female participants as per physical activity level classification.

Bonferroni							
Dependent variable	(I)	(J)	Mean difference (I-J)	Std. error	Sig.	95% CI	
						Lower bound	Upper bound
Handling pressure	Hyper	Moderate	1.55*	0.25	<0.001	0.95	2.14
		Low	2.31*	0.26	<0.001	1.68	2.94
	Moderate	Hyper	-1.55*	0.25	<0.001	-2.14	-0.95
		Low	0.76*	0.23	0.003	0.21	1.32
	Low	Hyper	-2.31*	0.26	<0.001	-2.94	-1.68
		Moderate	-0.76*	0.23	0.003	-1.32	-0.21
Concentration	Hyper	Moderate	1.62*	0.23	<0.001	1.06	2.18
		Low	2.23*	0.24	<0.001	1.64	2.82
	Moderate	Hyper	-1.62*	0.23	<0.001	-2.18	-1.06
		Low	0.61*	0.21	0.016	0.09	1.13
	Low	Hyper	-2.23*	0.24	<0.001	-2.82	-1.64
		Moderate	-0.61*	0.21	0.016	-1.13	-0.09
Mental rebounding	Hyper	Moderate	1.59*	0.27	<0.001	0.94	2.25
		Low	2.66*	0.28	<0.001	1.97	3.35
	Moderate	Hyper	-1.59*	0.27	<0.001	-2.25	-0.94
		Low	1.06*	0.25	<0.001	0.46	1.67
	Low	Hyper	-2.66*	0.28	<0.001	-3.35	-1.97
		Moderate	-1.06*	0.25	<0.001	-1.67	-0.46
Winning attitude	Hyper	Moderate	0.10	0.24	1	-0.49	0.70
		Low	1.35*	0.26	<0.001	0.73	1.97
	Moderate	Hyper	-0.10	0.24	1	-0.70	0.49
		Low	1.25*	0.23	<0.001	0.70	1.79
	Low	Hyper	-1.35*	0.26	<0.001	-1.97	-0.73
		Moderate	-1.25*	0.23	<0.001	-1.79	-0.70
Physical	Hyper	Moderate	1.83*	0.38	<0.001	0.91	2.75
		Low	2.21*	0.40	<0.001	1.24	3.17
	Moderate	Hyper	-1.83*	0.38	<0.001	-2.75	-0.91
		Low	0.37	0.35	0.863	-0.48	1.23
	Low	Hyper	-2.21*	0.40	<0.001	-3.17	-1.24
		Moderate	-0.37	0.35	0.863	-1.23	0.48
Mental	Hyper	Moderate	1.82*	0.36	<0.001	0.96	2.69
		Low	2.57*	0.37	<0.001	1.66	3.48
	Moderate	Hyper	-1.82*	0.36	<0.001	-2.69	-0.96
		Low	0.75	0.33	0.075	-0.05	1.55
	Low	Hyper	-2.57*	0.37	<0.001	-3.48	-1.66
		Moderate	-0.75	0.33	0.075	-1.55	0.05
Social	Hyper	Moderate	0.64	0.35	0.204	-0.20	1.48
		Low	-2.18*	0.36	<0.001	-3.06	-1.30
	Moderate	Hyper	-0.64	0.35	0.204	-1.48	0.20
		Low	-2.82*	0.32	<0.001	-3.59	-2.04
	Low	Hyper	2.18*	0.36	<0.001	1.30	3.06
		Moderate	2.82*	0.32	<0.001	2.04	3.59

(Continued)

TABLE 6 (Continued)

Bonferroni							
Dependent variable	(I)	(J)	Mean difference (I-J)	Std. error	Sig.	95% CI	
						Lower bound	Upper bound
Environmental	Hyper	Moderate	8.89*	0.39	<0.001	7.95	9.83
		Low	10.07*	0.41	<0.001	9.08	11.06
	Moderate	Hyper	-8.89*	0.39	<0.001	-9.83	-7.95
		Low	1.18*	0.36	0.004	0.31	2.06
	Low	Hyper	-10.07*	0.41	<0.001	-11.06	-9.08
		Moderate	-1.18*	0.36	0.004	-2.06	-0.31

*The mean difference is significant at the 0.05 level.

$p \leq 0.001$), social ($t = 4.58, p \leq 0.001$), and environmental ($t = 8.35, p \leq 0.001$). These findings are consistent with those of other researchers, as mentioned below.

Bergier et al. (2015) compared the levels of physical activity in males and females. They confirmed a more positive assessment of physical activity, as a high level of activity was recorded in males (57.1%) and in females (45.7%). In contrast, low activity was reported in males (3.6%) and females (6.3%). An assessment of physical activity levels among Ukrainian university students is promising because over 90% of the respondents reported high or moderate activity, while only a small percentage reported low activity (Bergier et al., 2015). A high level of physical activity was noted among males (20.9%) and females (17.3%), whereas a low level of physical activity was recorded among females (36.3%) and males (20.9%) (Peltzer and Pengpid, 2013). In the present study, high activity was reported in males (51.81%) and in females (25.45%), while low activity was reported in males (14.55%) and in females (32.73%). A total of 76.36% of respondents reported high or moderate physical activity, while 23.64% reported low activity.

The examination of physical activity differences between male and female students reveals a multifaceted landscape influenced by psychosocial factors, social support, and the nature of the physical activities undertaken. Kljajević et al. (2022) conducted a systematic review assessing physical fitness levels and physical activity among university students, indicating that males generally participate in more intense physical activity than females (Kljajević et al., 2022). These differences are further elaborated by Valis and Gonzalez (2017), who found that male university students reported higher levels of vigorous occupational physical activity and overall physical activity, suggesting inherent gender differences in activity preferences and engagement. Kretschmer et al. (2023) investigated the evidence across nine countries for physical activity differences by gender. They reported that higher mean volumes of moderate to vigorous physical activity were found in male participants, along with greater variability than in female participants. The results indicated minimal to no difference in participation between males and females regarding the distribution of light-intensity or sedentary activities. Research has shown that differences in physical activity levels exist across various gender groups, encompassing children, adolescents, adults, and older individuals, with findings consistently indicating that males tend to participate in higher levels of physical activity than their female counterparts (Azevedo et al., 2007; Trost et al., 2002).

Mental toughness is a multidimensional construct often highlighted as an essential component of successful performance (Ahsan and Mohammad, 2017; Golby and Sheard, 2004). Nicholls et al. (2008) revealed a significant difference in mental toughness between male and female participants. It was reported that male subjects exhibited a higher level of mental toughness than their female counterparts. Fisher et al. (2021) identify that men often use problem-based coping strategies and demonstrate self-reliance, which are elements of mental toughness, potentially reducing the likelihood of anxiety and depression among males. Newland et al. (2013) indicated a significant relationship between the mental toughness of male subjects and their performance, while this relationship was not observed in female subjects. Nicholls et al. (2008) investigated the mental toughness among athletes and found that males scored significantly higher than females on total mental toughness with low effect size (Cohen's $d = 0.33$). Putra et al. (2024) investigate the differences in mental toughness between genders and conclude that males have higher average mental toughness scores than females. They also elaborate that male participants generally exhibit better mental toughness, making them less susceptible to experiencing excessive psychological disorders such as stress and depression. Our findings align with existing literature and demonstrate that mental toughness is a more robust predictor of approach quality of life and physical activity. Participation in physical activities may also enhance mental toughness and quality of life in females.

The literature reveals that gender differences significantly affect quality of life across various health conditions. Females generally report a lower quality of life in areas related to mental health, physical health, and chronic disease management compared to males. The impact of physical activity on quality of life also exhibits gender-specific patterns. Nowak et al. (2019) observed that certain types of physical activity positively correlate with the quality of life among university students, with notable differences in activity patterns and quality of life outcomes between males and females. Additionally, Dos Santos et al. (2021) demonstrated that creatine supplementation, in conjunction with resistance training, significantly improves muscle strength in older females, potentially enhancing their physical quality of life. Mental health is another critical area where gender differences influence quality of life. Females are at a higher risk of experiencing depressive symptoms compared to their male counterparts, highlighting the need for gender-specific mental health interventions in the workplace (Torquati et al., 2019). Additionally, Mental health professionals, especially women, are

more vulnerable to secondary traumatization, which can significantly impact their quality of life and professional effectiveness (Baum, 2016). Van Den Eijnden et al. (2018) discovered that engagement with games and social media adversely impacts psychosocial wellbeing and academic performance, with gender differences shaping these results. Fergus et al. (2024) further elaborated on psychological wellbeing, emphasizing gender-based variations in wellness dimensions that enhance overall quality of life. The evidence underscores the need for gender-specific healthcare strategies that address not only the biological differences but also the socio-cultural and psychological dimensions that differentially affect males and females.

This study has some limitations. It utilized a cross-sectional approach, which restricts the ability to establish causality between physical activity, mental toughness, and quality of life. Longitudinal studies would provide more robust evidence of these relationships. A small sample size may reduce statistical power and impact the reliability of gender comparisons. Additionally, reliance on self-reported measures for physical activity, mental toughness, and quality of life could introduce response biases, and objective measures (e.g., accelerometers for physical activity) could enhance validity. The findings may not be generalizable to wider populations, as the data were gathered from only one institution. Factors such as diet, sleep, stress levels, and socioeconomic status were not controlled, which could influence mental toughness and quality of life independently of physical activity. The study might not account for cultural differences in perceptions of mental toughness or quality of life, which could vary across regions. Furthermore, the use of the questionnaires and scales may not capture all dimensions of mental toughness or quality of life, leading to incomplete assessments.

Conclusion

Statistically significant differences were found between genders in levels of physical activity, mental toughness, and quality of life. Future research should aim to unravel the complex interlink between physical activity, mental toughness, and quality of life, using longitudinal designs and diverse populations to validate the findings and explore the underlying mechanisms further. Such efforts will advance the development of holistic, gender-responsive interventions that promote mental toughness and quality of life for both males and females.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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Ethics statement

The studies involving humans were approved by Imam Abdulrahman Bin Faisal University, Dammam. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

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The impact of physical activity on self-emotion management among university students in Western China: the mediating roles of self-rated health and life satisfaction

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Objective: This study aims to investigate the impact of Physical Activity on Self-Emotional Management among university students and to verify the mediating roles of Self-Rated Health and Life Satisfaction.

Methods: A stratified cluster sampling method was used to enroll 10,300 university students from Western China. Questionnaires were used to collect data, which included demographic and sociological information, the Physical Activity Scale (for measuring Physical Activity), the Emotional Intelligence Scale (for measuring Self-Emotional Management), the Short-Form Health Survey (for measuring Self-Rated Health), and the Satisfaction with Life Scale (for measuring Life Satisfaction). The results were statistically analyzed by using SPSS 26.0.

Results: There was a positive correlation between different intensities of Physical Activity and Self-Emotional Management among university students in Western China ($p < 0.001$). Yet the direct predictive effect on Self-Emotional Management was not significant. Low-Intensity Physical Activity positively predicted Self-Rated Health ($\beta = 0.876$, $p < 0.001$), while Vigorous-Intensity Physical Activity negatively predicted Self-Emotional Management ($\beta = -1.500$, $p < 0.001$). Self-Rated Health positively predicted both Life Satisfaction and Self-Emotional Management ($\beta = 0.118$, $p < 0.001$; $\beta = 0.030$, $p < 0.001$), and Life Satisfaction positively predicted Self-Emotional Management ($\beta = 0.403$, $p < 0.001$).

Self-Rated Health partially mediated the relationship between Low-Intensity Physical Activity/Vigorous-Intensity Physical Activity and Self-Emotional Management, with effect sizes of 0.026 (95% CI: 0.002–0.052) and –0.045 (95% CI: –0.080 to –0.010) respectively. The serial mediation pathway, the Low-Intensity Physical Activity/Vigorous-Intensity Physical Activity→Self-Rated Health→Life Satisfaction→Self-Emotional Management was significant ($p < 0.05$).

Conclusion: Low-Intensity Physical Activity or Vigorous-Intensity Physical Activity cannot directly influence university students' Self-Emotional Management ability. Based on self-determination theory, Self-Rated Health can independently influence university students' Self-Emotional Management ability. It can also indirectly influence Self-Emotional Management by incorporating the chained mediation effect of Self-Rated Health and Life Satisfaction.

KEYWORDS

physical activity, self-emotion management, self-rated health, life satisfaction, mediating effect

1 Introduction

Emotion lies at the core of human experience. It represents the physiological and psychological responses to external environments and internal states (Hajiyeva and Kosonogov, 2023). Self-Emotional Management (SEM) denotes the scientific intervention in recognizing, expressing, experiencing, and regulating one's emotions to promote physical and mental health (Morales et al., 2023). University years are crucial for character formation. Enhancing students' SEM abilities is vital for cultivating good character during this period. Mental health does not merely refer to an individual's absence of symptoms or diseases. Instead, it signifies that an individual enjoys a sound physical and mental state and a psychological state that is well-adapted to society (World Health Organization, 1950). As society develops rapidly, academic and employment competition among university students has become more intense. This has substantially increased their stress levels, giving rise to negative emotions. Students with poor SEM skills are more prone to psychological problems. In severe cases, these problems can even be life-threatening (Hu et al., 2016).

The "2022 Survey Report on the Mental Health of Chinese University Students" reveals that 21.48% of Chinese university students are at risk of different degrees of depression, and 45.28% may face the risk of anxiety (Fu and Zhang, 2022). WHO statistics show that the prevalence of mental health problems in China is increasing (Chinese Government Website, 2023). A recent study in *The Lancet* found that about 173 million people in China are afflicted with mental disorders, such as anxiety, depression, and obsessive-compulsive disorder. Around 158 million have never received professional treatment, and only 15 million, <10%, have sought treatment. Only 15 million, <10%, have sought treatment (Lu et al., 2021). In recent years, there has been an increasing emphasis on the mental health of university students. The "Special Action Plan for Strengthening and Improving Students' Mental Health Work in the New Era" has been introduced (World Health Organization, 2022). This policy aims to boost students' mental health,

enhance their emotional management skills, and promote their all-round development. Currently, SEM is a key research area for scholars globally. They mainly explore the relationship between emotions and behavior.

Physical Activity (PA) involves bodily movements that increase energy expenditure above resting metabolic levels (Anshel et al., 1991). Regular participation in PA offers several benefits for university students. It enhances physical fitness and boosts immunity. Regular involvement in PA offers several benefits for university students, including enhanced physical fitness, improved cardiovascular health, and reduced cognitive decline from poor sleep (Haddad et al., 2024). Research suggests that PA is linked to improvements in at least one of the four dimensions of university students' quality of life: physical health, mental health, environmental vitality, and social interaction (Sette Abrantes et al., 2022). The mental health benefits of engaging in PA have drawn substantial attention and research from both domestic and international scholars. Recent studies indicate that PA intervention not only improves mood through physiological mechanisms but also indirectly alleviates psychological distress by enhancing self-rated mental health and optimizing dietary patterns, particularly evident among women and younger adults (Levante et al., 2024). Research has demonstrated that positive emotions are crucial protective factors for mental health (Tugade et al., 2004). Based on the cognitive-behavioral hypothesis, PA can enhance psychological and social mechanisms such as self-esteem and social support (Deng et al., 2023), improve emotional states, and induce positive emotions. Strengthening emotional regulation abilities and a sense of social belonging alleviates negative emotions like depression and anxiety, thereby protecting the mental health of college students. This effect is particularly prominent in group exercise settings (White et al., 2024). Emotional health is one indicator of mental wellbeing. Compared to college students who do not actively participate in PA, those who actively engage in PA effectively convert positive experiences during PA into long-term psychological benefits through emotional regulation. These students exhibit significantly lower levels of depression and higher levels of mental health (Wenig et al., 2023). Thus, there is a close relationship between PA and emotions.

Extensive international studies have demonstrated that the multifaceted regulatory mechanisms of PA on individual emotions, under the influence of various factors such as enhancing executive

Abbreviations: SEM, Self-Emotion Management; LS, Life Satisfaction; SRH, Self-Rated Health; PA, Physical Activity; LPA, Low-Intensity Physical Activity; MPA, Moderate-Intensity Physical Activity; VPA, Vigorous-Intensity Physical Activity.

function, strengthening psychological resilience, improving life satisfaction, and fulfilling basic psychological needs-oriented towards health, emphasize the positive impact of PA on emotional wellbeing (Chen et al., 2024; Díaz et al., 2024; Savikangas et al., 2024). A significant imbalance becomes evident when focusing on regional differences in China. The Western region of China has distinct characteristics in terms of economic development and ethnic distribution, which exhibit significant disparities and offer special research value. University students' participation in physical activities shows a gradient in the eastern, central, and western regions. The eastern region has the highest participation rate at 39.2%, followed by the central region at 30.1%, and the west region at the lowest at 25.8% (Cai et al., 2009). This trend aligns with China's current regional socio-economic development levels. There is a greater focus on emotion-related studies in the eastern and central regions (Meng et al., 2015; Wei et al., 2022; Liu W. J. et al., 2023). The fast pace of development, intense employment competition, and high academic and life pressures in these regions lead to significant emotional issues. Rapid social development has also heightened people's attention to personal health and their demand for a better quality of life, resulting in sufficient research samples and more complete data. Fewer studies in the Western region have examined the relationships between PA, SEM, Self-Rated Health (SRH), and Life Satisfaction (LS) in university students. Existing research primarily focuses on other demographic groups, such as professionals, children, and older people. Additionally, most studies explore the relationships between two or three variables without investigating their interactions in depth (Ma et al., 2002; Tian et al., 2021; Huang et al., 2023). There is a lack of attention to the emotional health of university students in western regions. The global research landscape is similar, with a lack of exploration of the relationship between self-rated health and life satisfaction assessment (Pelletier et al., 2017; Mayes et al., 2022). This study aims to fill this research gap by empirically investigating university students in Western China. It seeks to provide supplementary data and comparisons for related research nationwide. It aims to offer theoretical insights for refining the global health framework and developing targeted health promotion policies.

This study examines two mediating variables, SRH and LS, for the following reasons. SRH is an individual's expectation and subjective assessment of their health status and is an important indicator of university students' physical and mental health. It integrates objective health evaluation with subjective health perception and is a common method for international health measurement (Pigott et al., 2024). Enhanced individual self-awareness leads to a deeper understanding of health (Hulsege et al., 2023). Individuals with higher SRH levels exhibit stable and positive psychological states, possess effective emotional regulation, and have their quality of life assured. LS is a subjective cognitive assessment and emotional experience of one's life status based on personal standards (Foster and Judy, 2024). Previous research has shown that individuals who actively participate in PA have higher LS (Wypych-Slusarska et al., 2023). They have an optimistic attitude, lighter social anxiety, and improved emotional management by actively enhancing social support (Calleja et al., 2023; Sergio et al., 2024). Moderate LS can affect emotional stability and has a significant role in promoting the generation of positive emotions (Mihaela et al., 2022; Li R. et al., 2024). Self-determination theory (SDT) emphasizes that human behavior is motivated by internal, self-driven factors rather than external environmental influences.

Individuals have three basic psychological needs: autonomy, competence, and relatedness. The degree to which these needs are met significantly impacts their motivation and behavior (Ahmadi et al., 2023). Individuals leverage psychological resilience to enhance intrinsic motivation (Zhang et al., 2022), feeling a sense of control over their goals and plans for physical exercise and firmly believing in their ability to achieve these exercise goals (Saad, 2021). While achieving these goals, they establish a connection with their health assessments, consistently expressing vitality and positive emotions, thereby increasing life satisfaction, improving emotional self-regulation, and promoting mental health (Paldam et al., 2019).

Most existing studies focus on the relationship between SRH or LS and PA and emotions or explore the mediating effects of SRH and LS on PA and other factors (Feiyang et al., 2021; Yu et al., 2024), touching upon their influence on emotional management (Saad, 2021; Daniela et al., 2022). However, these studies often remain at the level of surface correlation analysis and fail to delve into the mechanisms by which SRH and LS function as mediators between PA and emotional management. Based on Self-Determination Theory (SDT), consistent exercise promotes the generation of positive emotions by fulfilling needs for autonomy, competence, and relatedness, thereby enhancing self-regulation of emotions and improving overall mental health among college students. In summary, this study aims to establish a pathway between PA and SEM for college students, grounded in existing literature frameworks on the physiological and psychological mechanisms through which PA influences SEM. Accordingly, Hypothesis *H1*: *There is a correlation between PA, SRH, LS, and SEM.* The study aims to explore the impact of PA, self-rated health, and life satisfaction on self-emotion management among college students in western China. To further investigate how PA affects emotion regulation abilities, and based on SDT principles, Hypothesis *H2*: *SRH has a mediating effect between PA and SEM*, *H3*: *LS has a mediating effect between PA and SEM.* These hypotheses aim to reveal how self-rated health and life satisfaction, as mediating variables, influence PA participation and indirectly affect self-emotion management. College students experience varying intensities of PA and perceive their ability to overcome challenges encountered during different PA intensities, adopting a series of positive mental health behaviors to regulate their emotional changes rationally. Therefore, Hypothesis *H4*: *SRH and LS sequentially mediate the relationship between PA and SEM.* This hypothesis analyses how self-rated health and life satisfaction interact and serve as key mechanisms through which PA influences self-emotion management. Hypothesis *H5*: *LS, SRH, SEM, and the intensity of PA are related*, aiming to explore the impact of different PA intensities on relevant mental health indicators (Figure 1).

2 Methods

2.1 Participants

The primary research method employed in this study is epidemiological investigation. The research encompasses the western regions of China, specifically Sichuan, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Guangxi, and Inner Mongolia. A total of 10,300 valid questionnaires were gathered during this investigation. The target population for this survey is

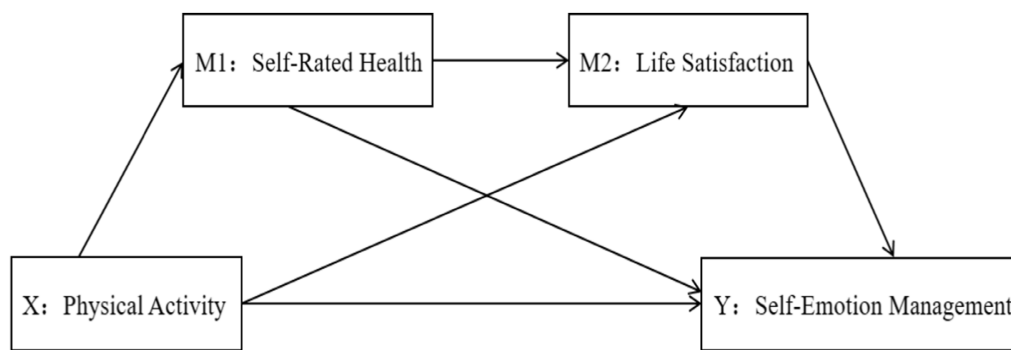


FIGURE 1
Hypothetical model diagram.

undergraduate students from general higher education institutions in China's western region; this includes both associate and bachelor's degree students while excluding postgraduate (master's and doctoral) candidates. Survey participants were selected using stratified clusters. The cluster sampling methods are based on geographical regions (such as provinces and urban administrative levels) and university types (such as comprehensive universities and local colleges). The specific sampling procedures are outlined as follows:

2.1.1 Determination of sampling sites

To ensure the representativeness of the surveillance subjects, an average of three sampling sites were distributed to each province (region, municipality). Based on the principle of drawing an equal number of samples from different cities, the specific approach is as follows: Prefecture-level cities, governed by provinces and autonomous regions, are designated sampling sites. Among these, the provincial capital is appointed as a "first-class" sampling location; the remaining two cities are selected based on the geographical considerations of the province or autonomous region. A city with an average socio-economic development level is classified as a second-class sampling site. In contrast, a city with lower socio-economic development is classified as a third-class sampling site. In municipalities directly under the central government district, sample collection does not adhere to these principles and primarily relies on random cluster selection. However, it must follow the requirement of three designated sampling sites.

2.1.2 Determination of sampling units

When selecting sampling units, three main aspects were considered: First, the affiliated higher education institutions should be established institutions registered with the Ministry of Education, including vocational colleges; second, units that can meet the sampling requirements (age, number, grade distribution, etc.); third, units with specific questionnaire distributors and a willingness to participate in long-term monitoring. Fourth, the sampling units are affiliated with higher education institutions where university students have completed their return to campus for the autumn semester.

2.1.3 Grouping and sample size

The population is divided into two groups based on sex (This study focuses solely on sex: male or female), then categorized into eight types of samples according to grade, with each type of sample

(e.g., male first-year university students) further divided into two categories based on ethnicity (Han, ethnic minorities). To ensure adequate representation of ethnic minorities in the sample, we specifically focused on the distribution characteristics of ethnic minority students in the Western region. We selected institutions with a higher proportion of ethnic minorities and ensured that at least one department within each institution contained a sufficient proportion of ethnic minority students. Furthermore, through the self-reported ethnicity section of the survey, we conducted statistical tests on the essential demographic characteristics of the sample (such as sex, grade, and ethnic proportions). We compared these with the overall distribution of university students in the Western region to validate the diversity and representativeness of the sample.

This study selected 10,300 college students aged 15–28 from the Western region as research subjects (46.1% male and 53.9% female). Questionnaire data collection was conducted online, with researchers and supervisors present. The researchers provided informed consent forms to participants at the beginning of the study. The form clearly outlined the study's purpose, methods, potential risks, and participants' rights, ensuring voluntary participation based on full awareness. All participants were informed that the questionnaire would take approximately 10 min. Participants were informed that they could withdraw from the study at any time without any negative consequences. A pre-survey was conducted before the main survey, and the questionnaire design was optimized based on the feedback received. Participants' responses were collected anonymously, and the sample data were kept confidential to minimize self-report biases. A total of 10,300 samples were collected (Table 1).

2.2 Measurement

2.2.1 Sociodemographic information

This encompasses sex, academic year, age, educational institution, and the school's geographical location [postal code must be provided (Luo et al., 2018)].

2.2.2 Physical activity

The Physical Activity Rating Scale-3 (PARS-3) measured PA participation levels among university students. Developed by Japanese scholar Hiroo Hashimoto (Kimio, 1990) and revised by Chinese

TABLE 1 Sample characteristics table.

Variable	<i>n</i>	%
Sex		
Male	4,749	46.1
Female	5,551	53.9
Nation		
Han Nationality	8,696	84.4
Ethnic Minorities	1,604	15.6
Age		
Aged 18 and under	3,928	38.1
19	3,850	37.4
20	1,515	14.7
21	596	5.8
22	218	2.1
23	106	1.0
24	38	0.4
Aged 25 and over	49	0.5
Grade		
First-year students	6,860	66.6
Sophomores	2,770	26.9
Juniors	446	4.3
Seniors	224	2.2
Total	10,300	100

scholars such as Qingde Liang into the Chinese version (Liang, 1994), the PARS-3 evaluates PA based on intensity, frequency, and duration of exercise sessions. The rating scale ranges from 1 to 5.

PA volume = Intensity × (Duration - 1) × Frequency...Formula A.

The World Health Organization categorizes physical activities into Low-Intensity Physical Activity (LPA), Moderate-Intensity Physical Activity (MPA), and Vigorous-Intensity Physical Activity (VPA) based on intensity (Foster et al., 2018). In PARS-3, each indicator is graded on a scale of three levels, corresponding to LPA, MPA, and VPA. The normative data for Chinese adults on PARS-3 are as follows: LPA scores ≤19, MPA scores range from 20 to 42, and VPA scores ≥43 (Liang, 1994). The results from PARS-3 serve as a metric for PA volume and, to a certain extent, reflect the current state of PA participation among university students within a specific time. The test–retest reliability of PARS-3 is 0.820, and its applicability in the Chinese university student population has been validated in numerous studies (Han et al., 2022; Li et al., 2022; Xu et al., 2023; Mu et al., 2024a).

2.2.3 Self-emotion management

The Emotional Intelligence Scale (EIS) was employed to assess the emotional self-regulation of university students. The EIS, developed by Mayer and Salovey in 1998 and based on the emotional intelligence theory, measures individuals’ abilities to perceive, understand, express, control, manage, and use their own and others’ emotions. The scale consists of 8 items, rated on a scale of 1 to 5. A higher total EIS score indicates a higher level of individual emotional self-regulation ability (Zhang, 2008). Translated and validated by Chinese scholar Caikang Wang in

2002, the EIS has demonstrated good reliability and validity (Cronbach’s $\alpha = 0.84$) and has been widely used and verified by Chinese scholars (Wang, 2002). The applicability of the EIS in the Chinese university student population has been confirmed in multiple studies (Wang et al., 2020, 2022a; Mu et al., 2024a).

2.2.4 Self-rated health

The 36-item Short Form Health Survey (SF-36) was utilized to measure the SRH of university students (Salovey and Mayer, 1990). This study selected the “general health” part of the SF-36 for analysis. The scale uses reverse scoring, consisting of 5 items with rating levels from 1 to 5. The higher the total score obtained by summing the 5 items, the poorer the health status. The reliability and validity of SF-36 in measuring health in university students have been validated. The consistency correlation coefficient is 0.92, and Cronbach’s alpha coefficient is 0.88. The reliability and validity are at a good level for use in practice (Han et al., 2015). The SF-36 has been validated for its applicability in multiple studies of Chinese university student populations (Li B. et al., 2024; Mu et al., 2024b).

2.2.5 Life satisfaction

The Satisfaction with Life Scale (SWLS) was used to measure university students’ LS. Developed by American scholars Diener et al. in the 1980s (Pavot and Diener, 1993). The scale consists of five items rated on a 7-point scale. Higher total scores show greater life satisfaction. The SWLS demonstrates good psychometric properties (Cronbach’s $\alpha = 0.82$) and has been widely used and validated by Chinese scholars. The applicability of the SWLS in the Chinese university student population has been confirmed in multiple studies (Xing et al., 2002; Feiyang et al., 2021).

This study localized the international scales (from English to Chinese) to ensure their applicability to the specific population of university students in Western China. Additionally, several domestic studies validated the language-adjusted scales’ suitability in the Chinese university student population (Wang et al., 2020; Feiyang et al., 2021; Han et al., 2022; Li et al., 2024a).

2.3 Statistical analysis

This study employed SPSS 26.0 and Excel software, divided into the following steps:

1. Preliminary data processing of questionnaire data obtained from Questionnaire Star was conducted using Excel software, with retesting or deletion of missing or problematic data.
2. Harman’s single-factor test was used to assess common method bias, preventing potential issues related to common method variance.
3. Descriptive statistical methods, including mean, standard deviation, and percentages, were used to analyze the basic information of the survey respondents, encompassing sex, academic year, ethnicity, school region, PA volume, SRH, LS, and SEM. In the descriptive analysis, differences were evaluated with η^2 effect sizes categorized as small (0.04), medium (0.25), and large (0.64).

4. Pearson correlation analysis was conducted to examine the relationships between university students' PA (LPA, MPA, VPA), SRH, LS, and SEM.
5. Mediation effect tests were performed through regression analysis, with the Process plugin used for multiple regression analysis and the Bootstrap method for mediation effect analysis.

3 Results

3.1 Analysis of normality tests

Scholar Kline indicates that when skewness is between ± 3 , and kurtosis is between ± 10 , it suggests that the sample data approximately follows a normal distribution (Kline, 2016). Using SPSS software, normality tests were conducted on the primary research variables PA, SEM, SRH, and LS in this study. The measurement results indicate that all variables meet the criteria, and the sample data can be used for subsequent analysis.

3.2 Test for common method bias

To address potential common method bias, Harman's single-factor test was used to conduct an exploratory factor analysis on all items related to PA, SRH, LS, and SEM abilities, considering the subjective nature of the data collection scales. The results revealed five principal components with eigenvalues >1 , with the largest factor explaining 32.57% of the variance, which is below the typical threshold of 40%. Consequently, it was concluded that there is no issue with common method bias in this study.

3.3 Descriptive statistics

As shown in Table 2, university students scored an average of 6.008 ± 4.811 in LPA, with significant differences observed in sex and academic year but not in ethnicity. The total score for SEM abilities was 29.360 ± 4.814 , with statistically significant differences at the levels of sex and academic year. The overall scores for SRH and LS were 62.942 ± 19.318 and 22.130 ± 6.235 , respectively, with minimal differences across sex, ethnicity, and academic year.

University students' scores for MPA averaged 26.060 ± 6.815 , with significant sex differences and academic year, but not in ethnicity. The total score for SEM abilities was 29.430 ± 4.696 , with significant differences at the levels of sex and academic year. The scores for SRH were 62.751 ± 19.076 , and for LS, the total score was 22.140 ± 6.193 , with minimal differences across sex, academic year, and ethnicity.

For VPA, university students scored an average of 62.910 ± 16.079 , with no differences observed in ethnicity and academic year, but significant sex differences. The total score for SEM abilities was 29.480 ± 4.740 , with no significant differences in SRH across sex and ethnicity but differences were noted in the academic year. The total score for LS was 22.080 ± 6.241 , with minimal differences across sex, academic year, and ethnicity.

The study found sex differences among college students in various PA levels (LPA, MPA, VPA) and SEM. Males scored higher than

females in all PA levels, and females had higher overall SEM scores than males (Figure 2).

3.4 Correlation analysis of the study variables

The Physical Activity Rating Scale (PARS) levels were categorized into LPA, MPA, and VPA and were analyzed about relevant variables (Nie and Heung, 2022). As indicated in Table 3, LPA exhibited significant positive correlations with LS and SEM. At the same time, SRH, LS, and SEM demonstrated significant positive correlations, with SRH and LS showing a notably positive relationship.

VPA showed a significant positive correlation with SEM. SRH, LS, and SEM had significant positive correlations, and SRH and LS showed a significant positive correlation (all $p < 0.01$).

3.5 Analysis of regression

A chained mediation model was tested using Model 6 in SPSS 26.0's PROCESS, controlling for variables such as sex, ethnicity, and grade, as shown in Table 4. The results indicated that LPA positively predicted SRH, while VPA and PA negatively predicted SRH. After incorporating LS into the regression equation, SRH positively predicted LS and SEM. LS significantly positively affected SEM, suggesting that PA might indirectly predict SEM through SRH and LS (all $p < 0.001$) (Figures 3–6).

3.6 Analysis of intermediation effects

3.6.1 Direct effects

Based on regression analysis, with VPA as the subject of analysis, the mediation effect testing procedure was followed to examine the coefficient c of VPA on SEM. The coefficient was not significant, indicating the presence of a suppression effect. This coefficient was not significant, indicating a masking effect. The direct effect of VPA is 0.187, with a 95% confidence interval of $(-0.044, 0.418)$. Since the confidence interval includes 0, it indicates a full mediation effect.

3.6.2 Indirect effects

Coefficients $a_1 = -1.500$, $a_2 = 0.030$; $b_1 = 0.148$, $b_2 = 0.403$ were evaluated with VPA as the independent variable; among these, a_2 was not significant, while the other three coefficients were significant, showing a significant indirect effect. The model and the path relationships between variables are depicted in Figure 2.

The Bootstrap method was used to test the mediating effects of SRH and LS, and the results (Table 5) show that the independent mediating effect of SRH (95% CI: -0.080 to -0.010) exerted a negative hindrance, accounting for 34.10% of the total effect. The independent mediating effect of LS (95% CI: -0.080 to -0.200) was insignificant and, therefore, did not play a role. The chained mediation effect between SRH and LS (95% CI: -0.126 to -0.017) is higher than the individual effect, and there is a significant difference between the chained mediation effect and the individual mediation effect of SRH. The chained mediation effect of both also exerts a negative

TABLE 2 Overview of descriptive analysis results.

Research variables												
	LPA	SEM	SRH	LS	MPA	SEM	SRH	LS	VPA	SEM	SRH	LS
Population												
M	6.080	29.360	62.942	22.130	26.060	29.430	62.751	22.140	62.910	29.480	61.411	22.080
SD	4.811	4.814	19.318	6.235	6.815	4.696	19.076	6.193	16.079	4.740	19.254	6.241
Sex												
Male												
M	6.770	29.260	63.050	22.150	26.800	29.370	62.575	22.100	63.690	29.510	61.569	22.020
SD	5.022	4.983	19.220	6.300	6.972	4.634	18.440	6.149	16.669	4.695	19.278	6.221
Female												
M	5.720	29.410	62.885	22.120	24.880	29.510	62.751	22.210	59.890	29.350	60.801	22.310
SD	4.655	4.721	19.372	6.202	6.390	4.794	19.076	6.267	13.175	4.915	19.184	6.324
F	73.589	1.403	0.111	0.042	42.105	0.459	0.046	0.164	12.567	0.259	0.355	0.494
P	<0.001	<0.001	0.739	0.837	<0.001	<0.001	0.830	0.686	<0.001	0.611	0.551	0.482
η^2	0.011	0.015	<0.001	<0.001	0.019	0.015	<0.001	<0.001	0.009	<0.001	<0.001	<0.001
Nation												
Han nationality												
M	6.030	29.350	62.846	22.140	25.980	29.430	62.587	22.170	63.020	29.450	61.346	22.020
SD	4.825	4.842	19.357	6.274	6.792	4.679	18.618	6.215	15.962	4.655	19.151	6.260
Ethnic Minorities												
M	6.370	29.430	63.493	22.050	26.440	29.420	62.919	22.000	62.380	29.590	61.724	22.40
SD	4.717	4.649	19.093	6.008	6.923	4.783	19.031	6.093	16.662	5.140	19.789	6.157
F	4.237	0.232	0.958	0.174	1.409	0.000	0.097	0.225	0.305	0.149	0.074	0.719
P	0.040	0.630	0.328	0.667	0.235	0.982	0.755	0.635	0.581	0.700	0.786	0.397
η^2	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Grade												
First-year students												
M	6.300	29.350	62.876	22.160	25.675	29.340	62.978	22.070	62.410	29.510	61.509	22.150
SD	4.873	4.807	19.252	6.248	6.717	4.683	18.451	6.162	16.032	4.756	19.432	6.179
Sophomores												
M	5.670	29.350	62.930	22.070	25.680	29.630	61.816	22.350	63.300	29.730	61.469	22.330
SD	4.621	4.753	19.477	6.183	6.909	4.833	19.308	6.250	16.618	4.535	18.803	6.275
Juniors												
M	5.510	29.560	63.728	22.210	27.650	29.790	62.723	23.040	64.810	28.800	60.868	21.540
SD	5.060	5.220	18.614	6.611	7.203	4.508	19.615	6.146	15.308	5.283	20.419	6.555
Seniors												
M	5.509	29.580	63.993	22.020	29.660	29.340	60.366	19.930	64.960	28.790	60.612	20.530
SD	4.571	5.225	20.499	5.989	6.966	3.838	17.153	6.377	15.306	4.178	16.061	6.262
F	9.375	0.242	0.273	0.113	6.297	0.682	0.704	2.737	1.124	1.256	0.069	1.520
P	<0.001	<0.001	0.845	0.952	<0.001	0.043	0.550	0.042	0.338	<0.001	0.997	0.207
η^2	0.004	0.009	<0.001	<0.001	0.009	0.001	0.001	0.004	0.002	0.013	<0.001	0.003

hindering effect, accounting for 54.50% of the total effect. The direct mediating effect of total PA on SRH (95% CI: −0.001–0.000) has a confidence interval that does not include 0, accounting for 26.70% of the total effect; The total chained mediating effect (95% CI: −0.126 to −0.017) also has a confidence interval that does not include 0, accounting for 40.00% of the total effect. In conclusion, the direct mediating effect of total PA on SRH and the total chained mediating effect is significant.

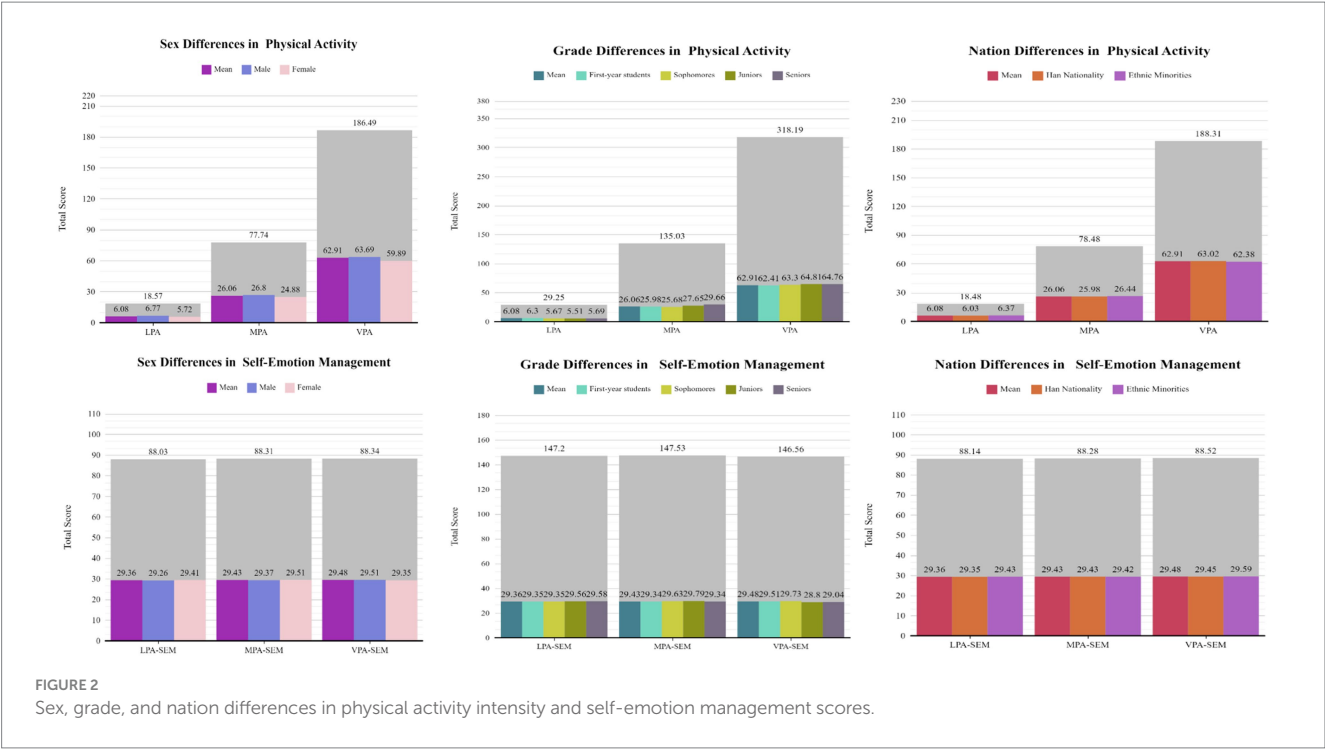


FIGURE 2 Sex, grade, and nation differences in physical activity intensity and self-emotion management scores.

TABLE 3 Correlation analysis.

PARS level		RARS total score	SEM	SRH	LS
LPA	RARS total score				
	SEM	0.023*			
	SRH	0.005*	0.309**		
	LS	0.030*	0.572**	0.365**	
MPA	RARS total score				
	SEM	0.006*			
	SRH	−0.019	0.314**		
	LS	0.014	0.553**	0.349**	
VPA	RARS total score				
	SEM	0.018*			
	SRH	−0.012	0.306**		
	LS	−0.016	0.579**	0.373**	

*The correlation is significant at the 0.05 level (two-tailed). **The correlation is significant at the 0.01 level (two-tailed).

4 Discussion

This study reveals the sequential mediating role of SRH and LS in the relationship between PA and SEM in university students, representing a positive exploration of how PA enhances SEM. From a theoretical perspective, while considerable research has been conducted on emotional management, relatively few studies have

integrated PA, SRH, and LS to examine their combined effects on SEM. Traditional research often focuses on the impact of only two factors on emotional management. This study’s innovation lies in treating these three as an interconnected and mutually influential system. Exploring their dynamic interaction mechanism from a comprehensive perspective, ultimately influencing SEM. The good physical fitness resulting from physical activity facilitates the improvement of SRH, promoting mental health (Bondarev et al., 2021). SRH includes psychological health assessment and is a known predictor of perceived emotional states (Stefansson et al., 2008; Rissanen et al., 2011). The level of SRH affects LS, which in turn affects emotion management (Putzke et al., 2002). The mechanisms through which these three factors influence emotional management are interconnected. Understanding their intrinsic relationships helps fill gaps in existing research and contributes to developing emotional management theories. Practically, promoting diverse campus activities can encourage students to exercise physically. Conducting psychological counselling courses can help establish a positive health concept. These efforts align with national policies that encourage university students to participate in sports to enhance mental health. Together, they contribute to the physical and mental wellbeing of university students.

4.1 Current status of university students’ physical activity

The study reveals that there are significant differences in PA of different intensities across the dimensions of sex, ethnicity, and grade level. In terms of sex, males scored higher than females in PA of various intensities (Figure 2), and this result is consistent with previous research findings (Shu et al., 2024). Based on the role expectation theory, both men and women strive for a sense of social belonging,

which gives rise to sex identity (Cardoso et al., 2022), and they are assigned different social expectations (David et al., 2019). Under the long-term influence of sports culture and values, males possess a particular advantage over females in physical fitness and sports ability. Consequently, they often demonstrate a strong interest in intense and physically demanding sports activities. In contrast, influenced by traditional concepts, females tend to prefer low-intensity, social, or flexibility-oriented activities.

From an ethnic perspective, LPA and MPA scores for ethnic minority students are higher than those of Han students. However, under VPA, Han students scored higher than ethnic minority students (Figure 2), which is consistent with previous research findings (Li et al., 2014). Western ethnic minorities are deeply influenced by their geographical environment and traditional culture, having unique traditional sports activities such as wrestling and horse racing. It strengthens physical fitness, provides entertainment, and offers emotional release, contributing to emotion management. With the acceleration of urbanization and the fast pace of life, traditional labor methods of ethnic minorities have been replaced by mechanization and automation, liberating labor but also reducing PA levels (Ye et al., 2019). Traditional sports have been affected by modern sports, and although they have exercise benefits, they have undoubtedly weakened the unique forms of traditional sports activities of ethnic minorities. Modernization has also impacted the cultural identity of ethnic minorities, affecting the participation of the younger generation in traditional activities.

The study found that students' PA participation levels increased with grade level under MPA and VPA, while under LPA, it showed a declining trend (Figure 2). The former is consistent with previous research results (Claire et al., 2024), while the latter shows a discrepancy. This result may be because as students' grade levels increase, academic and employment pressures intensify, leading to greater anxiety about the future and a neglect of the importance of LPA for health (Guo et al., 2023). Alternatively, some students may have developed sedentary habits during their college years (e.g., spending long hours in the dorm playing video games or watching TV shows), decreasing interest in PA and reducing participation.

4.2 Current status of university students' self-emotion management

The results indicate a sex difference in college students' SEM abilities. Female students have higher emotional management levels than male students (Figure 2), consistent with previous research findings (D'Amico and Geraci, 2022). Previous studies indicate that in certain societies, sex stereotypes align with specific role structures (Archer, 1996). In conflict situations, males often display aggressive behaviors, while females tend to be more compliant, reflecting distinct emotional tendencies based on sex (Atienza et al., 2003). Female university students transitioning from adolescence to adulthood,

TABLE 4 Regression analysis of the relationships among variables in the model.

Regression			Fitting indices			Coefficient		
Outcome variables	Predictive variables		<i>R</i>	<i>R</i> ²	<i>F</i>	<i>β</i>	<i>SE</i>	<i>t</i>
SEM	LPA		0.580	0.336	1221.102***			
						−0.115	0.089	−1.295
		SRH				0.030	0.030	13.807***
		LS				0.403	0.007	60.988***
		Sex				0.077	0.081	0.955
		Nation				0.621	0.106	0.587
		Grade				0.070	0.057	1.239
			0.576	0.329	138.951***			
	MPA					0.057	0.095	0.594
		SRH				0.030	0.002	13.784***
		LS				0.403	0.007	60.989***
		Sex				0.052	0.078	0.666
		Nation				0.066	0.106	0.620
		Grade				0.074	0.057	1.298
			0.587	0.342	118.748***			
	VPA					0.187	0.118	1.589
		SRH				0.030	0.002	13.822***
		LS				0.403	0.007	60.982***
		Sex				0.078	0.080	0.980
		Nation				0.063	0.106	0.597
		Grade				0.667	0.057	1.178

(Continued)

TABLE 4 (Continued)

Regression			Fitting indices			Coefficient		
Outcome variables	Predictive variables		<i>R</i>	<i>R</i> ²	<i>F</i>	β	<i>SE</i>	<i>t</i>
SRH	LPA		0.023	0.005	1.317			
						0.876	0.436	2.010*
		Sex				−0.076	0.400	−0.189
		Nation				0.542	0.522	1.038
		Grade				−0.062	0.279	−0.221
			0.011	0.000	0.308			
	MPA					−0.022	0.469	−0.046
		Sex				0.171	0.385	0.446
		Nation				0.504	0.522	0.966
		Grade				−0.082	0.158	−0.627
			0.028	0.001	1.984			
	VPA					−1.500	0.579	−2.589**
		Sex				−0.095	0.394	−0.242
		Nation				0.535	0.522	1.026
		Grade				−0.034	0.279	−0.121
			0.363	0.132	311.642***			
LS	LPA					−0.061	0.132	−0.462
		SRH				0.118	0.003	39.458***
		Sex				0.402	0.121	0.332
		Nation				−0.100	0.158	−0.639
		Grade				−0.076	0.084	−0.899
			0.363	0.131	311.600***			
	MPA					0.025	0.142	0.178
		SRH				0.118	0.003	39.456***
		Sex				0.026	0.116	0.224
		Nation				−0.099	0.084	−0.879
		Grade				−0.074	0.084	−0.879
			0.363	0.132	311.755***			
	VPA					0.148	0.175	0.841
		SRH				0.118	0.003	39.466***
		Sex				0.049	0.119	0.413
		Nation				−0.101	0.158	−0.642
		Grade				−0.080	0.085	−0.937

p* < 0.05, *p* < 0.01, ****p* < 0.001.

influenced by hormonal changes and neural development (Rong et al., 2024), tend to be more emotionally sensitive than their male counterparts and exhibit a stronger emotional management ability.

The results indicate little ethnic difference in emotional management ability among university students (Figure 2), with Han students scoring slightly higher than ethnic minorities. This may stem from cultural differences between ethnic groups (Li et al., 2023; Xu et al., 2025). Han students, exposed to educational concepts and values early on, align more closely with the school

education system (Deng et al., 2019). The Han culture emphasises traits like restraint and control in emotional management, whereas minority cultures may focus more on directly expressing emotions (Li et al., 2023).

The results indicate significant differences in emotional management skills among different grade levels of university students, displaying an inverted “V” trend (Figure 2), which contrasts with previous research findings (Saibani et al., 2013). Previous studies showed that emotion management ability increases overall with grade

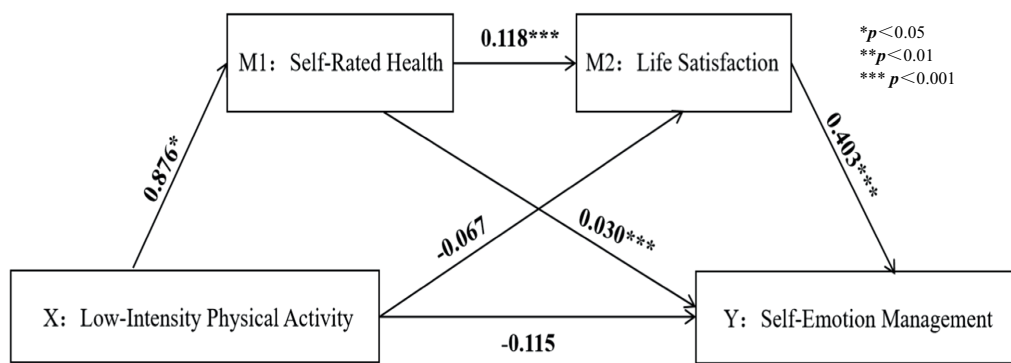


FIGURE 3
Low-intensity physical activity path analysis diagram.

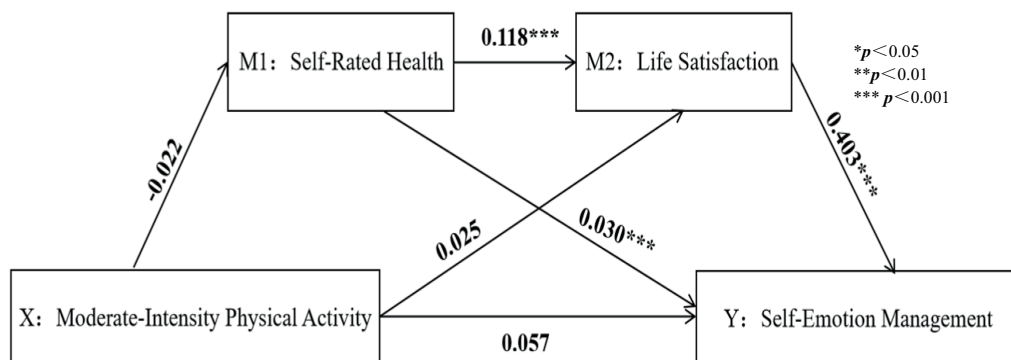


FIGURE 4
Moderate-intensity physical activity path analysis diagram.

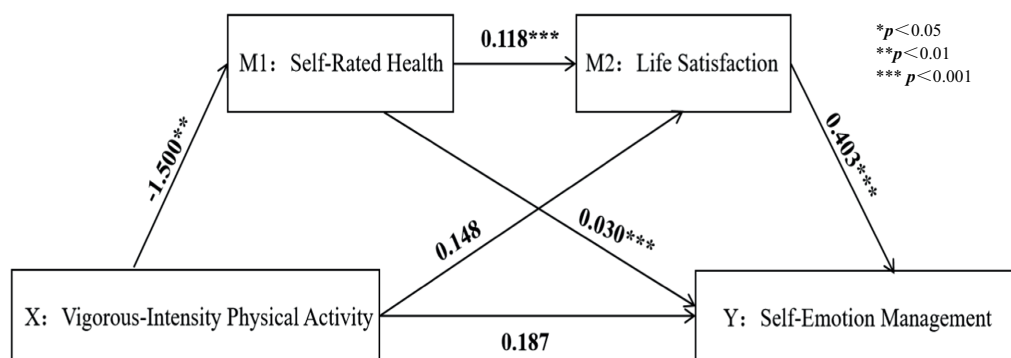


FIGURE 5
Vigorous-intensity physical activity path analysis diagram.

(Ikpe et al., 2021). The data from this study suggest that this may be because when students first enter college, they are young and lack mature cognitive abilities under the influence of family functions (Peng et al., 2024). They have less independent space and awareness, and their emotion management abilities are weaker. During the middle period, rationality increases with social relationships (Liu et al., 2024). Experience and cognitive levels also improve. These

factors lead to varying levels of exercise motivation, active participation in physical activity, and the development of positive peer relationships (Pandya, 2024). Individuals' emotions are expressed and relieved, and self-emotion management is improved. In the later stages of college, with the widespread adoption of the internet and social media in the information age, external information spreads rapidly and is complex (Jelleli et al., 2024). University students are affected by

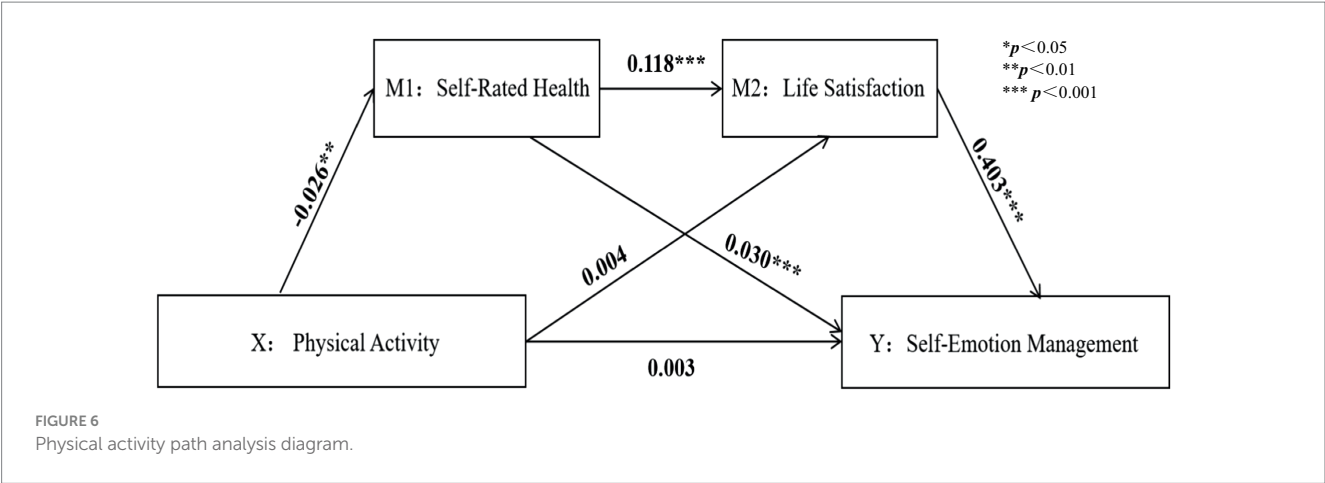


TABLE 5 Analysis of the mediating effects.

PARS Level	Effect	BootSE	95% CI		Proportion of effect
			LLCI	ULCI	
LPA					
Total effect	−0.072	0.109	−0.285	0.141	
Direct effect	−0.115	0.089	−0.288	0.059	
Indirect effect	0.043	0.063	−0.079	0.168	
LPA → SRH → SEM	0.026	0.013	0.002	0.052	36.10%
LPA → LS → SEM	−0.025	0.054	−0.128	0.081	34.20%
LPA → SRH → LS → SEM	0.042	0.020	0.003	0.082	57.80%
MPA					
Total effect	0.065	0.117	−0.164	0.294	
Direct effect	0.057	0.095	−0.130	0.243	
Indirect effect	0.009	0.068	−0.128	0.140	
MPA → SRH → SEM	−0.001	0.014	−0.028	0.026	0.90%
MPA → LS → SEM	0.010	0.056	−0.101	0.118	15.70%
MPA → SRH → LS → SEM	−0.001	0.022	−0.046	0.041	1.60%
VPA					
Total effect	0.131	0.144	−0.152	0.414	
Direct effect	0.187	0.118	−0.044	0.418	
Indirect effect	−0.056	0.083	−0.219	0.109	
VPA → SRH → SEM	−0.045	0.018	−0.080	−0.010	34.10%
VPA → LS → SEM	0.060	0.070	−0.080	0.200	45.50%
VPA → SRH → LS → SEM	−0.071	0.027	−0.126	−0.017	54.50%
PA					
Total effect	0.003	0.002	0.002	0.008	
Direct effect	0.003	0.002	−0.001	0.007	
Indirect effect	−0.001	0.001	−0.003	0.002	
PA → SRH → SEM	−0.001	0.001	−0.002	−0.001	26.70%
PA → LS → SEM	0.002	0.001	−0.001	0.004	56.70%
PA → SRH → LS → SEM	0.001	0.001	0.001	0.002	40.00%

academic achievement pressure, and they may neglect their emotions, affecting SEM (Hu et al., 2024).

4.3 The influence mechanism of physical activity on university students' self-emotion management

The study results show that different intensities of PA do not directly and positively predict SEM, but they can indirectly predict SEM through the roles of SRH and LS. The correlation between the four supports hypothesis H1 of this study, consistent with previous research results (Huang et al., 2023). Similar studies globally have also found that the relationship between PA and emotional health is complex rather than a simple direct effect. Some studies have validated the mediating role of health-related factors across different age groups and socio-cultural contexts (Morteza et al., 2023; Arimon et al., 2024; Díaz et al., 2024; Küng et al., 2025). In some Asian countries, studies on workplace environments have validated the positive role of participating in PA in alleviating work stress and improving mood (Bischoff et al., 2019; Taylor et al., 2020; Yook, 2020). This further confirms that the findings of this study have a certain universal foundation on a global scale.

This study demonstrates that LPA and VPA significantly impact emotional regulation, consistent with previous research findings (Wang and Hollett, 2022). Engaging in PA can stimulate the release of neurotransmitters such as endorphins and serotonin within the body, which regulate hormone levels and enhance brain function (Riegel et al., 2023), providing immediate benefits (Kim et al., 2020) and positively influencing emotional regulation. A cross-sectional study has pointed out that the nature of exercise may influence PA's impact on emotions. Aerobic exercise and yoga have shown effectiveness, and moderate to high-intensity exercise has particularly significant improvement effects (Lin and Gao, 2023), consistent with the theory of cognitive benefits (Nakagawa et al., 2020).

In addition, the study found that there may be situations where the influence of certain intensities of PA on emotions is not significant. We need to consider that sex is an important factor affecting the performance of emotional management with PA participation, which is consistent with the results of numerous previous studies (Campos-Uscanga et al., 2022; He and Qiu, 2022). On the one hand, regarding body composition, there are differences in the proportion of fat mass and muscle mass between males and females (Rodríguez-Carmona et al., 2022), which may affect athletic performance. Due to hormonal changes during their special physiological periods, females tend to have greater emotional fluctuations than males, which may influence the emotional benefits of PA at different intensities (Glavin et al., 2021). On the other hand, sex differences are also reflected in exercise motivation and expression patterns (Chu and Koppenhaver, 2025). Males participate in PA more frequently (Gonçalves and Martínez, 2018) and tend to use PA to transfer negative emotions. At the same time, females attach more importance to their appearance (Jones et al., 2021) and are more inclined to use PA for introspection or social interaction to relieve emotions (Meynadier et al., 2025). Research has shown that when females combine mindfulness training with PA, the effect of emotional management is more significant (Amin et al., 2025). When the goals of PA are inconsistent with emotional needs, it may exacerbate the emotional burden and affect emotional

management. Notably, grade level may also be an important influencing factor (Rauff and Kumazawa, 2024). Academic pressure and time allocation changes reflect the characteristic patterns of different grade levels (Semenova and Mahlovanyi, 2017; Wang et al., 2020). The results of a study reveal an inverted "U" shape relationship between students' PA on weekends and their academic performance. Additionally, it shows a sex difference in the optimal exercise duration, with males at 2 h and females at 1 h (Liu G. Q. et al., 2023). The finding of the inverted "U" shape is consistent with another study that investigated the relationship between the total weekly PA duration and mental health (Shimura et al., 2023). The influence of PA on college students' self-emotion management may be affected by various factors, which in turn impact students' physical and mental health development.

4.4 The chained mediation effect of self-rated health and life satisfaction

This study demonstrates that SRH mediates the relationship between varying intensities of PA and SEM. In contrast, LS does not mediate the relationship between PA intensities and SEM. This study's hypothesis H3 is partially set up. This is partially different from previous research results (Daniela et al., 2022). Good SRH implies a positive belief in one's health status, which helps improve emotional states. SRH may have a negative predictive effect on SEM in certain cases. This phenomenon may arise from differences in cultural values and the lack of social support. In some elite sports social environments, there is a highly competitive value system driven by achievement. Even when an individual's SRH is at a good level, failure to meet societal standards of "success" in career, academics, or social status may cause a significant psychological gap (Ingrid and Jeylan, 2015). This psychological gap can trigger negative emotions such as anxiety and depression, which may interfere with the normal functioning of self-emotion management. In social environments with weaker support networks, individuals may excessively worry about or misinterpret their health status due to a lack of necessary emotional support and feedback (Handique and Jang, 2025). There may even be a tendency to fully attribute health to individual responsibility, thereby negatively affecting SEM (Yao et al., 2025).

LS is a subjective evaluation of life quality based on personal standards, and the emotional improvement brought about by PA for university students is mostly short-term and immediate, while LS is a periodic and long-term stable state (Fernandes et al., 2024). Immediate emotional improvement may neglect the resolution of fundamental issues, such as academic pressure and tense interpersonal relationships. If these fundamental issues are not resolved and reoccur, they may offset the short-term emotional improvement brought about by exercise (Marlies et al., 2015). With social support, university students' emotions are supported, and long-term goals that align with their values and interests are set (Lee et al., 2024). They gain self-esteem and a sense of achievement through the process. This leads to stable and sustainable emotional improvement. It fosters deep happiness and satisfaction. Furthermore, comprehensive measures are taken to ensure long-term life satisfaction.

The results of this study show that MPA negatively predicts SRH, which seems counterintuitive. In people's conventional thinking, MPA is often reflected in physical manifestations (e.g., excessive

sweating, dehydration, muscle soreness), with short-term visible results. At this point, people tend to believe they have exercised adequately, leading to errors in their health self-assessment. However, in reality, several side effects of MPA are one of the key factors leading to negative health evaluations. MPA requires a high level of physical fitness. Individuals with lower fitness levels may experience adverse physical reactions. In some cases, they may impair cardiovascular function and increase the risk of exercise-related injuries, which can negatively impact overall health. People engage in PA for various motivations, influenced by psychological capital, desiring quick results. Excessive enthusiasm for exercise can also have the opposite effect, leading to exercise addiction, which harms both physical and mental health, thus making MPA negatively predict SRH.

This study demonstrates that SRH and LS serve as chained mediators between LPA, VPA, PA, and SEM. This supports the hypotheses H4 and H5 of this study. This indicates that when college students can control their exercise intensity themselves, they have a clear understanding of their health status and possess the ability to effectively manage and adjust their emotions. Previous studies suggest that as the frequency and intensity of exercise increase, there may be errors in perceiving exercise intensity (Wang et al., 2022b), and individual differences and exercise habits might affect health assessments, blurring the boundaries of emotional states and thereby diverting attention from negative emotions to improve self-emotion management.

The results of this study show that the mediating chain of MPA does not hold and that MPA has a negative prediction for SRH, which seems counterintuitive. In people's conventional thinking, MPA is often reflected in physical manifestations (e.g., excessive sweating, dehydration, muscle soreness), with short-term visible results. At this point, people tend to believe they have exercised adequately, leading to errors in their health self-assessment. However, in reality, several side effects of MPA are one of the key factors leading to negative health evaluations. MPA requires a high level of physical fitness. Individuals with lower fitness levels may experience adverse physical reactions. In some cases, they may impair cardiovascular function and increase the risk of exercise-related injuries, negatively impacting overall health (Buckley et al., 2019). People engage in PA for various motivations (Kercher et al., 2024), are influenced by psychological capital, and desire quick results. Excessive enthusiasm for exercise can also have the opposite effect, leading to exercise addiction (Sarah et al., 2023), which harms both physical and mental health. According to the World Health Organization guidelines, engaging in 150 min of moderate-intensity exercise or 75 min of vigorous-intensity exercise per week can effectively improve cardiorespiratory endurance, modify body composition, relieve stress and anxiety, and enhance the sense of wellbeing (Gabriel et al., 2022).

Due to evolving health concepts, university students may subjectively perceive their health as declining, yet objective improvements are evident. LS, as an aspect of long-term health outcomes, is closely linked to PA (Dong et al., 2024). The vast and sparsely populated region of Western China provides an ideal environment for PA. Due to the high altitudes in certain areas, moderate PA helps improve the body's adaptation to low-oxygen environments and enhances cardiovascular and pulmonary

function (Seok et al., 2018). People can stroll on the grassland and live in harmony with nature, or participate in some traditional projects unique to Western cultures, such as the "Tuyi Party," a dance party of the Uyghur ethnic group. This is not only a manifestation of the diversity of forms of PA, but also an interpretation of health in the cultural concepts of some ethnic minorities. Moreover, it is conducive to physical and mental relaxation, stress relief, and the accumulation of positive emotional experiences.

According to the Self-Determination Theory, if college students participate in exercise based on their internal interests and pleasures or to achieve their established goals, they can fully stimulate their internal and external motivations. Most forms of PA are challenging. College students can meet these challenges with strong psychological resilience. After successfully overcoming difficulties, their achievement motivation (Krapp, 2005) can be significantly stimulated. This sense of achievement derived from successful challenges is a powerful driving force to encourage them to continue exercising. During the exercise, college students actively engage in social interactions (Liu and Shi, 2023) and accomplish their goals through teamwork, genuinely experiencing a strong sense of achievement and pride (Chen et al., 2022). This strengthens their social connections, endows them with a profound sense of social belonging, effectively reduces their feelings of loneliness, and significantly enhances their self-efficacy. The enhancement of self-efficacy makes college students full of confidence in their abilities and more inclined to make positive evaluations of their health conditions. Consequently, their sense of happiness in life increases remarkably. When college students have a good physical and mental experience, they will be more proficient in emotion management and improve their self-emotion management ability (Cui and Yang, 2024).

4.5 Limitations

The limitations of this study are: (1) SRH and LS are subjective cognitive assessments and are not combined with objective assessments. (2) The study uses subjective recall questionnaires for analysis and does not use precise instrument measurements, which may lead to data errors. (3) This cross-sectional study makes it difficult to infer causal relationships between variables.

The findings provide valuable insights for understanding educational and health promotion strategies in the 21st century. However, future studies need further longitudinal and empirical research to address the existing causal relationship issues.

4.6 Practical implications

The study highlights the potential importance of enhancing SEM skills among university students in fast-paced times and explores strategies that may promote mental health through self-rated health and life satisfaction. It is recommended that universities integrate physical activity interventions into their curricula, establish periodic activity check-in tasks, and create incentive mechanisms. Understanding students' exercise needs, and respecting sex and ethnic differences. Encourage the offering

of traditional sports courses with regional characteristics of the West, such as the introduction of Uyghur traditional dance courses in universities in Xinjiang. The abundant natural resources in the West can also be utilized to offer outdoor adventure courses, such as organizing mountain hiking, rock climbing, and other activities in universities in Shanxi, Gansu, and other regions. Universities can collaborate with local outdoor sports clubs and hire professional coaches to ensure the safety and professionalism of the activities.

Universities can collaborate with communities to regularly organize various sports activities (such as community basketball games, and sports meets), set up health awareness boards, and encourage family physical activity interactions to increase students' PA levels and raise health awareness. Creating a positive social atmosphere for students enhances their sense of belonging, thereby improving LS. Through collaboration between universities, families, and communities, the aim is to increase PA levels while enhancing LS and SRH, promoting the coordinated development of students' physical and mental health.

5 Conclusion

LPA or VPA cannot directly influence university students' SEM ability. Based on self-determination theory, SRH can independently influence university students' SEM ability. It can also indirectly influence SEM by incorporating the chained mediation effect of SRH and LS.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of Nantong University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

X-yZ: Methodology, Writing – original draft, Writing – review & editing. Y-SZ: Data curation, Methodology, Writing – review & editing. S-sH: Data curation, Methodology, Writing – review & editing. GK: Data curation, Investigation, Supervision, Writing – review & editing. HuL: Data curation, Investigation, Supervision, Writing – review & editing. F-zM: Data curation,

Investigation, Supervision, Writing – review & editing. W-dZ: Data curation, Investigation, Supervision, Writing – review & editing. Y-pY: Data curation, Investigation, Supervision, Writing – review & editing. Y-xL: Data curation, Investigation, Supervision, Writing – review & editing. S-qM: Data curation, Investigation, Supervision, Writing – review & editing. SF: Data curation, Investigation, Supervision, Writing – review & editing. HaL: Data curation, Investigation, Supervision, Writing – review & editing. Z-IC: Data curation, Investigation, Supervision, Writing – review & editing. YZ: Data curation, Investigation, Supervision, Writing – review & editing. QZ: Data curation, Investigation, Supervision, Writing – review & editing. G-xW: Data curation, Investigation, Supervision, Writing – review & editing. L-lZ: Investigation, Supervision, Writing – review & editing, Data curation. B-wZ: Data curation, Investigation, Supervision, Writing – review & editing. YW: Data curation, Investigation, Supervision, Writing – review & editing. BL: Data curation, Writing – review & editing, Funding acquisition.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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Hope as a predictor of physical activity behavior in middle-aged and older adults with musculoskeletal pain

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Background: Musculoskeletal pain is a barrier to physical activity, enhancing functional decline in older adults. Thus, identifying psychological factors that promote physical activity in older adults with musculoskeletal pain is warranted. Prior research shows that the psychological construct of hope predicts the frequency of exercise in healthy younger adults. However, the impact of hope on physical activity behavior in an older population with clinical pain is unknown. This observational study was designed to determine whether hope predicted self-reported and objective physical activity levels in older adults with musculoskeletal pain.

Methods: Fifty-two middle-aged to older adults (age range 55–85 years; 67% female) completed all assessments. Participants completed questionnaires to assess hope (Adult Hope Scale), self-reported physical activity (Physical Activity Scale for the Elderly), bodily pain (SF-36), kinesiophobia (Tampa Scale of Kinesiophobia), and pain catastrophizing (Pain Catastrophizing Scale). Participants also wore accelerometers on the hip for one week to objectively measure physical activity levels. Correlations were conducted to determine relationships between variables. Hierarchical regressions were conducted to determine whether hope predicted self-reported and objective physical activity levels after controlling for relevant demographics, pain, and other psychological variables.

Results: After controlling for bodily pain, hope significantly predicted self-reported physical activity and was associated with greater physical activity levels. Bodily pain, but not hope, significantly predicted average daily steps derived from the accelerometer. Decreased bodily pain was associated with more daily steps.

Conclusion: These findings suggest that trait hope could be a key psychological predictor of self-reported physical activity in older adults with musculoskeletal pain. Clarifying the role of hope in the physical activity behavior of older adults could present a novel target for intervention.

KEYWORDS

trait hope, pathways, physical activity, musculoskeletal pain, older adults

1 Introduction

Chronic musculoskeletal pain in older adults is a major public health concern and a leading cause of disability, affecting 1.71 billion individuals globally and accounting for 300 billion dollars in healthcare costs annually (Welsh et al., 2020). Musculoskeletal pain is the most common type of pain in older adults and has biological, psychological, and social implications, posing a threat to healthy aging (Blyth and Noguchi, 2017). Research suggests that physical activity (PA) is critical in the management of musculoskeletal conditions. Yet, pain and pain-related fear are frequent barriers to PA engagement for this population, contributing to worsening health outcomes. Thus, identifying biopsychosocial factors that promote PA in older adults with musculoskeletal pain is warranted.

Accumulating evidence suggests the psychological construct of hope impacts behavior in a variety of contexts (Anderson and Feldman, 2020; Curry et al., 1997; Snyder et al., 1991). Snyder (Yarcheski et al., 2004) defines hope as an individual's ability to strategize pathways and cultivate agency to think in alignment with goals. Pathways represent the mental process of planning different ways to achieve goal attainment. Agency is conceptualized as an individual's belief in their ability to act according to the pathways, which contributes to their level of motivation to think in goal-directed terms (Yarcheski et al., 2004). Individuals who foster more hope tend to cultivate more positive emotions, allowing the cognitive capacity to overcome obstacles toward goals (Anderson and Feldman, 2020). Individuals with low dispositional hope have a decreased capacity for developing pathways and cultivating agency, which influences subsequent emotions and decreases their motivation to participate in goal-directed behavior (Anderson and Feldman, 2020).

Research suggests that hope could be a predictor of positive health behavior, contributing to lower self-reported pain intensity and interference in patients with chronic pain (Yarcheski et al., 2004; Shanahan et al., 2021). Another study examining the influence of hopeful versus fear-based messaging during COVID-19 revealed that individuals who received hopeful messages were more likely to adopt preventative behaviors, such as vaccination, to maintain optimal health amidst the health crisis (Lin et al., 2024). Anderson and Feldman (2020) examined the role of general and goal-specific hope, self-efficacy, and optimism on exercise behavior in a nonclinical younger adult sample. The results revealed that goal-specific hope, particularly agency, was independently associated with greater exercise frequency, even after controlling for other psychological variables (Anderson and Feldman, 2020). Similarly, Goubert et al. (2004) revealed that higher trait hope (i.e., hope measured without reference to a particular goal), particularly agency, longitudinally predicted perceived exercise goal attainment and greater vigorous PA in college students. It is important to note that PA is used to describe any form of bodily movement that results in energy expenditure, while exercise is a structured form of PA designed to improve or maintain physical fitness. The role of hope facilitating PA amongst populations that are likely to face greater barriers to PA, such as those with clinical pain, has not been explored. Based on Hope theory and the aforementioned research, it is hypothesized that pathways, rather than agency, will predict PA behavior in older adults with musculoskeletal pain.

The purpose of this observational study was to determine whether hope predicted self-reported and objective PA behavior in middle-aged to older adults with musculoskeletal pain. We assessed hope, clinical pain, kinesophobia, pain catastrophizing, and both subjective (self-report) and objective (accelerometry) PA levels in middle-aged and

older adults with musculoskeletal pain. We hypothesized that hope, particularly agency, would predict PA levels, even after controlling for relevant demographics, pain, and other psychological variables. Elucidating the function of hope in physical behavior among this population could present a new target for intervention.

2 Methods

2.1 Participants

The participants included 52 adults (17 males and 35 females). Participants were included if: they were between the ages of 55 and 85, community-dwelling men and women, had access to a smartphone, and answered yes to the following question: Have you experienced any musculoskeletal pain (pain affecting joints, bones, ligaments, tendons or muscles) in the past month? Individuals were excluded if: they had a history of cardiovascular issues such as uncontrolled blood pressure over 150/95 mmHg, heart failure, history of acute myocardial infarction, history of any systemic disease or physical condition (e.g., severe osteoarthritis, injury) that restricted normal daily activity, history of neurological disease (e.g., Parkinson's Disease, multiple sclerosis, epilepsy), serious psychiatric illness (schizophrenia, bipolar disorder) or hospitalization within the preceding year for psychiatric illness, or a history of peripheral neuropathy. Participants were recruited in the greater Indianapolis area through newspaper, email, social media, or posted advertisements.

2.2 Procedure

Participants were asked to complete one study session that included the informed consent process, health history assessment, and completion of a series of questionnaires. As part of this process, participants were asked questions regarding the location and duration of pain. Prior to doing anything else related to the study, research staff explained the study and reviewed the informed consent verbally with each participant. Participants were given time to read through the informed consent and ask questions. All participants signed the Informed Consent Form. To determine eligibility, participants completed a health history questionnaire. Participants then completed a series of additional questionnaires, which are described below. Additionally, participants were given an accelerometer and instructions on how to wear it. They were instructed to wear it for 7 consecutive days following the study session. Participants were also given an accelerometer diary in which they recorded the start and finish times of wearing the accelerometer each day, as well as when they took the accelerometer off. This study was approved by the Indiana University Institutional Review Board and all participants provided written informed consent prior to participating in the study.

2.3 Outcome measures

2.3.1 Objective physical activity with accelerometry

During the study session, participants were given an ActiGraph wGT3X-BT tri-axial accelerometer (ActiGraph™, Pensacola, Florida)

to measure regular PA levels. Participants were instructed to wear the accelerometer on their right hip for seven consecutive days following the initial study session. The Actigraph wGT3X-BT is a small lightweight tri-axial accelerometer that is designed to detect tri-axial accelerations in the range of 0.05–2 G. Wear time validation was performed with the Choi parameters using the ActiLife 6 software, which classifies accelerometer wear and non-wear time (Choi et al., 2011). A valid accelerometer collection day was defined as wearing the accelerometer for ≥ 10 h/day. Data download, reduction, cleaning, and analysis were conducted using the ActiLife 6 software. The Sasaki et al. cut points using the vector magnitude were used to classify PA as moderate to vigorous ($\geq 2,690$ step count/min) (Sasaki et al., 2011). For each valid day (≥ 10 h of wear time), the time spent in moderate-vigorous PA (MVPA) and steps per day were calculated for each participant (Migueles et al., 2017). Participants were also provided with an accelerometer diary in which they were asked to record the start and finish times for each day, as well as the duration and reason for any period the accelerometer was removed.

2.3.2 Physical activity scale for the elderly (PASE)

The PASE has a total of 18 items using a 4-point scale and yes/no questions (Washburn et al., 1993). The items capture seven dimensions of PA, encompassing work-related, household, and leisure activity. People with higher scores are more physically active. The PASE shows good validity as a measure of PA in older adults (Washburn et al., 1999).

2.3.3 Adult hope scale (AHS)

AHS is a measure of trait hope in adults formed from agency and pathways thinking. The AHS includes 12 statements that are separated into two subscales, agency and pathways. The survey consists of four questions dedicated to agency (Hope-Agency), four questions dedicated to pathways (Hope-Pathways), and four filler items. Participants rated each item for statement accuracy on an 8-point scale (1 = definitely false; 8 = definitely true). An individual's Total Hope Score is calculated by adding the eight items that comprise the subscales. The AHS has shown good convergent and divergent validity and represents trait hope (Snyder et al., 1991).

2.3.4 Short-form health survey-36 (SF-36)

The SF-36 is a health survey that yields 8-scale scores (physical functioning, role limitations due to physical problems, bodily pain, vitality, general health perceptions, social functioning, role limitations due to emotional problems, and mental health). This tool was used to measure bodily pain in the current study. The survey responses are organized in a 3-to-5-point Likert Scale or binary response format, which is scored out of 100. Higher scores on the SF-36 indicate lower bodily pain and better functioning, while lower scores point to higher levels of pain and decreased functioning (Ware et al., 2000). The SF-36 has been found to be a reliable and valid tool for measuring general health in community-dwelling individuals (Brazier et al., 1992).

2.3.5 Pain catastrophizing scale (PCS)

The PCS asks the respondents to reflect upon past painful experiences and to rate the degree to which they experienced negative thoughts or feelings about pain. Catastrophizing is a multidimensional construct composed of rumination, helplessness, and magnification (Sullivan et al., 1995). The questionnaire consists of four items examining rumination, five items related to helplessness, and three

items associated with magnification rated on a 4-point scale (Ware et al., 2000). The PCS has been deemed a valid and reliable method for measuring pain catastrophizing in community-dwelling individuals with pain (Osman et al., 1997).

2.3.6 Tampa scale of kinesiophobia-11 (TSK-11)

The TSK consists of 11 items and is rated on a 4-point scale. The TSK is used to measure the fear of movement with pain or re-injury (Kori et al., 1990). The TSK has been deemed a valid and reliable method for assessing fear of movement in both clinical and nonclinical populations (Goubert et al., 2004; Vlaeyen et al., 1995).

2.3.7 Pain body map

Participants completed a validated pain body map (Scherrer et al., 2021). Males were given a male body map, while females were given a female body map. The maps presented two side-by-side posterior and anterior illustrations of the body with a line separating the right and left sides. The entire body map comprised of 74 body regions. Participants were told to shade in the regions on the map in which they had experienced pain in the last 7 days. The sum of all the shaded regions on the map equals the total number of body regions experiencing pain.

2.4 Statistical analysis

A power analysis using G Power 3.1.9.7 indicated that 52 participants were needed for predicting the change in R^2 in a multiple linear regression model that included three covariates, with an estimated moderate effect size ($f^2 = 0.16$), a power of 0.80, and alpha set at $p = 0.05$.

Descriptive statistics were calculated for all outcome measures. Shapiro–Wilk's test of normality indicated that age, PCS, all Hope variables, and MVPA as well as steps derived from the accelerometer were not normally distributed; thus Mann–Whitney U tests were conducted to determine if these variables differed by sex. Independent t-tests were conducted to determine whether the normally distributed variables differed by sex.

Bivariate Spearman's Rho correlation analyses were conducted to determine the relationships of the PA variables with the Hope variables, age, bodily pain on the SF-36, TSK, and pain catastrophizing on the PCS. Hierarchical regressions were conducted to determine whether Hope predicted objective and subjective PA, after controlling for covariates (e.g., age, sex, bodily pain). For all regressions, age and sex were entered in step 1, SF-36 Bodily Pain subscale was entered in step 2, and the Hope variable was entered in step 3.

3 Results

3.1 Participant characteristics

Table 1 presents the descriptive statistics for participant demographics and all outcome measures separated by sex. Bodily pain on the SF-36 differed significantly between males and females. Males had higher scores (i.e., lower reported pain) on the SF-36 subscale compared to females. Back pain was reported by 75% of participants, with 44.2% of those experiencing it for more than 6 months. Neck pain was reported by 28% of participants, with 17.3% experiencing it for more than 6 months. Joint pain in the extremities (i.e., hands,

arms, legs, or feet) was reported by 75% of participants, with 53.9% reporting pain duration of more than 6 months. In summary of the Pain Body Map results representing pain experienced in the last seven days, participants reported on average 7 ± 5.15 body regions with pain. The most common sites included the knee (57.7%), the lower back (57.7%), foot (36.5%), shoulder (34.6%), and hip (25%). Eight participants reported taking prescription medications for pain.

3.2 Bivariate correlations

Table 2 presents the correlations (r values) between the PA variables and other outcome measures. Figure 1 provides scatterplots showing the relationship between PASE scores and the Hope variables. PA scores on the PASE positively correlated with Hope-Pathways ($p = 0.017$), the Total Hope Score ($p = 0.022$), steps on the accelerometer ($p = 0.047$), and bodily pain scores on the SF-36 BP ($p = 0.004$). Thus, greater self-reported PA was significantly related to greater hope and steps per day and lower bodily pain. Average steps per day was significantly correlated with bodily pain on the SF-36, with greater steps associated with lower pain ($p = 0.004$). Of note, scores on the PASE were not significantly correlated with steps and MVPA derived from the accelerometer.

3.3 Hierarchical regressions

3.3.1 Self-reported physical activity

Three separate regression models were conducted with the 3 separate Hope variables (i.e., Pathways score, Agency Score, Total Hope score) entered as the last predictor in each separate model. All

three models were significant. After controlling for age, sex, and bodily pain, Hope-Pathways significantly predicted self-reported PA, accounting for 16.0% of the variance. Bodily pain was also a significant predictor, accounting for 14.3% of the variance. In the model with Hope-Agency as the final predictor, bodily pain but not Hope-Agency significantly predicted PA. In the model with the Total Hope Score as the final predictor, bodily pain approached significance and the Total Hope Score significantly predicted self-reported PA, accounting for 14.3 and 14.2% of the variance, respectively. A greater Total Hope Score and Hope-Pathways and lower bodily pain were associated with greater PA. See Table 3 for a summary of the significant hierarchical regression models for the PASE.

3.3.2 Objective physical activity

Hierarchical regressions were conducted to predict average steps and MVPA per day as measured by the accelerometers. None of the regression models predicting MVPA were significant ($p > 0.05$). The regression models predicting steps per day were also not significant. However, the model predicting steps was significant (see Table 4) when only including steps 1 (age and sex) and 2 (bodily pain) in the regression model, with greater bodily pain predicting less steps per day. Bodily pain accounted for 10.6% of the variance in steps per day.

4 Discussion

This study aimed to elucidate the relationship between trait hope and subjective and objective measures of PA in community-dwelling middle-aged and older adults with musculoskeletal pain. The data revealed several key findings. First, hope, particularly the pathways

TABLE 1 Descriptive statistics for primary study measures in male and female participants.

Variable	Women ($n = 35$)	Men ($n = 17$)	p -value
Age, year	63.6 ± 7.0	64.9 ± 6.2	0.434
% aged 65 years or older	45.7%	41.2%	
BMI, kg/m^2	28.9 ± 5.9	27.8 ± 4.2	0.822
Race, %			
African American	28.6%	11.8%	
Caucasian	68.6%	70.6%	
Hispanic	2.9%	5.9%	
Other	0.0%	11.8%	
% Taking prescription pain medications	20.0%	5.9%	
PASE score (0–793)	193.0 ± 83.1	225.4 ± 110.9	0.243
Steps per day	$6,479 \pm 2,241$	$7,730 \pm 3,979$	0.338
MVPA per day, minutes	35.6 ± 19.2	41.8 ± 32.5	0.946
SF-36 bodily pain score (0–100)	67.4 ± 14.1	78.1 ± 11.2	0.009*
Tampa scale of kinesiophobia (11–44)	18.5 ± 5.5	19.3 ± 4.8	0.619
Pain catastrophizing scale (0–52)	8.0 ± 11.0	6.5 ± 6.7	0.961
Total hope score (8–64)	56.1 ± 4.4	52.7 ± 9.4	0.338
Hope pathways score (4–32)	28.6 ± 2.5	25.8 ± 5.6	0.080
Hope agency score (4–32)	27.5 ± 2.9	26.9 ± 4.5	0.798

* = significant sex difference at the $p = 0.05$ level. Descriptives are presented as means and standard deviations or percentages. BMI = Body mass index; MVPA = moderate to vigorous physical activity; PASE = Physical Activity Scale for the Elderly.

TABLE 2 Bivariate correlation matrix between primary outcome measures.

	1	2	3	4	5	6	7	8	9	10
1. PASE	1.00									
2. MVPA	0.257	1.00								
3. Steps	0.280	0.785**	1.00							
4. Hope-Pathways	0.329*	0.075	0.108	1.00						
5. Hope-Agency	0.164	0.058	0.110	0.473**	1.00					
6. Total Hope	0.318*	0.059	0.109	0.868**	0.805**	1.00				
7. Bodily Pain (SF-36)	0.391**	0.238	0.393**	0.199	0.213	0.261	1.00			
8. TSK	−0.055	−0.072	−0.223	−0.153	−0.194	−0.235	−0.332*	1.00		
9. Pain Catastrophizing	−0.180	0.049	−0.039	−0.224	−0.150	−0.268	−0.440**	0.593**	1.00	
10. Age	−0.046	−0.154	−0.063	0.057	−0.038	−0.052	0.186	−0.056	0.016	1.00

* = $p < 0.05$; ** = $p < 0.001$. TSK = Tampa Scale of Kinesiophobia; PASE = Physical Activity Scale for the Elderly; MVPA = moderate to vigorous physical activity.

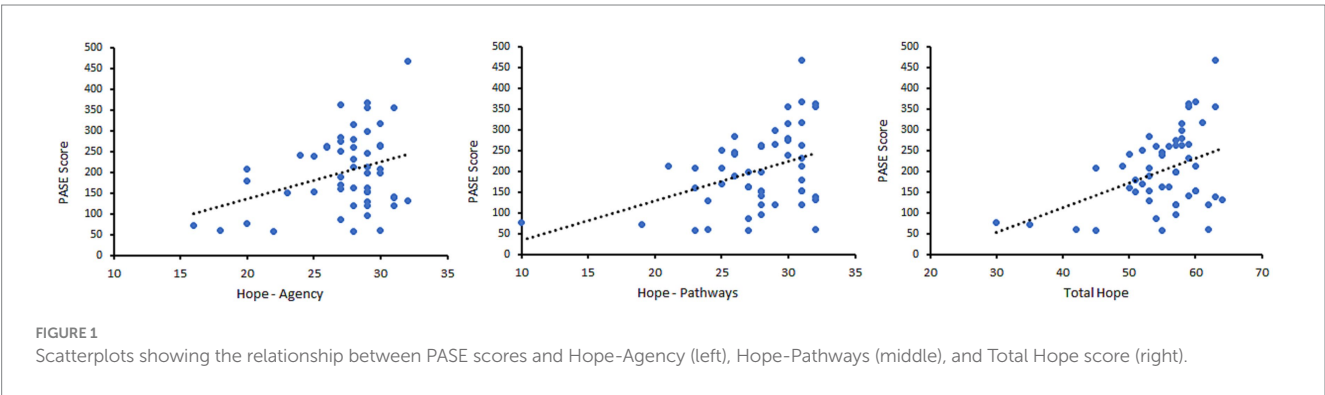


TABLE 3 Summary of significant hierarchical regression models for self-reported physical activity.

Step variables	ΔR^2	Standardized β	p value for β	Model p -value
(A) Physical activity scale for the elderly (PASE)				
1. Age	0.034	−0.162	0.187	<0.001
Sex		−0.230	0.108	
2. Bodily pain	0.143	0.277	0.046	
3. Hope-pathways	0.160	0.446	0.002	
(B) Physical activity scale for the elderly (PASE)				
1. Age	0.034	−0.128	0.329	0.011
Sex		−0.085	0.546	
2. Bodily pain	0.143	0.324	0.030	
3. Hope-agency	0.064	0.265	0.053	
(C) Physical activity scale for the elderly (PASE)				
1. Age	0.034	−0.142	0.254	0.001
Sex		−0.186	0.184	
2. Bodily pain	0.143	0.264	0.063	
3. Total hope	0.142	0.414	0.003	

subscale, predicted self-reported PA, above and beyond bodily pain. Second, bodily pain, but not any of the hope outcomes, predicted steps per day measured via the accelerometer. These findings suggest that trait hope could be a key psychological factor facilitating overall PA levels in adults with musculoskeletal pain.

4.1 Trait hope’s prediction of self-reported physical activity

These results partially supported our hypothesis that hope, particularly agency, would predict self-reported PA. Higher levels of

TABLE 4 Summary of significant hierarchical regression model for average steps per day.

Step variables	ΔR^2	Standardized β	p value for β	Model p -value
1. Age	0.049	−0.145	0.293	0.046
Sex		−0.085	0.561	
2. Bodily pain	0.106	0.355	0.019	

hope were associated with greater PASE scores even after controlling for bodily pain levels; however, this result was driven by the pathways versus agency subscale. This is in contrast to prior research showing that hope-agency predicts self-reported exercise frequency (Anderson and Feldman, 2020), perceived exercise goal attainment, and self-reported vigorous PA in younger adults (Blythe et al., 2025). The agency component is described as an individual's capacity to utilize the strategized pathways (Yarcheski et al., 2004), while pathways refer to the different ways individuals can take to achieve their goals (Yarcheski et al., 2004). Perhaps hope pathways play a more important role in PA behavior in populations facing barriers to PA, such as persistent pain.

4.2 Trait hope's prediction of objective physical activity

To our knowledge, this is the first study to objectively measure the impact of hope on PA. Contrary to our hypothesis, trait hope did not predict the accelerometer measures. However, bodily pain was a significant predictor of steps per day, suggesting older adults with more bodily pain accumulate less steps per day. This finding is in line with substantial evidence showing a negative relationship between PA behavior and musculoskeletal pain in older adults (Bruce et al., 2005; Hartvigsen and Christensen, 2007; Landmark et al., 2011).

4.3 Potential factors underlying the discrepant objective vs. subjective physical activity results

Several reasons could explain the contrasting self-report and objective PA results of the current study. First, previous research has shown a lack of concordance between objective and self-report measures of PA, with self-report measures often overestimating actual activity (Prince et al., 2008). For example, Hartvigsen and Christensen (2007) found a seven-minute increase in self-reported measures of MVPA compared to objective measurements (Liu et al., 2016). Second, these assessments are likely measuring different components of PA. Indeed, our correlation analyses indicated that the PASE scores were not significantly associated with steps and MVPA, even though the relationship trended in the expected direction. The accelerometers, which were worn on the hip, provide objective estimates of mostly ambulatory activity and may miss other activities such as swimming, lifting weights, and other activities primarily using the upper body (Ellis et al., 2014). On the other hand, the PASE attempts to capture all perceived activity, including dimensions covering work-related, household, and leisure activity that may encompass more than just ambulation (D'Amore et al., 2024). The PASE was designed to include activity thought to be more representative of typical activities performed

by older adults, such as household tasks and gardening that might heavily involve the upper body. Third, it is possible that individuals higher in hope perceive more positive outcomes (Pleeging et al., 2021), such as completing more PA than they actually do.

4.4 Integrating results into hope theory and clinical relevance

The findings of this study indicate that pathways and bodily pain significantly influence self-reported PA behavior among community-dwelling adults with musculoskeletal pain. According to hope theory, the achievement of goals is partly dependent on the 'routes' individuals take to progress toward those goals (Yarcheski et al., 2004). It is possible that individuals who are more adept at generating pathways possess better pain-coping mechanisms, enabling them to engage in PA more effectively than those with a lesser ability to strategize. Alternatively, Snyder (Yarcheski et al., 2004) posits that "reciprocal temporal thinking" may elucidate pathway development by prompting individuals to take present actions that promote optimal wellness in the future. In this perspective, those with a greater capacity to create pathways might perceive a more negative future outcome if they choose not to exercise, motivating them to participate in PA to reduce the likelihood of further loss of functionality. These individuals might already possess the agency to use positive coping and rely on the generation of pathways to achieve their goals related to PA. Furthermore, Landmark et al. (2011) found that individuals exhibiting more positive traits, such as hope, tend to experience lower levels of pain catastrophizing and demonstrate better adaptability to painful stimuli. This could lead to greater agency and reliance on the ability to create pathways for predicting PA behavior.

Prior research suggests that psychological therapies, such as cognitive-behavioral therapy (CBT), can be successfully utilized in a multidisciplinary approach to address psychosocial factors linked to musculoskeletal pain (Hassett and Williams, 2011). By reframing maladaptive thoughts and behaviors, these therapies assist individuals in fostering greater engagement in health-promoting behaviors (Ehde et al., 2014). Results from a qualitative study examining the effectiveness and behavioral changes following a mind-body intervention, which included CBT, indicated that increased mind-body awareness and the establishment of realistic goals led to positive beliefs about exercise in a sample of adults with musculoskeletal pain (Misje et al., 2024). Similarly, another study found that combining physical exercise with CBT showed greater benefits in modifying exercise-related thoughts and behaviors by improving coping mechanisms in a sample of adults with musculoskeletal pain (Cheng and Cheng, 2019). Hope has also been studied as a target for intervention in the adjustment and management of chronic pain. Results from a study examining the influence of hope on pain tolerance and pain thresholds using a cold pressor task found that women experienced increased hope, and all participants experienced an increase in pain tolerance post-intervention (Berg et al., 2008). Thus, targeting hope to improve health behaviors, such as PA, and pain management in older adults could be a promising approach, but additional research is needed.

4.5 Limitations

This study has several methodological limitations. First, the cross-sectional design limits directionality conclusions regarding the

relationship between PA and hope. Second, the inclusion criteria focused on general musculoskeletal pain instead of targeting a sample with specific musculoskeletal conditions. However, this approach strengthens the external validity of the study, as the sample likely represents the typical clinical pain experience for middle-aged to older adults. Indeed, research indicates that over half of older adults experience musculoskeletal pain in multiple body sites at once, with the knees, low back, and hips being the most common sites (Fejer and Ruhe, 2012). Participants in the current study reported experiencing pain in the past week on average at seven different body regions on the pain map, with the most common being the knee, low back, hip, and shoulder. Even with this variation in pain experiences within our sample, we still demonstrated a relationship between hope and self-reported physical activity. Given the reported location of pain in our sample, this study's results most likely generalize to those with back and extremity joint pain. Future research should explore the hope-PA relationship within specific pain conditions, such as low back pain, fibromyalgia, and knee osteoarthritis. Further, the participants represented both acute and chronic phases of pain. The stage of their pain may potentially influence their responses to the self-report measures. Third, this study does not account for or measure state hope in predicting PA behavior within this sample, which limits the analysis to the effects of trait hope alone. Importantly, Anderson and Feldman (2020) found that state hope versus trait hope was a stronger predictor of exercise outcomes. Fourth, the sample size was relatively small, had a gender imbalance (67% females), and we did not assess the cognitive status of participants. However, no participants enrolled in this study presented with obvious cognitive deficits based on researcher-participant interaction during the study session. Fifth, a person's experience of pain is multidimensional, with sensory, affective, and evaluative components. Our measure of pain (i.e., the Bodily Pain scale on the SF-36) did not evaluate these different components of pain. Whether certain dimensions of the pain experience pose a larger barrier to being physically active is unknown and could be an important avenue for future research. Finally, future research should also simultaneously assess other positive psychology constructs, such as self-efficacy and optimism, to deduce the most important psychological factors facilitating PA behavior in different populations. Self-efficacy is the belief that one can successfully engage in a behavior, while optimism refers to positive outcome expectations. Interestingly, two studies have found hope to be a stronger predictor of exercise or exercise goal attainment compared to optimism and self-efficacy (Anderson and Feldman, 2020; Blythe et al., 2025).

5 Conclusion

The extent of existing literature examining the role of hope in predicting PA is limited, and non-existent in pain populations. We provided the first evidence that trait hope influences self-reported PA levels above and beyond bodily pain in older adults with musculoskeletal pain. Older adults with low hope levels could be at a greater risk of sedentary behavior. Future research should consider studying this relationship using a longitudinal design, a more distinct sample, and adding measures of state hope. These methodological modifications will contribute to furthering our understanding of the role of hope in predicting PA behavior in older adults with musculoskeletal pain.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Indiana University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RK: Formal analysis, Writing – original draft. MT: Data curation, Methodology, Writing – review & editing. AK: Conceptualization, Supervision, Writing – review & editing. KN: Conceptualization, Formal analysis, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Motivation and self-efficacy in cycling and running athletes: a person-centered approach

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Introduction: The study aims to examine the motivation and self-efficacy of athletes who are practicing cycling and running using the person-centered approach.

Methods: A sample of 156 professional athletes (73 cyclists and 83 runners), including 65% of men, participated in the cross-sectional study. The mean age of athletes was 32 years old, ranging from 18 to 64 ($M = 31.68$, $SD = 11.26$). The online survey included the Sports Motivation Scale (SMS-28) and the Generalized Self-Efficacy Scale (GSES) to assess self-reported motivation for sports activity and the general sense of self-efficacy.

Results: The K-means cluster analysis identified three groups of athletes based on their scores in sports motivation and self-efficacy. The first sample included "Internally motivated athletes," who scored high in self-efficacy and three scales of intrinsic motivation (to know, to accomplish, and to experience stimulation) and simultaneously scored low in three scales of external motivation (introjected, identified, and external regulation), and amotivation. The second group comprised "Externally motivated athletes," scoring high in all dimensions of extrinsic motivation while low in intrinsic motivation scales and self-efficacy. The third group of "Highly motivated athletes" scored high on self-efficacy and all dimensions of sports motivation. The multivariate analysis of variance (MANOVA) and one-way ANOVA showed several differences in sports motivation and self-efficacy between particular clusters.

Discussion: Classifying athletes into three groups based on their motivation and self-efficacy can be utilized in sports psychology. In particular, those externally motivated athletes require psychological support to increase their intrinsic motivation and self-efficacy.

KEYWORDS

cluster analysis, cyclists, cycling athletes, runners, self-efficacy, sports motivation

1 Introduction

Achieving success in sports necessitates that athletes possess a range of skills, including concentration, stress management, and the ability to perform optimally under challenging and demanding environmental conditions. Psychological support is deemed essential, as it aids in identifying an athlete's capabilities and limitations, thereby enabling the minimization or maximization of their impact on sports competition. The enhancement of psychosocial skills is identified as the primary and most critical component for maintaining consistent performance at a high level of competition. This study endeavors to investigate the associations between self-efficacy and sports motivation among cycling and running athletes, employing a person-centered approach.

Both self-efficacy and motivation are critical variables in endurance sports, as these disciplines impose significant mental and physical demands on athletes, necessitating sustained effort over time. Motivation to engage in systematic actions may be a pivotal factor during the preparatory phase for competition, while self-efficacy can be instrumental during the competition itself and in shaping athletes' sports profiles. This study aims to identify specific patterns of psychological resources, such as self-efficacy and sports motivation, within a cohort of cyclists and runners. The interaction between self-efficacy beliefs and the configuration of sports motivation dimensions may be essential for determining both current performance and long-term career trajectories in sports.

According to social cognitive theory (Bandura, 1977), self-efficacy is defined as an individual's belief in their capacity to succeed in specific situations or accomplish tasks. This belief is pivotal in determining how individuals approach goals, tasks, and challenges. The enhancement of self-efficacy is influenced by past achievements, vicarious experiences, verbal persuasion, and alterations in the perception of physiological arousal. A meta-analysis has demonstrated a positive correlation between self-efficacy and sports achievements (Moritz et al., 2000). High self-efficacy is associated with a greater propensity to confront and persist through difficulties, thereby enhancing sports performance. In particular, self-efficacy has been shown to be a significant predictor of performance in endurance sports, such as cycling and running, where maintaining a consistent level of physical activity is crucial (Samendinger et al., 2019; Horcajo et al., 2022). In a study of cyclists, self-efficacy was found to increase over time, explaining a larger portion of the variance in performance as the sessions progressed (Samendinger et al., 2019). Similarly, in ultra-marathon runners, self-efficacy was highly related to mental toughness, although it did not directly correlate with performance outcomes in elite competitions (Brace et al., 2020).

Engagement in sports and physical activity is influenced by a variety of factors, including psychological motivations, body image, social interactions, and health benefits. Psychological need satisfaction and achieving a flow state, as well as enjoyment and mastery, plays a crucial role in sports participation and are important for maintaining long-term engagement in physical activities (Sierra-Díaz et al., 2019; Zhou et al., 2019). Participants in extreme sports are motivated by factors such as vertigo and catharsis, in addition to traditional motives like competition and ego (Zhou et al., 2019). Concerns about body image and the desire for fitness are common reasons for participation, especially among young people and university students (Allender et al., 2006; Diehl et al., 2018). Social factors, including affiliation and contact with others, are significant motivators. Engaging in sports provides opportunities for social interaction and building a support network, which is particularly valued by older adults (Allender et al., 2006; Diehl et al., 2018). Maintaining physical health, feeling good, and refreshing the mind are primary motivators for engaging in leisure-time physical activity and club sports among university students (Motevalli et al., 2024), wellbeing is a significant motivating factor across different age groups, particularly for older adults (De Maio Nascimento et al., 2023).

Research showed that competitive cyclists are primarily motivated by goal achievement, competition, and recognition, whereas non-competitive cyclists are more driven by weight concerns and social affiliation esteem (LaChausse, 2006). Road cyclists often prioritize goal achievement and competition, while mountain bikers find life meaning as a significant motivation (LaChausse, 2006). In mass cycling events, motivations such as interest/enjoyment, competence/challenge, and fitness are prevalent (Malchrowicz-Moško et al., 2019). Notable differences between male and female cyclists were also found (LaChausse, 2006; Malchrowicz-Moško et al., 2019). Runners in ultra-endurance events are often motivated by their attachment to the event, involvement in the sport, and satisfaction from previous events (Koronios et al., 2016). Runners exhibit various motivation profiles, such as "autonomy achievers" who have high levels of autonomous motivation and engage more frequently in running activities. These profiles are associated with distinct training patterns and can inform interventions aimed at increasing physical activity through running (Skejø et al., 2024).

Self-determination theory (SDT) posits that behavior is driven by intrinsic motivation (engaging in an activity for its inherent satisfaction and enjoyment), extrinsic motivation (engaging in an activity due to external rewards or pressures), or amotivation (Ryan and Deci, 2017; Standage and Ryan, 2020). The theoretical framework posits a continuum of motivation ranging from amotivation, characterized by a lack of motivation, to intrinsic motivation, encompassing various forms of extrinsic motivation, including external regulation, introjected regulation, and identified regulation. Identified regulation involves the acknowledgment of the value and benefits of an activity, even in the absence of inherent enjoyment. Individuals consciously accept the behavior and demonstrate a relative willingness to engage in the activity. For instance, an athlete may comprehend the significance of fitness or team spirit, recognizing how participation in sports contributes to these objectives. Introjected regulation is influenced by internal forces, such as guilt or fear, rendering it less self-determined. Individuals may engage in behavior out of a sense of obligation or to avoid negative emotions, such as shame. For example, an athlete may experience guilt or fear of disappointing parents, coaches, or teammates if performance is suboptimal. Further along the spectrum, external regulation represents the least self-determined form of motivation, where individuals act primarily to meet external expectations, obtain rewards such as trophies or monetary compensation, or receive recognition. At the extreme end of the continuum lies amotivation, where individuals lack the intention or drive to engage in a behavior. They may act without conscious effort or planning, feeling ineffective and lacking control. An athlete may lose interest and no longer feel motivated to continue with the training regimen (Teixeira et al., 2012; Rodrigues et al., 2023).

In contrast to the aforementioned perspective, Chemolli and Gagné (2014) assert that an alternative viewpoint can be adopted in research. They demonstrate that motivation varies in its nature rather than in the degree of autonomy. Consequently, an individual may engage in an activity by employing multiple motives simultaneously or may alternate between motives based on situational factors or previous experiences. They

highlight that any motive can be adopted by an individual at any time, irrespective of the continuum of relative autonomy. The questionnaire designed to assess these various types of motivation within sports contexts was developed in the 1990s (Briere et al., 1995; Pelletier et al., 1995) and has been utilized in numerous studies globally. Individuals frequently report high levels of intrinsic motivation, with enjoyment being the primary factor, or identified regulation, wherein they engage in exercise due to an acknowledgment of its significance. In terms of introjected motivation, gender differences are observed; males are more inclined to cite social pressure or the desire for ego enhancement as motivations for exercising, whereas females are more likely to mention guilt as a motivating factor. Introjected regulation, which is driven by ego enhancement or contingent self-worth, is heavily dependent on external environmental support. If not internalized, the environment may be perceived as controlling rather than supportive of autonomy, leading to cessation of engagement once external, contingent factors are removed (Gillison et al., 2009). The fulfillment of three fundamental needs—autonomy, competence, and relatedness—can also contribute to motivation for PA and sports (Almagro et al., 2020; Vasconcellos et al., 2020). According to SDT, individuals possess innate psychological needs, such as autonomy, competence, and relatedness, which, when fulfilled, promote optimal functioning, growth, and wellbeing. Consequently, individuals are autonomously motivated. Conversely, when these needs are unmet or only partially satisfied, individuals are more likely to regulate their behavior based on controlled reasons (Vasconcellos et al., 2020).

Vallerand and Losier (1999) observed that athletes exhibiting elevated levels of intrinsic, integrated, and identified motivation demonstrated superior outcomes, including enhanced affective experiences, improved sportsmanship orientations, and increased persistence in their sport, in comparison to those with controlled motivation (introjected, external). In the context of professional American football, players with high intrinsic motivation experienced an augmentation in self-identity and success, which subsequently influenced their performance. Furthermore, the significance of relatedness with fellow players and fans was emphasized as a factor that bolstered their internal motivation (Clancy et al., 2017; Harrolle and Klay, 2019) reported that intrinsic motivation among competitive athletes is lower than that of recreational athletes, as the presence of external rewards in competitive settings may undermine intrinsic motivation.

The relationship between self-efficacy and motivation has been the subject of extensive investigation in recent years. Social cognitive motivation models (SCMM) integrate the interplay of motivational and cognitive factors influencing academic or athletic performance (Schunk, 1991, 1995; Linnenbrink and Pintrich, 2002). Within the SCMM framework, motivation is conceptualized as a dynamic and multifaceted construct, encompassing critical elements such as self-efficacy, attributions, intrinsic motivation, and goals (Linnenbrink and Pintrich, 2002). Notably, self-efficacy can enhance motivational engagement in goal attainment, mastery, and improved performance (Linnenbrink and Pintrich, 2003; Dogan, 2015; Beri and Stanikzai, 2018). Research indicates that a strong sense of self-efficacy predicts more favorable subsequent

motivational outcomes (Schunk and DiBenedetto, 2020, 2021). Specifically, self-efficacy exhibits a robust positive correlation with intrinsic motivation, as individuals with high self-efficacy are more inclined to engage in tasks for their inherent interest and enjoyment (Gan et al., 2023).

Research showed that self-efficacy is associated with overall academic motivation among students (Husain, 2014; Maraghi et al., 2018; Ariff et al., 2021; Shengyao et al., 2024). In particular, studies suggest that higher self-efficacy is associated with lower amotivation and higher intrinsic motivation (Walker et al., 2006; Brown, 2010; Blecharz et al., 2015; Buch et al., 2015; Kheirkhah et al., 2017; Fominykh and Kornienko, 2020; De La Cruz et al., 2021; Gan et al., 2023; Morelli et al., 2023). The relationship between self-efficacy and extrinsic motivation is less clear-cut. Some studies found no significant correlation between self-efficacy and extrinsic motivation (Walker et al., 2006; Brown, 2010; Blecharz et al., 2015), while other research showed negative (Buch et al., 2015; Morelli et al., 2023) or even positive association (Kheirkhah et al., 2017; Fominykh and Kornienko, 2020; Gan et al., 2023). This suggests that the relationship may vary depending on the specific contextual circumstances or population studied. Therefore, an identification of specific patterns of the relationship between self-efficacy and motivation using a person-centered approach may explain the inconsistency in previous research.

Previous research predominantly employed variable-centered (nomothetic or group-based) methodologies, which operate under the assumption that the mean score of a given variable is representative of entire populations, thereby presuming human homogeneity (Saqr et al., 2024). This variable-centered approach utilizes population data to establish generalizable laws or norms applicable to the population. Conversely, the person-centered approach posits the existence of subpopulations with potentially varying parameters. While individuals within these subgroups may exhibit similar levels of specific variables, they display diversity in the interactions among variables, leading to the formation of distinct subgroups or individual profiles (Saqr et al., 2024).

Some previous research has focused on motivation within SDT theory, using the person-centered approach. Analyses of motivational cluster profiles included an examination of the relationship between motivation and physical self-perception in adolescent athletes (Çaglar and Aşçi, 2010; Sahin and Bastik, 2019), the relationship between motivational clusters and dispositional flow in young athletes (Murcia et al., 2007), motivational profiles and burnout in professional athletes (Gustafsson et al., 2018), motivational clusters and physical activity relationship (Friederichs et al., 2015), motivation and mental toughness in connection with goal orientations in elite tennis players (Gustafsson et al., 2018). Other research concerned motivational profiles and achievement goal orientation, the nature of athletic beliefs, perceived competence, and perceived motivational climate (Wang and Biddle, 2001; Chian and Wang, 2008). The number of motivational profiles found in athletes varied from three clusters (Murcia et al., 2007; Friederichs et al., 2015) through four clusters (Chian and Wang, 2008; Çaglar and Aşçi, 2010; Sahin and Bastik, 2019), up to five clusters (Wang and Biddle, 2001; Gustafsson et al., 2018). The inconsistency between these solutions suggests that more research is necessary to explain motivational profiles in

the PA context by using various variables, measurement methods, and diverse groups of athletes across various sports disciplines. To our knowledge, no previous studies have examined the relationship between motivation and self-efficacy in professional athletes using cluster analysis. This study addresses a gap in the literature by integrating the SDT motivation approach with the concept of self-efficacy, understood as a relatively stable trait, within a single investigation utilizing a person-centered approach in a sports setting context. Also, applying person-centered approach classifies athletes in groups based on dominant motivation character for each group and thus apply universal intervention for each group.

In vast majority of research papers, motivation is discussed from extrinsic, intrinsic, and amotivation perspective. This paper highlights the significance of intrinsic motivation in fostering commitment to sports, serving as a catalyst that not only promotes participation but also enhances the enjoyment of engaging in sports activities. Motivation and the degree of adopting it internally may indicate the behavior tendencies concerning physical activity (Duncan et al., 2010) or sport participation (Anthony and Rosario, 2023). Some researchers point out the diversity of motives for physical activity within the SDT theory and its progression along the continuum or its hierarchical model (Schüler et al., 2023). Numerous research adopt the perspective of motivation as a link between aspects such as: burnout and engagement in sport (Cresswell and Eklund, 2005; Graña et al., 2021; Groenewal et al., 2021), perfectionism (Stoeber, 2011), injury (Machado et al., 2025) or personality (Vlašić and Ivanišević, 2022) in order to find universal characteristic of motivational process not only in sport. It is worth noting that SDT theory offers also alternative perspective of motivation, which takes into account the satisfaction of three psychological needs: competence, autonomy, and relatedness. However, it is concluded that the three areas contribute to self-determined kind of motivation (De Francisco et al., 2020).

Consistent with the person-centered approach, we assume the heterogeneity of cyclists and runners, acknowledging that they may have different profiles or configurations of sports motives and self-efficacy beliefs. Understanding individual differences in self-efficacy and sports motivation can help sports psychologists and coaches develop training strategies and interventions focused on target groups in professional sports settings. We employed K-means cluster analysis to evaluate the diversity among athletes. This statistical method focuses on person-centered analysis, allowing for the identification of subgroups within a population by grouping individuals based on shared traits across various variables. K-means cluster analysis can reveal significant subgroups, each displaying a distinct arrangement or pattern of the variables being examined. This approach uses multivariate and quantitative data to categorize objects and events based on their similarities. Our current study investigates the variability in a particular configuration of self-efficacy and sports motivation within professional sports environments, specifically among cycling and running athletes. Taking into account previous studies described above (Wang and Biddle, 2001; Murcia et al., 2007; Chian and Wang, 2008; Çağlar and Aşçi, 2010; Friederichs et al., 2015; Gustafsson et al., 2018; Sahin and Bastik, 2019), we assume that there are three to five clusters that exhibit differences in motivational and self-efficacy patterns among athletes representing cycling and running.

2 Materials and methods

2.1 Study design and procedure

The cross-sectional online study was performed using Google Forms. The eligibility criteria included adults (18 years or older) training in cycling or jogging with a membership status to either a sports club or an association. The study was anonymous and voluntary, and the IRB approved the research project. The sample size was determined a priori using G*Power ver. 3.1.9.7 (Faul et al., 2007). For the Student's *t*-test, a minimum of 102 people was expected (51 in each sample of runners and cyclists), considering $p < 0.05$ (α), power 0.80 ($1 - \beta$), and medium effect size (Cohen's $d = 0.50$). The required sample size was 159 for one-way ANOVA if assumed three groups, $p < 0.05$ (α), power 0.80 ($1 - \beta$), and medium effect size ($f = 0.25$). A minimum sample size of 153 individuals was determined for the global effect of MANOVA, considering three groups, seven response variables, $p < 0.05$ (α), power 0.80 ($1 - \beta$), and medium effect size ($f^2 = 0.06$). Finally, the statistical power of minimum 0.80 for K-means clustering requires a total of 60 people (20 observations per each of the three subgroups), assuming an assured cluster separation of $\Delta = 4$ or greater and subgroups of approximately equal size to detect high accuracy in classifying the group membership of individual observations (Dalmaijer et al., 2022).

A link to an online survey was sent to the sports clubs. If sports clubs agreed to participate in the study, they disseminated the survey via e-mail (private mailing list) or by posting information about the study and the link to the survey on the sports club's Facebook profile. Some of the surveys were carried out through direct contact with running and cycling athletes during competitions. The study involved cyclists from cycling clubs associated with the Polish Cycling Association (Lower Silesian Cycling Association, Kuyavian-Pomeranian Cycling Association, District Cycling Association in Łódź, Lublin Regional Cycling Association, Małopolska Cycling Association, Lubusz Cycling Association, Masovian-Warsaw Cycling Association, Opole Cycling Association, Podkarpacki District Cycling Association, Podlasie Regional Cycling Association, Pomeranian Cycling Association, Warmian-Masurian Cycling Association, Wielkopolska Cycling Association, Silesian Cycling Association, Świętokrzyskie Cycling Association) and members of the Cyloopole, Cyklofun cycling associations as well as participants of cycling competitions. The runners who took part in the study were members of running clubs belonging to the Polish Running Association, members of the athletics section of the Academic Sports Association at the Opole University of Technology, the "Harcownik" running association, and participants of the 10 km street runs.

The data were collected between 3 July 2023 and 6 April 2024. Information about the study and the informed consent form were included on the first page of the survey; therefore, the study was completed if the individual agreed to participate. Initially, 163 people responded to the invitation, but one runner refused to take part in the study, and six people did not meet the criteria for the sports discipline. The final sample included 156 athletes. There were no missing data in the study because responding to

all survey questions was mandatory for the study to be completed. *Post-hoc* G*Power analysis showed that a sample of 156 participants (including 73 cyclists and 83 runners) indicated a power of 0.93 for Student's *t*-test, 0.80 for ANOVA, 0.81 for MANOVA, and 0.97 for K-means cluster analysis (Faul et al., 2007; Dalmajer et al., 2022).

2.2 Measures

2.2.1 Self-efficacy

The Generalized Self-Efficacy Scale (GSES) is a 10-item scale capturing the strength of an individual's general beliefs, expressing their confidence in coping with difficult situations and obstacles (Schwarzer, 1992; Juczyński, 2000). The GSES has been widely adapted and used in 25 countries across various languages and cultures, demonstrating generally acceptable psychometric properties and global applicability. This scale is one of the most frequently used tools for measuring self-efficacy across various domains, including sports and physical activity (Aizava et al., 2024). Participants rate their response using a Four-point Likert Scale (from "Not at all true" = 1 to "Exactly true" = 4). A higher total score (ranging from 10 to 40) indicates a greater generalized sense of self-efficacy. The internal consistency of the GSES in this study was Cronbach's $\alpha = 0.82$.

2.2.2 Sports motivation

The Sports Motivation Scale (SMS-28) was developed by Pelletier et al. (1995) and Walczak and Tomczak (2019) as a 28-item measure of motivation in a sports context based on self-determination theory (Ryan and Deci, 2017). The SMS-28 is one of the most widely used tools in research to assess motivation in sports contexts. It has been translated, adapted, and validated in multiple languages, including Czech, Arabic, Spanish, Serbian, and Polish, confirming its reliability and validity in various settings and different cultural contexts. The scale has also been used in diverse populations, such as college athletes, senior athletes, and high school students, demonstrating its applicability across different age groups and competitive levels (Clancy et al., 2017). The SMS-28 contains seven subscales (4-item each), arranged into three dimensions of motivation: intrinsic motivation (To know, To accomplish, and To experience stimulation), extrinsic motivation (Identified, Introjected, and External regulation), and one Amotivation scale. A seven-point response scale (1 = "Does not apply to me at all," 7 = "Applies to me exactly") assessed the degree to which the given reasons for practicing sports were met. In the present study, Cronbach's α was as follows: 0.78, 0.76, 0.79, 0.73, 0.68, 0.72, and 0.67, 0.90, and 0.80 for the scales To know, To accomplish, To experience stimulation, Identified, Introjected, External regulation, Amotivation, Intrinsic motivation, and Extrinsic motivation, respectively.

2.2.3 Demographic characteristics of the sample

The demographic characteristic of the sample was assessed using several questions about age (continuous variable), gender (women, men, other), sports discipline (cycling, running), additional sport discipline (trained formerly, currently, or none),

years of sport experience (continuous variable), the highest level of competitions, number of days trained during a typical week (ranging 1–7), number of minutes trained on a typical day (continuous variable), and a frequency of participation in competitions during the last season (1–5 times, 5–10 times, above 10 times, or none).

2.3 Participants

The study involved 73 cyclists aged 18–57 ($M = 27.86$, $SD = 11.17$) and 83 runners aged 18–64 ($M = 35.04$, $SD = 10.28$), with the majority of men (76.71% of cyclists and 59.04% of runners). The characteristics of the study participants are presented in Table 1. In both groups, the vast majority of athletes used to practice an additional sports discipline or still practice it. Most cyclists declared that they participated in training 6 days a week, while most runners trained 3 days a week. The frequency of competition starts to vary. In the group of cyclists, the highest frequency of starts was over 10 times a season, while in the group of runners, almost half of the respondents chose the frequency of 1–5 times. The level of competitions in which the cyclists took part was the Polish Cup, Polish Championships, and international competitions, while runners took part in competitions in Poland and abroad. The average sports experience was 9 years for both cyclists (ranging from 1 to 30 years, $M = 9.27$, $SD = 6.89$) and runners (ranging from 1 to 32 years, $M = 9.12$, $SD = 7.90$). Runners declared on average 5 days a week of training frequency (ranging from 2 to 7 days a week, $M = 4.80$, $SD = 1.47$), while cyclists declared 4 days a week (ranging from 1 to 7 days a week, $M = 4.07$, $SD = 1.69$). The sample of cyclists trained on average 119 min per week (ranging from 40 to 300 min weekly, $M = 118.63$, $SD = 48.34$), while 68 min per week was noted in the runners' group (ranging from 30 to 230 min weekly, $M = 67.17$, $SD = 27.81$).

2.4 Statistical analysis

Initially, the parametric properties of all variables were examined using mean (M), standard deviation (SD), Median ($Mdn.$), skewness, and kurtosis for self-efficacy and sports motivation, considered as continuous variables. We considered close to a normal distribution of data in the medium size study sample ($50 < n < 300$) since skewness (a measure of the asymmetry) ranged between -0.85 and 2.66 , and kurtosis (a measure of "peakedness" of a distribution) ranged between -1.34 and 1.46 . As a sensitivity analysis, the Student's *t*-test was performed to examine the differences between cyclists and runners in self-efficacy and motivation. The effect size was assessed using Cohen's *d* statistic.

Three clusters ($k = 3$) were considered in the K-means clustering using Hartigan and Wong's method. The K-means clustering model consisted of eight continuous variables ($n = 8$), including three scales of intrinsic motivation (to know, to accomplish, and to experience stimulation), three scales of extrinsic motivation (identified, introjected, and external regulation), amotivation, and self-efficacy. All variables were standardized

TABLE 1 Demographic characteristics of athletes ($N = 156$).

Variable	Categories	Cyclist ($n = 73$)		Runner ($n = 83$)	
		n	%	n	%
Gender	Women	17	23.29	34	40.96
	Men	56	76.71	49	59.04
Additional sport discipline	Formerly	30	41.10	15	16.87
	Currently	19	26.03	45	54.22
	None	24	32.88	23	27.71
Training frequency during a typical week	1 day	0	0.00	3	3.61
	2 days	5	6.85	10	12.05
	3 days	13	17.81	23	27.71
	4 days	10	13.70	21	25.30
	5 days	17	23.29	5	6.02
	6 days	20	27.40	10	12.05
	7 days	8	10.96	11	13.25
Frequency of participation in competitions during the last season	1–5 times	22	30.14	40	48.19
	5–10 times	12	16.44	24	28.92
	Above 10 times	36	49.32	19	22.89
	None	3	4.11	0	0.00

prior to the statistical analysis to ensure a fair comparison across different scales. Then, the principal component analysis (PCA) was performed to visualize the data, with the 2-dimensional plane spanned by three cluster centroids and modeled by ball-shaped clusters. Also, the plot of means across clusters was performed to show differences in variables in the model. Finally, the statistical difference between clusters in each variable was assessed using multivariate analysis of variance (MANOVA) for seven scales of motivation and one-way ANOVA for self-efficacy, age, and sports experience. The partial eta square statistic (η^2_p) was performed to assess effect size, and the Bonferroni *post-hoc* test was carried out to identify statistically significant differences between particular groups. Also, Pearson's χ^2 test of independence was performed for the comparison of clusters across categories of gender and sports discipline, with Cramer's V as an effect size. All statistical tests were performed using JAMOV ver. 2.3.28 for Windows.

3 Results

3.1 Differences between cyclists and runners in self-efficacy and sport motivation

The independent sample of the Student's *t*-test was performed to examine the differences in self-efficacy and motivation, including intrinsic motivation (to know, to accomplish, and to experience stimulation), extrinsic motivation (identified, introjected, and external regulation), and amotivation (Table 2). No intergroup differences were noted, neither for self-efficacy nor for sports motivation.

3.2 Cluster analysis for sports motivation and self-efficacy among cycling and running athletes

The K-means cluster analysis was performed for three clusters, as shown in Table 3 and Figure 1. The prevalence in the first cluster (blue color) included 62 athletes, the second group (in gray) comprised 46 individuals, and the third sample (in orange) consisted of 48 people.

The PCA analysis (Figure 2) showed that self-efficacy was loaded on the lowest value on axis Y (below 0), together with sequentially all three scales of intrinsic motivation (negative values). Amotivation, in contrast, was presented on the highest value on axis Y (above 0), with all three scales of extrinsic motivation (positive values). Axis Y explains 18.5% of the variance in the clustering model and seems to represent the motivational aspect due to self-determination theory, from believing in a high dependence, sense of certainty, and externally driven behavior (a high value in amotivation) to fully autonomous and internally driven behavior (low value for self-efficacy). The dimension on axis X explains 41.2% of the variance. It may represent the internal need for achievement, with the highest positive value for intrinsic motivation to accomplish and close to 0 (or below) for amotivation. Interpreting these results, we can assume that sports motivation can be explained by the need for achievement (Figure 2).

The mean scores of standardized variables are presented for three clusters in Figure 3. For the first cluster of "Internally motivated athletes" ($n = 62$, blue line), three scales of intrinsic motivation and self-efficacy were relatively high, whereas three scales of extrinsic motivation and amotivation were relatively

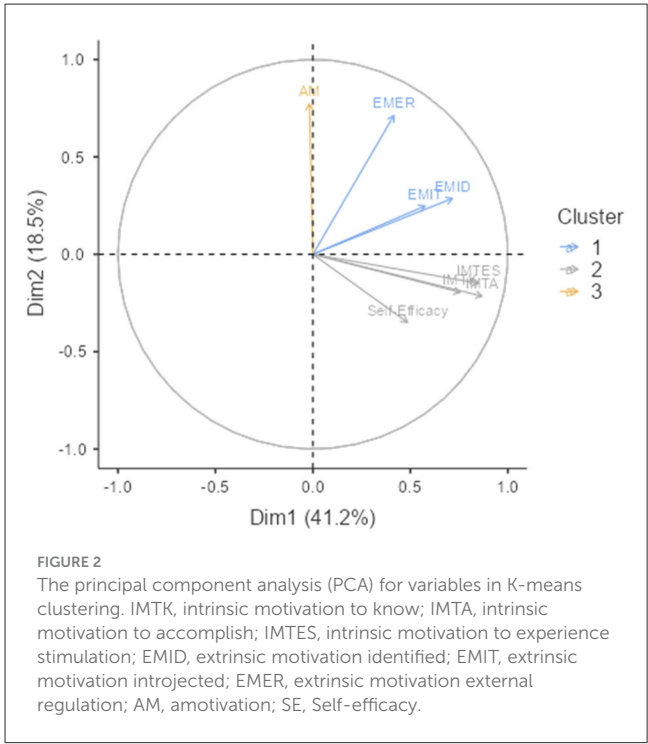
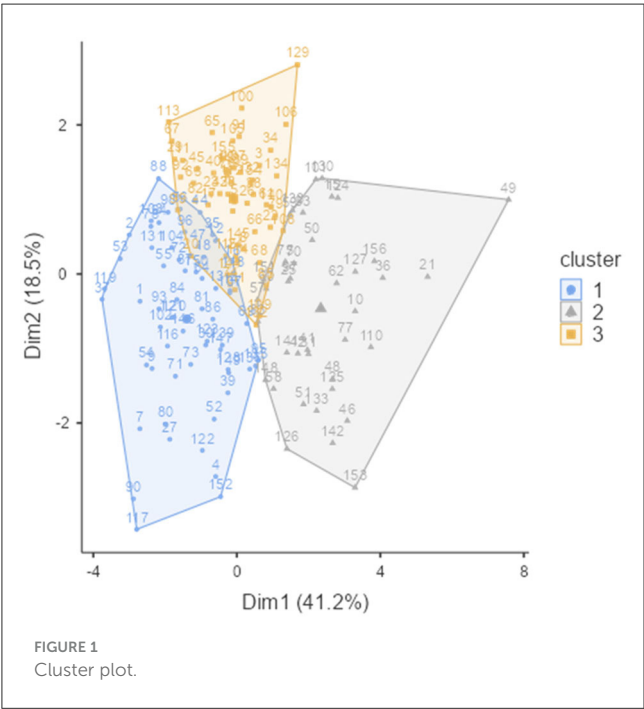
TABLE 2 Student's *t*-test to assess differences in sports motivation and self-efficacy between cyclists and runners.

Variable	Cyclist(<i>n</i> = 73)		Runner (<i>n</i> = 83)		<i>t</i> ₍₁₅₄₎	<i>p</i>	<i>d</i>
	M	SD	M	SD			
Self-efficacy	32.6	4.28	32.02	4.16	0.86	0.394	0.14
Intrinsic motivation	63.33	13.85	64.82	12.44	−0.71	0.480	−0.11
To know	19.45	5.48	19.78	5.33	−0.38	0.703	−0.06
To accomplish	21.59	5.15	21.66	4.51	−0.1	0.924	−0.02
To experience stimulation	22.29	5.23	23.37	3.97	−1.47	0.143	−0.24
Extrinsic motivation	51.25	12.11	51.36	12.07	−0.06	0.953	−0.01
Identified	17.92	5.38	17.45	5.36	0.55	0.584	0.09
Introjected	20.81	4.97	21.42	4.41	−0.82	0.415	−0.13
External regulation	12.52	5.72	12.49	5.89	0.03	0.977	0.01
Amotivation	7.86	3.73	9.08	5.15	−1.68	0.096	−0.27

TABLE 3 Centroids of clusters.

Cluster No	Sum of squares	IMTK	IMTA	IMTES	EMID	EMIT	EMER	AM	SE
1 (<i>n</i> = 62)	284.239	0.360	0.413	0.326	−0.188	−0.225	−0.663	−0.384	0.343
2 (<i>n</i> = 46)	291.129	−0.997	−1.176	−1.087	−0.640	−0.406	−0.129	0.159	−0.689
3 (<i>n</i> = 48)	218.180	0.491	0.593	0.620	0.856	0.680	0.980	0.344	0.217

IMTK, intrinsic motivation to know; IMTA, intrinsic motivation to accomplish; IMTES, intrinsic motivation to experience stimulation; EMID, extrinsic motivation identified; EMIT, extrinsic motivation introjected; EMER, extrinsic motivation external regulation; AM, amotivation; SE, Self-efficacy.



low. The second cluster of “Externally motivated athletes” (*n* = 46, gray line) showed the opposite pattern to the first cluster, namely relatively high scores in three scales of extrinsic motivation and amotivation, while relatively low scores in three scales of intrinsic motivation and self-efficacy. The third cluster of

“Highly motivated athletes” (*n* = 48, orange line), was presented with relatively high scores in all motivational scales and self-efficacy.

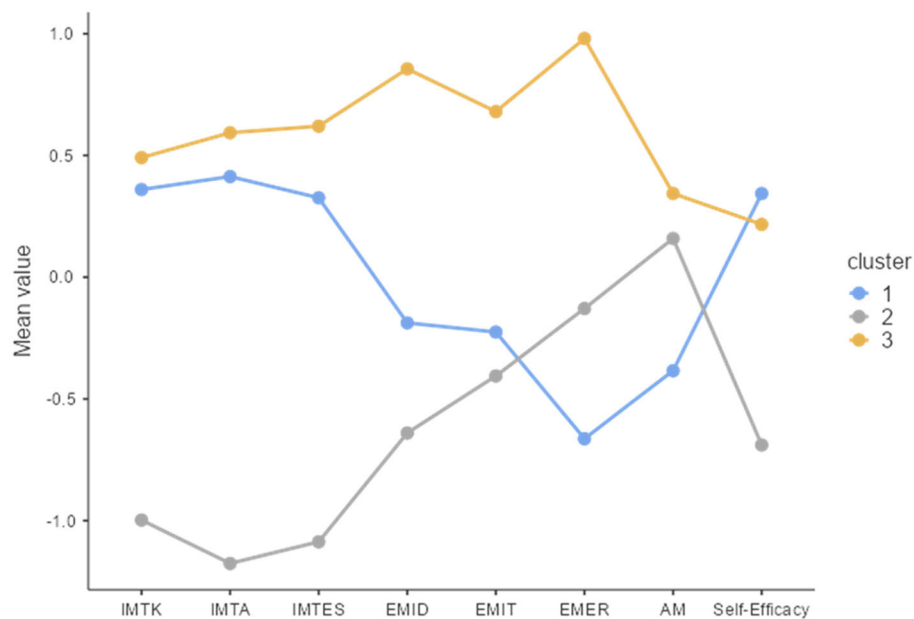


FIGURE 3

Plot of means across clusters. IMTK, intrinsic motivation to know; IMTA, intrinsic motivation to accomplish; IMTES, intrinsic motivation to experience stimulation; EMID, extrinsic motivation identified; EMIT, extrinsic motivation introjected; EMER, extrinsic motivation external regulation; AM, amotivation.

TABLE 4 The one-way ANOVA for sports motivation scales and self-efficacy.

Variable	Cluster 1 (n = 62)		Cluster 2 (n = 46)		Cluster 3 (n = 48)		$F_{(2,153)}$	η^2_p	Post-hoc
	M	SD	M	SD	M	SD			
IMTK	21.57	3.71	14.26	4.79	22.27	3.93	55.79***	0.422	(1 > 2)***, (1 = 3), (2 < 3)***
IMTA	23.61	2.65	15.98	3.79	24.48	2.93	109.01***	0.588	(1 > 2)***, (1 = 3), (2 < 3)***
IMTES	24.37	2.59	17.85	4.67	25.73	2.18	80.32***	0.512	(1 > 2)***, (1 = 3), (2 < 3)***
EMID	16.66	4.76	14.24	4.51	22.25	3.39	43.48***	0.362	(1 > 2)*, (1 < 3)***, (2 < 3)***
EMIT	20.08	4.39	19.24	5.20	24.31	2.43	20.62***	0.212	(1 = 2), (1 < 3)***, (2 < 3)***
EMER	8.66	4.11	11.76	4.62	18.19	3.93	70.19***	0.478	(1 < 2)***, (1 < 3)***, (2 < 3)***
AM	6.76	3.09	9.24	4.14	10.08	5.75	8.79***	0.103	(1 < 2)*, (1 < 3)***, (2 = 3)
SE	33.74	4.09	29.39	3.36	33.21	3.78	19.44***	0.203	(1 > 2)***, (1 = 3), (2 < 3)***

IMTK, intrinsic motivation to know; IMTA, intrinsic motivation to accomplish; IMTES, intrinsic motivation to experience stimulation; EMID, extrinsic motivation identified; EMIT, extrinsic motivation introjected; EMER, extrinsic motivation external regulation; AM, amotivation; SE, Self-efficacy. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3.3 Differences between three clusters in sports motivation and self-efficacy

The one-way MANOVA was performed to examine cluster differences in all seven scales of sports motivation, including intrinsic motivation to know, intrinsic motivation to accomplish, intrinsic motivation to experience stimulation, extrinsic motivation identified, extrinsic motivation introjected, extrinsic motivation external regulation, and amotivation. Multivariate analysis showed a significant effect, Wilks' $\lambda = 0.158$, $F_{(14,294)} = 31.83$, $p < 0.001$. There was a significant difference between particular sports motivation scales, $F_{(6,150)} = 296.42$, $p < 0.001$, $\eta^2_p = 0.66$, between particular clusters in sports motivation, $F_{(2,153)} = 119.52$, $p < 0.001$, $\eta^2_p = 0.61$, and an interaction effect between sports motivation

scales and clusters, $F_{(12,918)} = 24.877$, $p < 0.001$, $\eta^2_p = 0.25$. The effect size for all of these comparisons was large. A series of one-way ANOVAs were performed to examine differences in sports motivation scales and self-efficacy between particular clusters. Differences between clusters in sports motivation scales and self-efficacy are presented in Table 4.

3.4 Differences between three clusters in demographic variables

As a sensitivity analysis, we also compared clusters across age, sports experience, sports discipline (runner, cyclist), and gender (women, men). Differences in age and sports experience

TABLE 5 Comparison of clusters for demographic variables.

Variable	Cluster 1 (n = 62)		Cluster 2 (n = 46)		Cluster 3 (n = 48)		$F_{(2,153)}/\chi^2_{(2)}$	p	η^2_p /Cramer's V
	M/n	SD/%	M/n	SD/%	M/n	SD/%			
Age	32.92	10.61	31.13	12.06	30.60	11.37	0.65	0.525	0.01
Sports experience	8.89	7.10	10.30	9.10	8.52	5.90	0.76	0.468	0.01
Sports discipline							1.11	0.574	0.08
Runner	30.00	36.1	25	30.1	28	33.7			
Cyclist	32	43.8	21	28.8	20	27.4			
Gender							4.96	0.084	0.18
Women	26	51	10	19.6	15	29.4			
Men	36	34.3	36	34.3	33	31.4			

between clusters were assessed using one-way ANOVA, whereas cluster differences in sports discipline and age were assessed using Pearson's χ^2 test of independence. As shown in Table 5, athletes representing three clusters did not differ statistically significantly in age, sports experience, sports discipline, or gender.

4 Discussion

The concept of a person-centered approach is not novel. While variable-centered analyses are valuable for discerning individual differences or examining relationships among a limited set of variables within a group, they do not adequately capture the comprehensive patterns of how variables function within individuals. It is crucial to investigate how variables combine and interact within each individual, which constitutes the core of a person-centered approach. The combination of variables can differ among individuals, indicating that some individuals may encounter distinct configurations of variables compared to others. Rather than concentrating exclusively on the variables and their interrelationships within the entire population, person-centered research identifies and compares subgroups of individuals who exhibit similar patterns of variables. Nevertheless, a person-centered approach can complement variable-centered methods and address a unique set of research questions (Meyer et al., 2013).

The study sought to delineate the motivational profiles of athletes through the lens of self-determination theory and self-efficacy measures. This research adopts a novel approach by focusing on athletes engaged in highly demanding endurance disciplines at both regional and national levels. The integration of motivational perspectives with an analysis of their relationship to self-efficacy may serve as a valuable tool for application in professional sports interventions. A non-hierarchical clustering method (k-means), which categorizes observations by employing nearest centroid sorting, was utilized. The study identified the following motivational clusters based on self-determination theory and self-efficacy measures: (1) *internally motivated athletes*, characterized by relatively high scores on three intrinsic motivation scales—namely, motivation to know, to accomplish, and to experience stimulation—as well as self-efficacy; (2) *externally motivated athletes*, who exhibited relatively high scores on three

extrinsic motivation scales—identified, introjected, and external motivation—and amotivation, while scoring low on all intrinsic motivation scales and self-efficacy; and (3) *highly motivated athletes*, who demonstrated relatively high scores across all intrinsic and extrinsic motivation scales and self-efficacy, although the mean value of self-efficacy was slightly lower compared to the internally motivated group. Similar to previous studies (Murcia et al., 2007; Friederichs et al., 2015), a three-cluster solution was identified in the data. Contrary to previous studies, it was demonstrated that there exists a group of highly motivated athletes for whom all types of motivation, not solely intrinsic motivation, and self-efficacy were at the highest levels. Furthermore, among a group of externally motivated athletes, amotivation was elevated while self-efficacy was diminished, indicating a potential direction for future intervention.

Furthermore, the comparative analysis of the clusters revealed that Cluster 1 and Cluster 3 exhibited similar levels of intrinsic motivation. However, these two groups diverged in their levels of extrinsic motivation and amotivation, with Cluster 3 displaying higher values in these areas. The self-efficacy values for both clusters were comparable. These findings align with the theoretical framework of the self-efficacy construct, which pertains to individuals' beliefs regarding their capability to accomplish a task. This construct may influence the selection of actions, the exertion of effort, perseverance in goal pursuit, and ultimately, achievement, regardless of whether the goal is driven by internal or external motivations (Bandura, 1977). Previous research (Kheirkhah et al., 2017; Fominykh and Kornienko, 2020; Gan et al., 2023) has demonstrated a positive correlation between self-efficacy and both intrinsic and extrinsic motivation. Furthermore, athletes who possess greater confidence in their abilities tend to exhibit lower levels of demotivation, as evidenced by their low scores on the amotivation subscale. Notably, within cluster 3, introjected motivation achieved the highest value among all extrinsic motives. Teixeira et al. (2012) propose that behavior driven by introjected regulation is rooted in self-approval, leading to anticipated intrapersonal rewards, which may contribute to elevated motivation levels. However, behavior driven by external factors is often short-lived and may result in dropout. This cluster illustrates the multidimensional nature of motivation (Chian and Wang, 2008) and suggests that athletes may display more adaptive behaviors across all motivational scales.

According to SDT, introjected regulation may be perceived as a form of self-regulatory motivation driven by internal pressure and obligation (Vasconcellos et al., 2020). However, it is considered non-autonomous, as the underlying reason for engaging in an activity is externally derived (Chemolli and Gagné, 2014). Concurrently, introjected regulation may impede motivation due to the presence of anxiety and self-criticism. It is positively correlated with need satisfaction, indicating that supportive environments may facilitate its occurrence. Meta-analyses across domains such as exercise, education, public health, work, and sport have corroborated these findings, suggesting potential adaptive and maladaptive outcomes when introjected regulation and other SDT constructs are examined (Vasconcellos et al., 2020).

It is important to consider that intrinsic motivation and identified motivation are often challenging to differentiate, as some adolescents may perceive intrinsic motivation (activities they enjoy) similarly to identified regulation (activities they value). The distinctions between these forms of motivation may be ambiguous, complicating the establishment of their relationship with self-efficacy. Furthermore, introjected regulation and external regulation are collectively categorized as controlled motivation; however, they should be examined as distinct categories, akin to amotivation (Vasconcellos et al., 2020). When intrinsic motivation is evaluated, it is essential to first acquire an internal representation of the outcome, which necessitates prior experience with the goal. The authors highlight that intrinsic motivation can manifest even when outcomes are novel or pertain to uncertain or ambiguous behaviors. Conversely, motivation may be constrained in scenarios involving entirely predictable activities where rewards are anticipated. It is underscored that intrinsic and extrinsic motivation are distinct processes. Their interaction has been demonstrated, raising questions about their dis-sociability. It is noted that both mechanisms are utilized in the pre-decisional deliberation phase of behavioral choice as separate drivers of behavior (Morris et al., 2022).

In light of varying behavioral patterns and outcomes, Chemolli and Gagné (2014) propose that individuals may integrate diverse behavioral regulations, irrespective of the proposed continuum of autonomy. Consequently, the cluster analysis presented aligns with this proposition, as it conceptualizes the motivational profile as a dynamic interplay between motivation and self-efficacy. Person-centered analyses indicate that multi-motivational profiles cultivate different types of motivation, with positive outcomes contingent upon the predominance of autonomous motivation over controlled mechanisms in relation to behavior (Howard et al., 2017).

Despite the limited number of variables, the approach demonstrates significant applicability in sports contexts. Shelly et al. (2020) utilized the k-means clustering technique to categorize elite American football student-athletes, based on physiological data collected over two seasons, into effective training groups with the objective of optimizing the benefits of individualized training approaches. They advocated for the adaptation of training to align with both game demands and athletes' capabilities, which proved to be an efficient aspect of this analysis. This study can also be applied in professional sports by coaches and sports psychologists. The

intervention should involve the concurrent enhancement of self-efficacy and intrinsic motivation. Such an intervention is expected to support the achievement of sports success and prevent dropout from physical activity.

While the current study yielded significant findings, certain limitations must be acknowledged to avoid overgeneralization. Primarily, the sample size of cyclists and runners was relatively small, despite comprising only professional athletes. To ensure maximal representativeness among cyclists and runners, invitations were sent to all sports clubs in Poland that associate professional cyclists and runners. However, the response rate was relatively very small. Consequently, the results may not fully represent both disciplines. We also wanted to obtain data from different training stages during one sports season as well as during competitions. Therefore, the data collection lasted 9 months. However, it may be more beneficial to conduct the research at a specific time during the competition season and repeat it during the autumn detraining period to capture the anticipated differences between athletes. A longitudinal study is recommended for future research to thoroughly verify the present results. Further research is required to validate the present findings in a larger and more diverse sample of sports disciplines. Although the SMS-28 scale was well-suited to this research, future studies should employ a revised version of the scale (SMS-6) to broaden the scope of motivation with an integrated perspective. The study was limited to two variables, namely motivation and self-efficacy. Future research should also consider incorporating sports achievements (both lifetime and current) in the profiling of athletes using cluster analysis. Including sports achievements, in addition to motivation and self-efficacy, in the clustering model may provide new insights into the current findings. Since K-means cluster analysis is an unsupervised learning method, the results may not be generalizable to all cyclists and runners. Future studies may use more generative methods of classifying and profiling athletes based on selected variables, such as discriminant analysis or latent profile analysis.

5 Conclusions

This study contributes to the existing body of knowledge by demonstrating that the three identified profiles of sports athletes do not merely correspond to three levels of motivation or the basic types of motivation—intrinsic, extrinsic, and amotivation. The research findings indicate that athletes can be categorized into three distinct groups: (1) *highly motivated athletes*, characterized by high levels of self-efficacy and all forms of motivation, ranging from intrinsic motivation to amotivation; (2) *intrinsically motivated athletes*, who exhibit high self-efficacy and intrinsic motivation but low extrinsic motivation; and (3) *lowly motivated athletes*, who display low self-efficacy and intrinsic motivation, coupled with high levels of amotivation and extrinsic motivation. The identified behavioral patterns may serve as valuable criteria for athlete selection and for providing psychological support to those in the third group, characterized by low motivation. The present findings underscore the critical role of enhancing self-efficacy within sports environments to bolster motivation and

engagement in physical activities. The outcomes of this research offer insights into evaluating athletes' capabilities in their pursuit of achieving the highest objectives. Given the absence of statistically significant differences concerning age, sports experience, discipline, or gender, it is proposed that interventions could be effectively implemented in a more universal context. As self-efficacy is bolstered by achievements and feedback, such as awards and evaluations from judges and fans, the training process should be structured to afford athletes opportunities for success. This can be achieved by establishing specific long-term objectives, intermediate short-term goals, and a comprehensive action plan. The phased implementation of assumptions, coupled with feedback from a coach, is instrumental in enhancing self-efficacy. At this juncture, cognitive techniques may be introduced, such as imaginative strategies (including relaxation techniques with success visualization), the avoidance of negative thinking and pessimism, and the use of affirmations. Additionally, it is essential to bolster intrinsic motivation by fostering enjoyment and satisfaction derived from physical and sporting activities, setting more effective sporting goals, celebrating achievements, and supporting tasks that lead to development independent of current sports performance and accomplishments.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: <https://data.mendeley.com/drafts/24fw5z3y7c>.

Ethics statement

The studies involving humans were approved by Institutional Review Board of the Institute of Psychology at the University of Opole (Decision No. KOJBN 31/2023, 5 December 2023). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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Athlete profiles along grit, sport orientation and sport persistence based on a quantitative research on Hungarian athletes

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Introduction: Sport persistence, the sustained engagement in sporting activities, is influenced by a combination of intrinsic and extrinsic motivational factors. Understanding these factors is crucial for supporting long-term athlete commitment and preventing dropout. The study examines athlete profiles based on sport persistence, sport orientation, and grit, aiming to identify distinct clusters that reveal different psychological and sociodemographic characteristics.

Methods: A survey was conducted among 1,105 young athletes (aged 14–25) from secondary and tertiary education institutions in Hungary. The sample included both competitive and recreational athletes. Data collection involved validated psychological measures, including the Sport Persistence Questionnaire, Short Grit Scale, Sport Orientation Questionnaire, beside a block of sociodemographic questions. Cluster analysis (K-Means clustering) was used to identify athlete profiles based on sport persistence, grit, and sport orientation.

Results: Four distinct athlete profiles emerged: (1) Consistently persistent athletes ($n = 363$; high levels of sport persistence, grit, and sport orientation); (2) Athletes prone to dropout ($n = 174$; low level persistence, grit, and sport orientation); (3) Oriented lagging athletes ($n = 387$; moderate sport orientation but lower grit and persistence); (4) Disoriented persistent athletes ($n = 180$; high grit but low sport orientation). Sociodemographic factors, such as parental employment status and educational background, significantly influenced group membership.

Discussion: These results indicate that gender, educational level, parental employment, and sport type significantly influence an athlete's likelihood of maintaining sport participation. The findings also suggest that competitive team sports support networks may contribute to sustained engagement, while university transitions and socioeconomic challenges can lead to a decline in sport persistence.

KEYWORDS

sport persistence, grit, sport orientation, athlete profiles, cluster analysis

1 Introduction

Sustained and active sporting activity can be influenced by several factors, which determine the manner, frequency and type of sporting activity. Based on the general (1) and sport-adapted (2) ecological model, intrapersonal, interpersonal, environmental and cultural factors are all relevant.

Motivation is an umbrella concept, i.e., a multifaceted and complex phenomenon, and its examination can have several aspects, in each case it depends on the way the question is posed which aspect is considered (3). It is based on need, which is always linked to a state of deficiency. It may be physiological or higher, conscious or unconscious. The way in which the need is met is influenced by the environment, but also by our past experiences.

Beyond, but based on regular physical activity, commitment to sport refers to a higher level of engagement where a person builds on their strengths and overcomes their disadvantages by engaging in active sport (4). As with regular sport participation, motivation is the cornerstone of commitment and determines the extent and quality of engagement (5, 6). Scanlan and colleagues' Sport Engagement Model (7–9) are considered authoritative in international practice. Their model has been modified and extended several times. In their later model, Scanlan et al. (9) based their model of sport engagement on the factors that determine sport participation mentioned above. Among the factors within the individual, enjoyment of sport as a basic segment is highlighted, alongside which internal resources and opportunities are emphasised. Other influencing factors may also be the opportunities given to the individual or arising for the individual, as well as other commitments that may distract the athlete from sporting activity, even leading to drop-out in the long term. It is the combination of these components that leads the athlete to decide on the intensity of sporting activity or on sport as a career. In a social context, the social support, including the role of family, peers and the sports club, should be mentioned. At the same time, peer pressure should not be left out, referring to societal expectations and norms (9, 10).

Commitment to sport is the basis for the main thrust of the research, called sport persistence that can be regarded as an indicator of effectiveness. It is a complex concept, a terminology used to express the mastery, form, level and effectiveness of sporting activity. However, its use is less widespread as theories tend to focus on sport motivation and commitment, which do not fully correspond to the concept of sport persistence, as it encapsulates the physical, mental and social aspects of sport (11). It goes beyond sport motivation and commitment; it is the embodiment of sport performance and mental toughness. Overall, sport persistence encompasses psychological skills such as resilience (11), adaptive and proactive coping (4, 10) and positive personality traits, which may also contribute to dropout prevention and enable athletes to show greater commitment and perseverance (12). This refers to the attempts to resolve, process and use stressful situations related to performance plateaus, failures, injuries or even successes and positive events. This behaviour and performance is captured by the concept of sport persistence, the study of which is not widespread in international practice, as research typically focuses on sporting habits, sport motivation and engagement (4, 13). Overall, sport persistence can be considered an outcome indicator, while it refers to a person's performance through sustained physical activity (regardless of the level of activity).

Research findings on sporting behaviour and engagement, both at national and international level and at sporting discipline level, suggest that the issue of sport persistence is worth addressing. Investigating the sporting habits, commitment to sport and persistence of student athletes at different educational levels is also crucial to understanding the balance between the field and the role of the athlete (14). For this reason, investigating the dual career model of student athletes is key, especially for competitive athletes. On the one hand, we need to recognise the unique challenges faced by young people who aspire to perform at a high level in both academic and athletic fields. This highlights the complex balance required between athletic behaviour and academic aspirations (15). Understanding this model will help to design tailored support systems to ensure that student athletes can thrive in both areas without sacrificing one for the other. In addition, exploring this concept will help to optimise training schedules, academic pathways and career transition strategies, ultimately improving the holistic development and well-being of student athletes as they navigate the pillars of their dual careers.

The study aims to identify athlete profiles based on sport persistence, sport orientation, and grit. During the research, we had the following assumption: *It is assumed that distinct athlete profiles can be created along the lines of sport persistence, sport orientation and grit, which are characterised by different sociodemographic and athlete, individual and social psychological characteristics.* It investigates the psychological and sociodemographic characteristics that influence sport persistence and examines how factors such as gender, education level, parental employment, and sport type contribute to an athlete's likelihood of maintaining long-term engagement in sports.

2 Methods

2.1 Sample

A total of 1,209 completions were received, but the data cleaning (based on the inclusion and exclusion criteria) allowed the analysis of data from 1,105 respondents. Inclusion criteria were established as follows: (1) participation in sporting activities on a regular basis (at least once a month), regardless of the type (individual or team) or level (recreational or competitive) of the activity; (2) enrollment in secondary or higher education; and (3) age ranging from 14 to 25 years. Individuals younger than 14 years, older than 25 years, or those not currently engaged in secondary or tertiary education were excluded from the study.

To investigate secondary school students, the primary aim was to include students from grades 9–13 learning in educational sports schools, as these institutions offer an ideal environment for examining both competitive and recreational athletes. The sports school program serves a dual purpose: it fosters both athletic and academic pursuits, thereby offering suitable opportunities for adolescents engaged in higher-level sports (16). Furthermore, prior studies have indicated that a considerable number of students enrolled in sports schools are primarily recreational athletes rather than competitive ones. Additionally, sports schools

generally feature various types of classes (i.e., different profiles), which makes educational sports schools a fitting context for the development of recreational athletes to serve as a control group. In the context of higher education institutions, it is not feasible to continue this line of sports schools, as currently, the only establishment that can be classified as an educational sports school in Hungary is the Hungarian University of Sports Science. However, the presence of only one higher education institution would not suffice for a comprehensive study. Consequently, the integration of students engaged in competitive sports within higher education institutions was intended to be facilitated through university sports clubs. Finally, the combination of institutional outreach and snowball sampling was applied to maximise participation, while acknowledging the limitation that convenience sampling may still introduce some selection bias. In our study, snowball sampling was considered as a non-random sampling technique in which initial participants refer new subjects to the study (17). This method is particularly useful for studying hard-to-reach or special populations where a complete list of potential participants is not available. Initial participants were identified and contacted by age and sports school membership. They referred additional participants who later joined the study. This chain reaction of recruitment continued until the desired number of elements was reached.

Data collection took place between 8 January 2024 and 20 June 2024. The basic concept of the sample design was organised around the secondary school and university student population, and therefore, our sample presentation follows primarily this distribution. 43.3% of participants studied secondary education, and 56.7% studied tertiary education.

Regarding gender, 52.3% of the sample are female and 46.9% male, while 0.8% of the respondents did not specify their gender. Regarding the frequency of participation in sports, almost half of the sample (49.5%) participates in sports several times a week. The proportions of daily (18.5%) and several times a day (14.8%) exercisers are also relatively high, followed by those exercising once a week (9.3%) and monthly (7.9%).

The proportion of individual athletes is higher (57.5%) compared to team athletes (42.5%). The differences in distribution are also significant for the two subsamples in this case. The proportion of sports club members and non-members is almost equal, with 49.5% of the former and 50.5% of the latter.

Regarding the sporting level, the highest proportion of recreational athletes is 51.8%, which implies that 48.2% of the sample can be considered competitive athletes. Of these, 28.2% regularly take part in national championships and cups, 9.2% in county championships, 5.7% in international competitions and 5.1% in local and city competitions.

2.2 Instruments

The research was conducted using validated questionnaires and questionnaires under validation. Accordingly, the questionnaire consists of the following units: a socio-demographic questionnaire, a block of sport and health-specific questions, a

block of questions related to academic performance, psychological measures (perception of success, sport orientation, sport persistence, sports anxiety, grit, resilience, well-being, vision, peer support, perfectionist climate, human values), and questions on relational embeddedness. While several psychological constructs were measured during the study, we selected grit, sport orientation, and sport persistence for analysis because these constructs were most theoretically relevant to our research questions. Therefore, we used only these psychological variables as independent ones in our analysis.

2.2.1 Socio-demographic questionnaire

At the beginning of our questionnaire, various socio-demographic questions were registered: gender, age, current level of education (secondary or higher) and grade, type of settlement, parents' educational attainment, parents' employment, and objective financial situation.

2.2.2 Sport-and health-specific issues

After the socio-demographic data, sport-specific data were queried: self-rated health (10-point Likert scale), self-assessed fitness status (10-point Likert scale), frequency of exercise (several times a day, daily, several times a week, once a week, monthly, less often), sporting activity in an association (yes/no), weekly time spent in sports club training (hours), weekly time spent on individual training (hours), type of sport (individual, team), sporting level (international competitions, national championships, county-level championships, local championships, non-competitive)

2.2.3 Short Version Sport Orientation Questionnaire

The questionnaire consists of 13 items and includes three subscales: win orientation, goal orientation and competition. Win orientation measures the willingness to win, and goal orientation focuses on sports goals through winning the game (17). Competition, on the other hand, measures competitive orientation through anticipation of the game, enjoyment of the game and achievement of the goal of the game. The statements are rated by the respondents on a 5-point Likert scale. The validity of the measure was adequate for all subscales (Cronbach's $\alpha = 0.86$; 0.85 and 0.89).

2.2.4 Sport Persistence Questionnaire

The Sport Persistence Questionnaire (19) is a 13-item questionnaire that measures sport persistence through a factor. Items are rated on a 5-point Likert scale. The reliability measured in the original survey is Cronbach's $\alpha = 0.943$. The minimum score on the overall index is 14 points, and the maximum score is 65 points. A higher score indicates higher persistence.

2.2.5 Short Grit Scale

The instrument is designed to measure grit, a combination of passion and perseverance, through a single-factor question structure consisting of eight statements (20). The average of the scores obtained is used as the basis for the assessment. The items are interpreted on a 5-point Likert scale. The questionnaire also

contains four reverse items. The measure includes two subscales: consistency of interest (Cronbach $\alpha = 0.77$) and perseverance of effort (Cronbach $\alpha = 0.82$).

2.3 Statistical analysis

The data was collected in an Excel spreadsheet. Data analysis was performed using IBM SPSS 22.0 and Jamovi 2.3.28 statistical software. The distribution of the data was examined using normality tests, such as Kolmogorov–Smirnov and Shapiro–Wilk tests. The data follow a non-normal distribution ($p < 0.05$). To create student profiles, cluster analysis (K-Means cluster, Iteration: 100) was used including the following variables: sport persistence, grit (persistent effort and consistency of interest), and sport orientation (competition, goal and win orientation).

3 Results

Since these scales do not have the same score, the clustering of athletes was done after standardization of the variables. The results showed that the athletes in the sample could be classified into four clusters (Figure 1). To determine the optimal number of clusters, we evaluated internal validation metrics, including the Silhouette Score and the Elbow Method. The silhouette analysis revealed that the optimal cluster count was $k = 4$, which maximized inter-cluster

separation and intra-cluster cohesion. The elbow plot showed a marked inflection at $k = 4$, supporting this choice. These results suggest that the selected number of clusters represents a stable and well-separated grouping structure in the data.

The *consistently persistent athletes* ($N_{\text{consistently persistent}} = 363$) cluster included those with high grits and sport persistence, and significantly above average scores for different types of sport orientation. The opposite pole was the group of *dropout-prone athletes* ($N_{\text{dropout-prone athletes}} = 174$), with low values for both general and sport-specific persistence and below average values for sport orientation. In addition to the two “extreme” groups, two clusters with mixed patterns were formed. The cluster of *oriented lagging athletes* ($N_{\text{oriented lagging athletes}} = 387$) consisted of individuals with slightly positive, i.e., slightly above average, levels of goal, victory and competition orientation, but with below average grit and sport persistence scores. Finally, for *disoriented endurance athletes* ($N_{\text{disoriented persistent athletes}} = 180$), none of the types of sport orientation are present and sport persistence is only slightly above average, while overall persistence and grit are relatively high.

A significant difference in the distribution of group profiles along gender was observed ($\chi^2 = 77.152$; $df = 3$; $p < 0.001$). Women were overrepresented in the disoriented persistent and dropout-prone groups, while men were overrepresented in the oriented lagging and consistently persistent groups of athletes (Supplementary Table S1).

Significant distributional differences were also observed with respect to level of study ($\chi^2 = 189.550$; $df = 3$; $p < 0.001$; Fisher

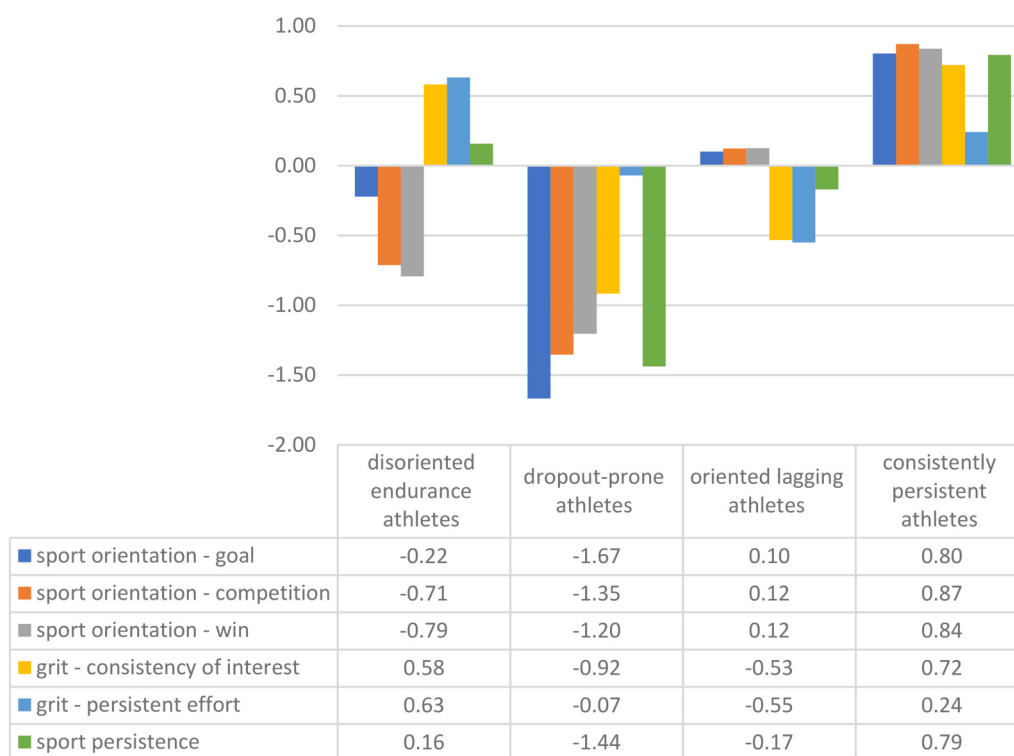


FIGURE 1
Characteristics of athlete profiles.

exact test = <0.001; Cramer's $V = 0.261$; Kendall's Tau-B = 0.210). Consistently persistent athletes were clearly over-represented among high school athletes. In contrast, disoriented persistent athletes and dropout-prone athletes are found in significantly higher proportions among secondary school students (Supplementary Table S2).

There are also significant distributional differences in the labour market status of the father across athlete clusters ($\chi^2 = 24.952$; $df = 3$; $p < 0.001$; Fisher exact test = <0.001; Cramer's $V = 0.277$; Kendall's Tau-B = -0.231). Among consistently persistent athletes, athletes whose father is employed are overrepresented, while among disoriented persistent and dropout-prone athletes, athletes whose father is not employed are overrepresented (Supplementary Table S3).

Concerning mother's education ($\chi^2 = 8.382$; $df = 6$; $p = 0.211$) and father's education ($\chi^2 = 6.471$; $df = 6$; $p = 0.373$), mother's employment ($\chi^2 = 2.329$; $df = 3$; $p = 0.507$), change in family structure ($\chi^2 = 3.903$; $df = 3$; $p = 0.272$), having a sibling ($\chi^2 = 6.560$; $df = 3$; $p = 0.087$), no significant difference was detected.

There were also significant differences in distribution along sporting frequency. Consistently persistent athletes were over-represented among those who participated in sport daily or more than once a week and under-represented among those who participated in sport less than this. Among dropout-prone athletes, there is an over-representation of those who participate in sport several times a week, monthly and less frequently, while those who participate in sport daily or several times a day are markedly under-represented in this group. For disoriented persistent athletes, the representation of weekly athletes was detectable, while athletes who exercise daily or several times a day and those who exercise monthly or less frequently were underrepresented. Neither over- nor under-represented cluster membership rates were found for oriented lagging athletes (Supplementary Table S4; Cramer's $V = 0.260$; Kendall's Tau-B = 0.221).

In terms of the type of sport (Supplementary Table S5), it can be seen that team athletes are over-represented among consistently persistent athletes and are also more prevalent in the oriented lagging athlete cluster. In contrast, individual athletes are overrepresented in the disoriented persistent and dropout-prone athlete clusters. The difference in distribution is also significant in this case ($\chi^2 = 95.281$; $df = 3$; $p < 0.001$; Fisher exact test = <0.001; Cramer's $V = 0.294$; Kendall's Tau-B = -0.233).

A significant difference in the distribution of cluster memberships was also found with respect to sporting level ($\chi^2 = 189.550$; $df = 3$; $p < 0.001$; Fisher exact test = <0.001; Cramer's $V = 0.414$; Kendall's Tau-B = 0.358). The consistently persistent athlete cluster showed a clear overrepresentation of competitive athletes, while the disoriented persistent athlete cluster and the disoriented recreational athletes were also overrepresented (Supplementary Table S6).

Finally, significant distributional differences were also found for sport-specific variables along association membership ($\chi^2 = 142.529$; $df = 3$; $p < 0.001$; Fisher exact test = <0.001; Cramer's $V = 0.359$; Kendall's Tau-B = -0.309). Among

consistently persistent athletes, young people playing sport in sports associations were over-represented, while among disoriented persistent and dropout-prone athletes, those pursuing sport without sports association membership were significantly over-represented (Supplementary Table S7).

To assess the variables influencing cluster membership, multinomial regression has been performed (Table 1). Gender was a consistent and significant predictor in all models, with males being more likely than females to belong to dropout-prone, oriented lagging and consistently persistent athletes compared to disoriented endurance athletes. Sporting level was

TABLE 1 Results of the multinomial regression analysis.

Model Coefficients—cluster membership					
Cluster membership	Predictor	Estimate	SE	Z	p
Dropout-prone athletes—disoriented endurance athletes	Intercept	0.37	0.28	1.32	0.19
	Gender				
	Male-female	0.67	0.25	2.72	0.01
	Sporting level				
	Competitive-recreational	-1.02	0.31	-3.29	<.001
Oriented lagging athletes—disoriented endurance athletes	Level of education				
	Tertiary-secondary	-0.49	0.28	-1.75	0.08
	Sporting frequency				
	Every day—rarer than every day	-0.11	0.35	-0.32	0.75
	Intercept	0.78	0.24	3.27	0.00
Consistently persistent athletes—disoriented endurance athletes	Gender				
	Male-female	1.24	0.21	5.82	<.001
	Sporting level				
	Competitive-recreational	0.28	0.23	1.20	0.23
	Level of education				
	Tertiary-secondary	-0.98	0.23	-4.19	<.001
	Sporting frequency				
	Every day—rarer than every day	0.15	0.28	0.54	0.59
	Intercept	-0.20	0.26	-0.76	0.45
	Gender				
	Male-female	0.97	0.22	4.41	<.001
	Sporting level				
	Competitive-recreational	1.21	0.24	5.10	<.001
	Level of education				
	Tertiary-secondary	-0.52	0.24	-2.14	0.03
	Sporting frequency				
	Every day—rarer than every day	0.78	0.27	2.86	0.00

also a significant factor; individuals engaged in competitive sports were less likely to be in the cluster of dropout-prone athletes ($p = 0.001$) but more likely to be in the cluster of consistently persistent athletes ($p = 0.001$), compared to those involved in recreational sports. Education level showed a significant negative association with the cluster of oriented lagging athletes ($p = .001$) and that of consistently persistent athletes ($p = 0.03$), indicating that individuals with tertiary education were less likely to be in these clusters compared to those with secondary education. Lastly, sporting frequency significantly predicted membership in the cluster of consistently persistent athletes ($p = .00$), with those who exercise daily more likely to belong to this group than those with less frequent activity. These results suggest that gender, sporting level, education, and frequency all play roles in determining cluster affiliation. The model shows statistical significance and acceptable (though modest) explanatory power (AIC = 2,600; BIC = 2,705; $R^2_{McF} = 0.100$; $R^2_N \chi = 0.132$; $\chi^2 = 289$; $df = 12$; $p < 0.001$).

4 Discussion

In this research, four athlete profiles were identified using cluster analysis based on the variables of athlete persistence, grit and sport orientation. *Consistently persistent athletes* were characterized by high sport persistence and grit, and above average sport orientation scores. Such athletes have a deep intrinsic motivation that helps them to achieve long-term goals. They are able to clearly define their goals and work continuously to achieve them. *Dropout-prone athletes* have low levels of both general and sport-specific persistence and sport orientation. They find it difficult to stick with sport in the long term. They often lack clear goals and orientations in sport. They are less persistent and determined, easily giving up sport when faced with difficulties. *Oriented lagging athletes* have a slightly above average goal, winning and competitive orientation, but their grit and sport persistence scores are below average. While they have the desire to compete and win, they lack the perseverance and determination to keep participating. They lack the internal resources, such as grit and sports persistence, needed for long-term commitment. Finally, *disoriented endurance athletes* are characterised by relatively high overall endurance but below average sport orientation and sport persistence. They are persistent and determined in everyday life, but less motivated to participate in sport and less committed to sport. They may not have found a sport in which they are truly committed and motivated, or they may have taken up sport under external pressure or expectations but not find intrinsic motivation and enjoyment.

In terms of gender differences, women are overrepresented in the disoriented persistent and dropout-prone groups, while men are overrepresented in the oriented lagging and consistently persistent groups. This finding is consistent with the research finding of typically high sport persistence among men, and further research has highlighted higher levels of grit and sport orientation among men (21, 22). For girls, social

expectations often lead to less incentive for competitive attitudes and persistence in sport, which may result in lower sport persistence (23).

In terms of level of study, it can be seen that consistently persistent athletes are over-represented among high school athletes, while disoriented persistent athletes and drop-out prone athletes are over-represented among tertiary students. This trend is not surprising in light of our research finding that high school athletes have significantly higher levels of sport persistence compared to university athletes. This may be due to a number of factors, such as the career potential of secondary school students or the fewer responsibilities in secondary school students' lives (e.g., work, family), which may result in more time and energy for sport (24, 25). In comparison, university students' schedules are often less structured and require more autonomy, which may make it difficult to maintain regular sport participation. In addition, university students often have more responsibilities (e.g., study commitments, work, financial burdens), which can reduce the time and energy available for sport (24, 25).

In terms of sociodemographic factors, a significant distributional difference in athlete profiles was found based on the labour market status of the father, with a higher proportion of athletes with a working father/carer among consistently persistent athletes, while children of non-working fathers were over-represented among disoriented persistent and drop-out-prone athletes. Sporting activities often involve significant costs (e.g., equipment, coaching fees, travel). Working parents are more likely to be able to provide these financial resources, which allows their children to continue playing sport (26). Financial security reduces stress on families, which can have a positive impact on children's overall wellbeing and allow them to focus on sport (27). In addition, working parents often serve as strong role models for their children in terms of perseverance, responsibility and work ethic, which can have a positive impact on children's sporting habits and perseverance (19).

There was also a significant difference in the distribution of sporting frequency. Among consistently persistent athletes, daily or multiple daily sporting activity is a characteristic, which is logical given that high intensity sport is a straightforward contributor to sport persistence (28, 29). For them, sport is not just a hobby, but a lifestyle and a passion. These athletes often have specific sporting goals, such as preparing for competitions, improving performance or maintaining health, which motivate them to train regularly. Athletes at risk of dropping out are more likely to participate in sport on a monthly or less frequent basis, which was also a previously hypothesised finding given that athletes at risk of dropping out typically have lower sporting intensity (30). Athletes at risk of dropping out often struggle with a lack of motivation, which contributes to lower sporting frequency. For these athletes, playing sport is not a priority and other activities such as studying, work or social life take precedence over sport in their schedule (31). Among disoriented endurance athletes, weekly athletes are in the majority. These types of athletes have a certain level of commitment to sport, but it is not as intense as seen in their consistently persistent counterparts. For them, playing sport is important but not a

priority. The frequency of weekly sporting activities indicates that they try to find a balance between sport, work/study and social life. Although not as intensively as the consistently persistent sportsmen and women, they try to include sport regularly in their lives.

There were also significant differences by sport type. Team athletes were overrepresented in the consistently persistent and oriented dropout groups, while individual athletes were overrepresented in the disoriented persistent and dropout-prone groups. This distribution reflects our research findings that team athletes are characterized by higher sport persistence. In team sports, players strive for common goals, such as winning a championship or improving team performance. These shared goals increase the level of grit, as athletes are willing to persevere over the long term to achieve these goals (21). In addition, this trend confirms the findings of previous research that team athletes are also considered to be more effective in terms of grit as well as sport orientation (21, 32).

In terms of sporting level, there is a clear over-representation of competitive athletes in the consistently persistent group, while recreational athletes are significantly over-represented in the dropout-prone and disoriented persistent groups. Competitive athletes often set high goals for themselves, such as winning competitions, championships or national level success. These goals increase commitment and persistence in sport. In addition, competitive athletes often compete not only for themselves but also for their team or association, which further increases motivation and commitment (26, 33). In contrast, the main motivation for recreational athletes is often for fun, health maintenance or social interaction. These goals are less powerful than those in competitive sports and do not necessarily require ongoing commitment (34). In addition, recreational athletes are more flexible in managing their sporting habits, which can make them less consistent and persistent (35).

Differences by sports club membership show an overrepresentation of athletes pursuing sport in sports associations in the consistently persistent group, while athletes who do not pursue sport in sports associations have a significantly higher proportion of disoriented persistent and dropout-prone groups. This is consistent with our research findings that members of sports clubs have higher sport persistence. In clubs, athletes often find themselves in a motivating environment where they can be inspired by the success of others, which can also be reflected in higher levels of competitive participation (36).

The novelty of our study lies in the identification and typology of athlete profiles through a multivariable cluster analysis based on grit, sport orientation, and sport persistence, a combination that has not been previously used in this population. The emergence of two mixed-profile types—oriented lagging athletes and disoriented persistent athletes—is particularly noteworthy. These groups reflect psychological inconsistencies, such as high orientation but low grit (or vice versa), which have not been distinctly captured in prior literature. This offers a nuanced view of athlete motivation and engagement beyond high or low persistence categorisations. Moreover, the study also highlights

how sociodemographic and contextual factors (e.g., parental employment, educational level, club membership) systematically relate to psychological profiles. This has important practical implications for targeted interventions in sport psychology and athlete development, especially in the Hungarian context, where such large-scale data has been previously lacking.

Among the limitations of the research, the limitations of the sampling method should be highlighted. The originally planned two-stage stratified sampling was not feasible as most institutions refused to participate in the research. For this reason, snowball sampling was used, but this may distort the results and reduce their generalisability. In addition, it should be mentioned that some questionnaires are not considered as validated instruments in the country, and the primary objective of the research itself was not to validate the instruments, but the study sample allows for the domestic validation of non-validated questionnaires, which could be a further research direction. For some of the insignificant effects, it is suggested that the use of other instruments may be justified to measure certain influencing factors (e.g., peer support, social values). Furthermore, explanatory variables related to meso- and macrosystem levels were underrepresented in the research compared to individual and microsystem levels, and although the research findings suggest that sport persistence is best explained by individual psychological factors, and that system levels, which are distanced from the individual, are becoming less prominent in persistent sport behaviour. Also, no replication or cross-validation of the clusters was attempted on a separate dataset yet which may provide a basis for further analysis.

5 Conclusions

The primary objective of the research was to explore the characteristics of sport persistence, the underlying factors and the determinants of its formation, which were specifically interpreted along the ecological model. Although our results are in line with previous research, the present study is unique in that no detailed analysis has yet been done in this specific approach. Our study not only confirms what has been known so far, but also provides a more accurate picture of the dynamics of the phenomenon in question, thus contributing to the advancement of the field. The experience and results of the present research allow us to create a sport persistence training that can effectively contribute to the performance and commitment of athletes, taking into account their individual strengths and weaknesses. This could provide sports professionals, coaches and psychologists with a toolbox to enhance athletes' performance and also serve as a drop-out prevention tool. Such training programme can support student-athletes' perseverance in sport, with a focus on internal strengths, based on the research findings. Similar training programmes can be useful and effective when working with competitive athletes, for example to reduce drop-out tendencies, strengthen team relationships (37, 38). For recreational athletes, there is also the possibility of contextualising sporting support, which in an

academic context could mean supporting secondary and tertiary studies through sport persistence (39).

Data availability statement

Data are available only on request due to ethical restrictions. For further information, please contact the following email address: kovacs.karolina@arts.unideb.hu.

Ethics statement

The studies involving humans were approved by United Ethical Review Committee for Research in Psychology. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

KK: Writing – original draft, Formal analysis, Resources, Funding acquisition, Conceptualization, Writing – review & editing, Investigation.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fspor.2025.1594365/full#supplementary-material>

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The influence of ego-involving climates on perceived competence and commitment for U.S. Masters swimmers

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Introduction: The climate adults experience in their sport and physical activity endeavors may be central for them staying active and promoting healthy aging. Researchers have focused on the adaptive effects of the task-involving climate on adults' sport experiences, though little attention has been given to the maladaptive influences of an ego-involving climate.

Methods: The purpose of this study was to assess the relationship between Masters swimmers' perceptions of an ego-involving climate, competence, and commitment, as well as investigate the moderating effect of perceived competence on Masters swimmers' commitment within ego-involving climates. U.S. Masters swimmers ($n = 566$; $M_{age} = 54.82$; White 73.70%; female 67%) competing in coach-led programs completed an online survey.

Results: Latent moderated SEM analyses revealed that Masters swimmers' perceptions of an ego-involving climate did not predict their sport commitment, although the interactive effect of an ego-involving climate and perceived competence was significant for commitment. Conditional effects further revealed that while athletes with higher perceptions of competence showed a positive relationship between ego-involving climate and sport commitment, a stronger negative association was observed for Masters swimmers with lower perceptions of competence in an ego-involving climate.

Discussion: Adults, regardless of experience or expertise, can benefit from participating in physical activity and avoiding ego-involving tendencies is essential to fostering their commitment to staying active.

KEYWORDS

adults, seniors, achievement goal perspective theory, physical activity, motivational climate

1 Introduction

The worldwide population is aging, with the percentage of older adults (aged 60 years or over) increasing from 9.2% in 1990 to an estimated 18% in 2024, and projected to continue growing, reaching 24% of the global population by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2023). Physical activity has proven beneficial for healthy aging throughout the lifespan and vital for adults to continue engaging in fundamental skills required to live independently (Edemekong et al., 2023). Beyond supporting activities of daily living, physical activity fosters the basic psychological needs (i.e.,

competence, relatedness, and autonomy); enhances mobility; reduces falls, disease, and illness risk; and overall promotes quality of life and longevity (Stehr et al., 2021; Stavrinou et al., 2022; Wickramarachchi et al., 2023). Despite the known benefits, approximately 80% of U.S. adults do not meet recommended physical activity guidelines for optimal health (Elgaddal et al., 2022). Supporting adults' physical activity participation is essential, as even individuals who meet the guidelines may discontinue if they perceive a lack of support (Burton et al., 2017). Time constraints and lack of motivation are common factors contributing to attrition, prompting researchers to call for a deeper understanding of behavioral constructs that may prevent physical activity withdrawal (Collins et al., 2022; Martínez-Ramos et al., 2015; Stehr et al., 2021).

Master athletes are an ideal group to gain valuable insights into promoting physical activity among adults, recognized for their exemplary exercise participation. Master athletes are individuals aged 35 and older who demonstrate high levels of consistent participation in physical activity through competitive sport, often exhibiting the physical, mental and social benefits of sustained physical activity to longevity and quality of life (Bortz and Bortz, 1996; Geard et al., 2017). While most physical activities are beneficial, swimming has grown increasingly popular among adults for improving aerobic fitness and building muscle due to its lower impact on knees and hips (Cooper et al., 2007). The decision whether to engage and persist in sport and physical activity is multi-factorial (Selejó Joó et al., 2024), and athletes will have varying levels of psychological factors (e.g., motivation, enjoyment) and external factors (e.g., social support, access to facilities), which can all play critical roles in their commitment (Bauman et al., 2012). Specific to motivation, Masters swimmers can be motivated by both intrinsic factors (e.g., enjoyment) and extrinsic factors (e.g., competition) contributing to their long-term physical activity participation (Brilliant et al., 2021), with adults more likely to prioritize health and well-being over other fitness goals as key drivers to their commitment (Molanorouzi et al., 2015).

Understanding the antecedents that promote sustained engagement in physical activity is essential for promoting adults' long-term participation. Achievement goal perspective theory (AGPT; Nicholls, 1984, 1989) provides a valuable framework to foster adaptive outcomes promoting physical activity engagement. A central tenet of AGPT is the motivational climate, where leaders are encouraged to cultivate a task-involving climate that values effort, improvement, cooperation, and learning from mistakes while minimizing ego-involving climate tendencies that focus on normative comparison, rivalry, and recognition of only the highest performers. Research consistently supports the benefits of a task-involving climate (Fry and Moore, 2019). For example, Fry et al. (2023) found that Masters swimmers' perceptions of a task-involving climate were linked to greater effort, enjoyment, and flourishing.

Despite these benefits, ego-involving climates persist across physical activity contexts for all age groups, leading motivational researchers to raise concerns about their negative impact, particularly for those with low perceived competence (Duda and Whitehead, 1998; Roberts, 2012). Nicholls (1984, 1989) emphasized the role of the motivational climate in shaping individuals' perceptions of competence and predicting individuals' affective, cognitive, motivational, and behavioral responses. While the task-involving climate is universally adaptive, regardless of individuals' perceptions of competence, low perceived competence is particularly problematic in an ego-involving climate where emphasis is on comparison to others and success is based

on a normative standard (Ames, 1992; Nicholls, 1992). In an ego-involving climate, individuals with low perceived competence are more likely to struggle, feel inadequate, and experience frustration or discouragement (Ingrell et al., 2016; Roberts, 2012; Sarrazin et al., 2002; Wu et al., 2024; Yoo, 2003). As individuals are vulnerable to feelings of failure in comparison-based settings, they may experience declining motivation as enjoyment decreases, undermining commitment to long-term participation in the activity (Granero-Gallegos et al., 2017; Jøesaar et al., 2011; MacDonald et al., 2011; Smith et al., 2008).

While much of the research including the ego-involving climate has been conducted in youth sport settings, early evidence suggests the potential negative impact of an ego-involving climate persists in adult physical activity settings as well. For example, researchers have found the ego-involving climate was associated with lower commitment to exercise among college students 18 years and older (Brown and Fry, 2013). Ego-involving climates have been associated with negative physiological and psychological effects, such as increased inflammation and inhibiting basic psychological needs, illustrating the detrimental effects when comparison and competition overshadow personal progress and effort (Hogue, 2024). Jo (2022) demonstrated older adults (60 years and older) experienced greater competence, well-being, and commitment to exercise in group fitness classes where ego-involving tendencies were minimized. Similarly, Santi et al. (2014) found Masters swimmers in ego-involving climates showed lower sport commitment and participation, suggesting that such climates can reduce long-term engagement in the activity. Despite these findings, the adult population spans a wide age range, and further research is needed to fully recognize the impact in different physical activity settings.

This study addresses a gap in the current literature by examining the role of an ego-involving climate specifically within the context of Master athletes competing in their sport, a population that is often underrepresented in research on physical activity. Building on AGPT's insights into physical activity and the established negative relationship between an ego-involving climate and motivational responses, the primary purpose of this study was to examine the relationship between Masters swimmers' perceptions of an ego-involving climate, competence, and commitment. Masters swimmers' perceptions of competence were expected to be positively associated with their commitment to continue swimming, with no significant association with their perceptions of an ego-involving climate. The secondary purpose of this study was to explore how perceived competence moderated the relationship between Masters swimmers' perceptions of an ego-involving climate and their sport commitment. The hypothesis was that highly competent athletes would exhibit greater commitment to their sport in a high (vs. low) ego-involving climate. However, athletes with low competence would show lower commitment to their sport in a high (vs. low) ego-involving climate. Understanding how ego-involving climates influence older adults' commitment to sport is crucial for developing strategies that encourage sustained participation in physical activity and promote long-term health benefits.

2 Materials and methods

2.1 Participants

U.S. Masters swimmers ($N = 566$; female 67%) were invited to complete a brief survey to provide feedback on their swim experiences

in the U.S. Masters Swimming (USMS) organization. USMS is a national organization providing adults with the opportunity to participate in organized swim programs, competitions and events and promotes fitness and camaraderie through swimming for adults of all skills levels. Only Masters swimmers who were 35 years and older ($N = 479$; $M_{age} = 55.72$; age range = 35–87; female 69.20%; White 94.70%; Hispanic 2.10%; Asian 1.90%) were included in the sample. This sample size was considered excellent to perform structural equation modeling (SEM), as the sample size recommended in a typical SEM analysis is 200 (Feng and Hancock, 2023; Kline, 2023).

2.2 Procedure

The Institutional Review Board at the lead author's university approved this study. The anonymous Qualtrics survey was distributed by USMS administrators to all members who fit the identified qualifications. Those agreeing to participate were required to complete an informed consent. The survey included self-reported measures of Masters swimmers' perceptions of the ego-involving climate, commitment to their sport, perceived competence in swimming, and demographic information (i.e., age, race).

2.3 Measures

2.3.1 Ego-involving climate

Masters swimmers' perceptions of the ego-involving climate in their swim environments was assessed using the 6-item ego-involving climate scale of the Perceived Motivational Climate in Exercise Questionnaire—Abbreviated (Moore et al., 2015). The stem for the items was “At my swim facility...” and a sample item is “Coach(es) give most of their attention to only a few Masters swimmers.” Masters swimmers responded to items on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Moore et al. (2015) have supported the reliability ($\alpha = 0.72$ – 0.80) of this scale with three different adult samples in the exercise setting (i.e., international exercise franchise, university physical activity classes, campus recreation center).

2.3.2 Sport commitment

The 4-item sport commitment subscale of the Sport Commitment Model (Scanlan et al., 1993) was utilized to evaluate Masters swimmers' commitment to swimming. Although established in the youth baseball and softball setting, the measure is readily adapted to the swimming context. A sample item is “How determined are you to keep swimming?” Masters swimmers responded using a five-point Likert scale ranging from 1 (Not At All/Nothing) to 5 (Very Dedicated/Very Hard/Anything). Alexandris et al. (2002) found support for the reliability ($\alpha = 0.86$) and validity of this instrument with adult exercise and fitness participants using Confirmatory Factor Analysis (CFA).

2.3.3 Perceived competence

The 5-item competence subscale of the Intrinsic Motivation Inventory (McAuley et al., 1989) was employed to measure Masters swimmers' perceptions about their abilities with respect to swimming. Although established with undergraduate students enrolled in physical activity courses, the measure is readily adapted to the

swimming context. A sample item is “I feel pretty competent at swimming.” Masters swimmers responded using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). McAuley et al. (1989) have provided CFA and reliability ($\alpha = 0.80$) support for using this measure in college physical education classes. Additionally, Huddleston et al. (2012) have provided support for the reliability of the measure ($\alpha = 0.84$) with adult fitness members.

2.4 Data analyses

Before the main analysis, descriptive statistics and reliabilities of all measures were calculated and the data was assessed for data normality (i.e., skewness and kurtosis) and missingness in IBM SPSS version 29 (IBM Corp., 2021). The skewness of all variables ranged between -1.62 and 1.13 and kurtosis ranged between -1.86 and 2.46 . These skewness and kurtosis values were within the normality range for a sample that is larger than 300 (Mishra et al., 2019). There were 5.43% of missing values in all observations. Little's (2013) MCAR (Missing Completely At Random) test yielded a nonsignificant result ($\chi^2_{(320)} = 350.37, p = 0.12$), suggesting that the missing values were missing completely at random. Latent moderated Structural Equation Modeling (SEM) analysis was used, which is a sophisticated statistical method incorporating the examination of measurement models and structure models simultaneously to analyze the moderation relationships among latent variables (Kline, 2023). Latent moderated SEM analysis allows researchers to test whether the relationship between an exogenous variable (i.e., ego-involving climate) and an endogenous variable (i.e., sport commitment) is influenced by a moderator (i.e., perceived competence), after controlling the measurement errors. The analysis was conducted in Mplus 8.11 using an iterative maximum likelihood estimation procedure in the latent moderated SEM (Muthén and Muthén, 1998–2012).

The measurement model was tested first using CFA to support the construct validity of all the latent variables (Anderson and Gerbing, 1988). Then, the interaction between ego-involving climate and perceived competence was assessed using three methods. First, the fit indices of log-likelihood, Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), and sample-size adjusted BIC were produced both without the interaction (Model 0) and with the interaction (Model 1). Smaller values in AIC and BIC indicate better fit, while a statistically significant log-likelihood ratio test suggests a better fit between the two models. It is important to note the latent moderated SEM does not produce the same fit indices used in other SEM analyses (e.g., mediation) such as Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR); instead, it produces log-likelihood, AIC, BIC, and sample-size adjusted BIC. Second, the variance explained by the interaction was examined as the effect size. Third, the interaction effect is visualized in a plot to help interpret the relationship between the exogenous and endogenous variables by using pick-a-point strategy (Rogosa, 1980), in which the moderator was estimated at a higher level (mean plus 1 standard deviation) and a lower level (mean minus 1 standard deviation) (Béland et al., 2022). Additionally, all the indicators of the exogenous variable were standardized and used ALGORITHM = INTEGRATION syntax to estimate latent variable distributions. Full information

maximum likelihood (FIML) was implemented to account for missing data in the analysis (Enders and Bandalos, 2001), and 95% confidence intervals were calculated.

3 Results

3.1 Descriptive statistics and correlations

The majority of Masters swimmers reported perceiving a moderately ego-involving climate within their swimming environment and overall high sport commitment and perceived competence (Table 1). The Pearson correlations indicated that having higher sport commitment was associated with Masters swimmers reporting greater perceived competence.

3.2 CFA

The original CFA of all the measures showed adequate model fit [CFI = 0.92, TLI = 0.90, RMSEA = 0.06 (90% CI: 0.055, 0.07), SRMR = 0.05]. Based on the modification index suggested by *Mplus*, the error variance of the sixth and seventh items of the ego-involving climate construct were correlated, yielding excellent model fit [CFI = 0.95, TLI = 0.94, RMSEA = 0.05 (90% CI: 0.042, 0.060), SRMR = 0.05]. Additionally, most factor loadings of the items for the latent variables fell between 0.53 and 0.89 (Figure 1).

3.3 Moderated SEM

First, a latent moderated SEM analysis was performed with ego-involving climate (exogenous variable), perceived competence (moderator), and sport commitment (endogenous variable) (Figure 2). Results from the analysis indicated that perceived competence had a significant and strong relationship with sport commitment [$\beta = 0.309$, $p < 0.001$, 95% CI (0.217, 0.401)], while perceptions of an ego-involving climate had no significant relationship with sport commitment [$\beta = -0.092$, $p = 0.186$, 95% CI (-0.207, 0.022)]. Furthermore, the model with interaction had a slightly better AIC, BIC, and sample-size adjusted BIC than the model without interaction (Table 2). The log-likelihood ratio test was not significant. Although the p value of the interaction between the two variables was 0.055, the 95% CI for the interaction effect was 0.019, 0.253, which did not include 0, suggesting a significant interaction effect between perceptions of an ego-involving climate and competence on sport commitment. The standardized coefficient of the interaction was 0.136, though the variance explained by the interaction was small (0.007).

Further conditional effects were analyzed for the moderation analysis based on two groups with high and low levels of perceived competence, which were determined by being one standard deviation above and below the mean level of perceived competence, respectively. There was a positive relationship between being in an ego-involving climate and sport commitment for Masters swimmers with higher perceptions of competence, though the relationship was not significant ($b = 0.102$, $p = 0.213$). In contrast, a significant negative relationship was found between Masters swimmers' perceptions of an ego-involving climate and sport commitment for Masters swimmers with lower perceptions of competence ($b = -0.245$, $p = 0.048$). The plot showed the same trend (Figure 3), with a positive relationship between the ego-involving climate and sport commitment for athletes with higher perceptions of competence; and a negative relationship for athletes' sport commitment when they had lower perceptions of competence.

4 Discussion

The primary purpose of this study was to assess the relationship between Masters swimmers' perceptions of an ego-involving climate, sport commitment, and their perceived competence. As hypothesized, Masters swimmers who reported higher levels of sport commitment also reported greater sport competence, whereas perceptions of the ego-involving climate were not significantly associated with their competence or sport commitment. Additionally, the moderating role of competence between the ego-involving climate and sport commitment was examined. For those perceiving an ego-involving climate, lower competence was associated with less sport commitment and those with greater competence reported greater sport commitment to swimming. The significant interaction effect, indicated by the confidence interval not including zero, demonstrated perceived competence influenced how perceptions of the ego-involving climate impacted sport commitment. These findings are consistent with theoretical predictions and existing AGPT research, emphasizing the nuanced role perceived competence plays in the relationship between the ego-involving climate and long-term commitment to physical activity (Brown and Fry, 2014; Granero-Gallegos et al., 2017; Ingrell et al., 2016; Nicholls, 1984, 1989; Wu et al., 2024).

Nicholls (1984, 1989) theorized that in an ego-involving climate, competence would be undermined for a large portion of the group, as only those with the best normative performances are valued and recognized. The current study findings suggest an ego-involving climate may be particularly detrimental with Masters swimmers who have low competence in their swim abilities. Noteworthy was the steeper slope for the low perceived competence group indicating a sharper decrease of sport commitment in the ego-involving climate. Santi et al. (2014) have found that supportive teammates and coaches

TABLE 1 Means, standard deviations (SD), minimum, maximum, Cronbach alpha (α), and Pearson correlations.

Measure	<i>M</i>	SD	Min	Max	α	1	2	3
1. Ego-involving climate	2.31	0.63	1.00	4.50	0.75	1		
2. Perceived competence	3.98	0.64	1.00	5.00	0.87	-0.06	1	
3. Commitment	4.36	0.50	1.75	5.00	0.80	-0.06	0.27**	1

All measures utilized a 1 to 5 Likert scale. * $p < 0.05$; ** $p < 0.001$.

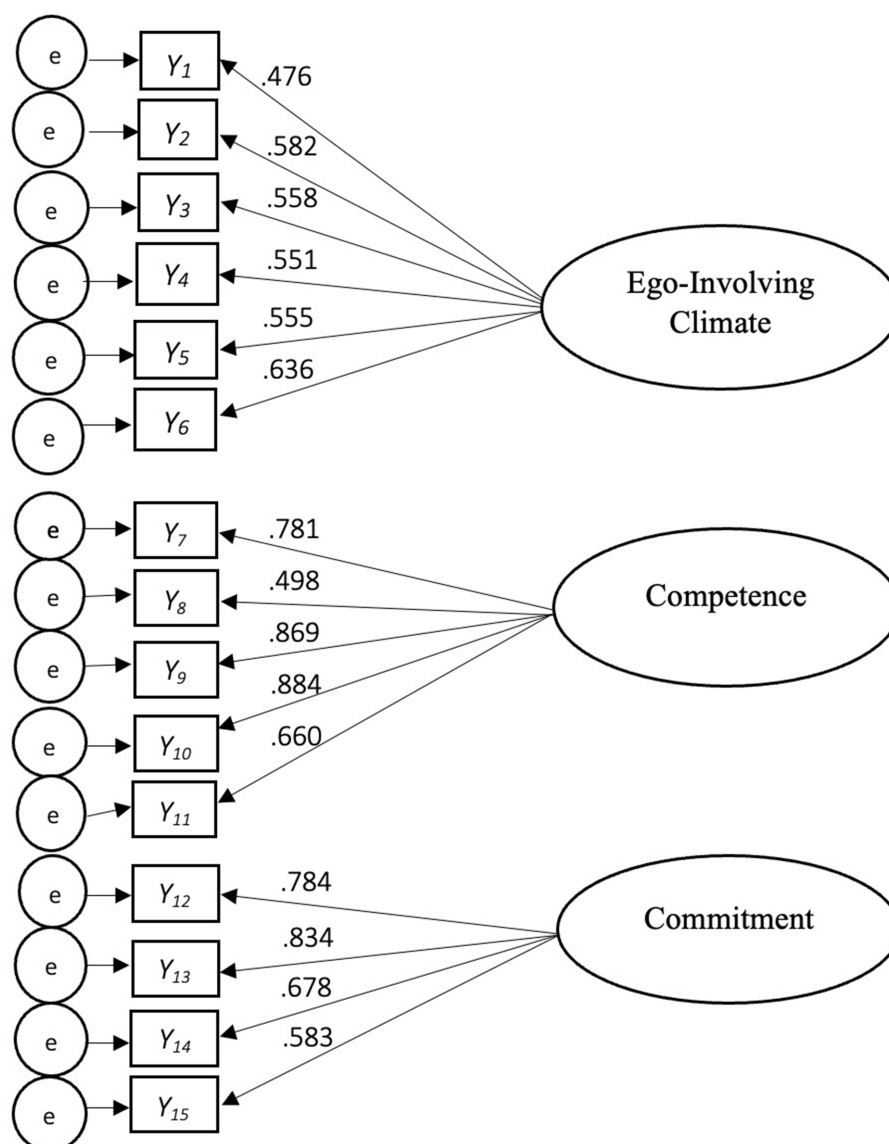


FIGURE 1
Final measurement model.

play a key role in fostering sport commitment among Masters swimmers. The current results further support these recommendations, suggesting professionals supporting adult sport and physical activity endeavors should avoid creating an ego-involving climate, especially when perceived competence levels may not be known and the goal is to promote long-term engagement.

While one may conclude from the current results an ego-involving climate might be advantageous for athletes with high perceived competence, such a conclusion is problematic for several reasons. First, survey measures capture perceived competence at one time point, yet perceptions of competence can fluctuate as individuals navigate different challenges and experiences over time (Liem, 2022). These fluctuations to perceived competence are particularly salient with adults, as aging can affect competence through factors like declining health, reduced performance, increased risk of falls or

injuries, and the likelihood of competing with others who may perform better (Overdorf et al., 2016).

Second, the goal in applied motivational climate research is to optimize motivation and participation in physical activity for all individuals, regardless of their perceived competence. When a climate emphasizes normative comparisons, rivalry, and recognition based solely on top performers, it risks alienating those with lower perceived competence. In contrast, a task-involving climate, which emphasizes effort, progress, and personal growth, benefits both high and low-competence participants, fostering a more inclusive and sustainable environment where everyone is encouraged to continue participating. Social comparisons can be a deterrent for adults in exercise contexts, especially if they fear appearing incompetent among their peers (Kappen et al., 2016). Ego-involving climates naturally promote these types of comparison, something avoidable in a

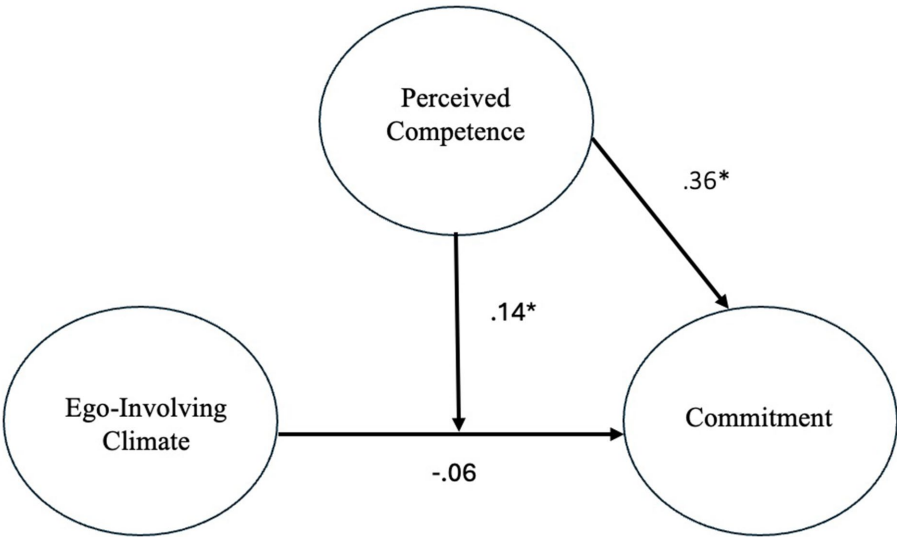


FIGURE 2
Moderation model. $*p \leq 0.05$.

TABLE 2 Model fit comparison.

Model	AIC	BIC	Sample-size adjusted BIC	Log-likelihood	Number of parameters	R^2
Model 0	15939.93	16152.69	15990.82	−7918.97	51	0.123
Model 1	15934.88	16151.80	15986.76	−7915.44	52	0.130
Difference	5.05	0.89	4.06	−3.53	1	0.007

Model 0 is without interaction and model 1 is with interaction.

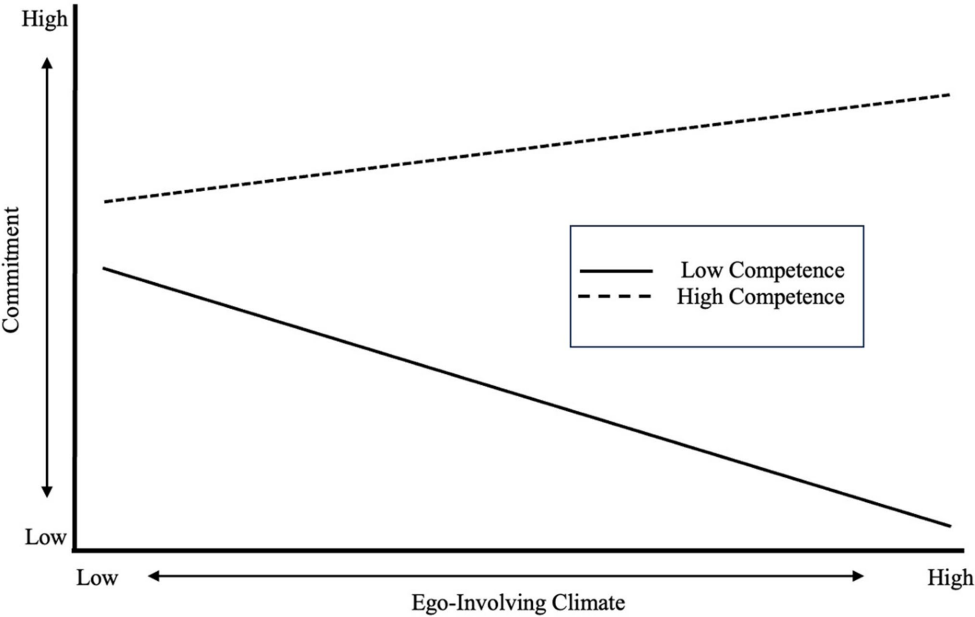


FIGURE 3
Relationship between commitment and perceived competence when in an ego-involving climate.

task-involving approach (for review, see [Fry and Moore, 2019](#), [Harwood et al., 2015](#)).

Third, maximizing adults' sport commitment to live a physically active lifestyle is critical to promote healthy aging across the lifespan ([Edemekong et al., 2023](#)). To encourage consistency, all active adults should be recognized for their effort and commitment, with greater focus on what they can control, rather than spotlighting the best performers at any given time. As the populations of the United States and world continue to age ([Caplan, 2023](#); [United Nations, Department of Economic and Social Affairs, Population Division, 2023](#)), healthy aging is especially critical. Physical inactivity costs the worldwide health-care system billions annually, with a particularly severe impact in wealthier countries such as the U.S. ([Ding et al., 2016](#); [Tang et al., 2022](#)). Physical inactivity is largely preventable, and any intentional approach to encourage more movement is needed to promote movement as a means to improve quality and quantity of life ([Santos et al., 2023](#)).

Drawing from previous studies, specific coaching interventions aimed at reducing the ego-involving climate for Master athletes can be effectively delivered through targeted coach education programs that focus on fostering a task-involving climate. For example, while specific to youth, the Promoting Adolescent Physical Activity (PAPA) project ([Duda, 2013](#)) and coaching interventions in community-based sport leagues ([Smith et al., 2007](#)) demonstrate that short, focused educational interventions can significantly alter coaches' motivational approaches. Likewise, [Claunch and Fry \(2016\)](#) designed a coaching intervention to help Native American college football coaches implement more task-involving characteristics into their coaching style, leading coaches to modify their behaviors during practices and games. While these examples are specific to a younger age cohort, coaching programs for Master athletes could provide education on how to create a climate where athletes are motivated by personal growth and enjoyment rather than external validation or competition. To support the coach training, the coaching programs could adopt structured psychological safety measures, such as regular check-ins and feedback opportunities, setting clear expectations, celebrating effort over outcome, and providing supportive and constructive feedback. By incorporating these principles, coaching staffs could help Masters athletes improve their performance, and experience continued enjoyment and longevity in their sport.

5 Limitations and future direction

The findings highlight the negative impact of an ego-involving climate on adult sport participants, supported by a large sample size and robust moderation model. Despite these strengths, there are opportunities to advance the research further. The results of this study were based on a single timepoint, precluding any causality inference. The physiological consequences of being in an ego-involving climate suggest that the long-term effects of remaining in such an environment could be detrimental, as researchers have noted maladaptive physiological and psychological responses ([Hogue, 2024](#)). However, the specific changes and long-term effects associated with prolonged exposure to an ego-involving climate are not well known. Future research should explore experimental designs (e.g., qualitative) and multiple data collection points to better infer causal relationships

between variables and examine long-term impact of athletes experiencing an ego-involving climate.

While the theoretical framework for this study focused on the impact of the ego-involving climate, future research might also consider how other identifiers moderate the relationship between motivational climate and commitment to sport. Previous work with Master athletes has suggested age is not related to athletic commitment and rather, other drivers impact commitment and performance such as intrinsic motivation, social support, improved health benefits, and habit ([Stones, 2019](#)). These factors could act as additional moderators explaining the relationship between the motivational climate and sport commitment as well as other considerations such as prior competitive experiences or whether Masters swimmers are currently competing. To that end, future researchers would benefit by investigating experiences of both athletes and coaches through qualitative studies.

Lastly, the present study focused solely on the impact of an ego-involving climate on Masters swimmers' commitment to the sport, and there is opportunity for additional outcome variables such as goal orientations, motivational responses (e.g., worry, anxiety, burnout), and enjoyment among adult populations. High ego orientation is often linked to maladaptive responses such as worry, anxiety, burnout, decreased effort, and less enjoyment ([Fry and Moore, 2019](#)). [Newton and Fry \(1998\)](#) found that senior Olympians' high in task orientation had higher intrinsic motivation and believed success was driven by hard work. A high task orientation may buffer the effects of low competence, helping individuals maintain intrinsic motivation and commitment, whereas those with a high ego orientation might experience stress in an ego-involving climate, where performance outcomes dominate.

6 Conclusion

Overall, this study contributes to the AGPT and sport psychology literature by highlighting the impact of ego-involving climates, particularly among adults with low perceived competence. Given the importance of physical activity for optimizing physical and mental health across the lifespan, coaches should be cautious when fostering highly ego-involving team environments. This research illustrates how such climates may undermine the experiences of Masters swimmers, particularly those who feel less competent. The findings are both novel and impactful, replicating similar results observed in younger sport and exercise participants ([Sarrazin et al., 2002](#); [Smith et al., 2008](#)), while expanding our understanding of adults' sport experiences, which have been less studied. Of particular note is the demonstrated moderating effect of perceived competence on adults' sport commitment within an ego-involving climate. This research can be used to enhance adults' physical activity experiences, which is crucial for promoting sustained movement throughout the lifespan.

Data availability statement

The raw data supporting the conclusions of this article may be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Institutional Review Board, University of Kansas. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because participants providing their name on a consent form would have been the only information linking them to the study, so the IRB provided a waiver of consent. In addition, there was no personal or identifying information in the survey that could have compromised participants' confidentiality.

Author contributions

TW: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. MF: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. HL: Conceptualization, Data curation, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. TB: Writing – original draft, Writing – review & editing.

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Promoting physical activity: the contribution of regulatory fit

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Background: Existing research primarily focuses on external strategies for promoting physical activity, while the influence of individual characteristics on engagement in physical activities has been largely overlooked. This study aims to explore the impact of combining individual regulatory focus and exercise information frame on cognition, emotion, intention, and behavior based on the regulatory fit theory.

Methods: In Study 1, participants were randomly assigned to read one of two types of exercise information with different frames but the same content after measuring their chronic regulatory focus. Subsequently, they completed a measure of exercise-related cognition, emotion, and intention. Study 2 replicated this by manipulating situational regulatory focus and extended this by tracking participants' actual engagement in physical activity for one week.

Results: Both studies revealed significant interactions between regulatory focus and the information frame on information value, emotional intensity, and behavioral intention, indicating the regulatory fit effect. More importantly, Study 2 found a significant interaction on vigorous physical activity during one week after the manipulation of situational focus.

Conclusion: When chronic/situational regulatory focus fit with the exercise information frame, individuals evaluated the exercise information more positively, showed more positive emotions, were more willing to take part in exercise, and engaged in more actual physical activity.

KEYWORDS

regulatory fit, regulatory focus, exercise, information frame, physical activity

1 Introduction

According to international guidelines, adults are advised to engage in 150–300 min of moderate-intensity or 75–150 min of vigorous-intensity physical activity per week, or a combination of both, in order to meet the recommended aerobic exercise guidelines (1). In fact, 27.5% of adults and 81% of adolescents fail to engage in sufficient physical activity (1). The prevalence of insufficient physical activity among Chinese adults exhibited an increasing trend from 2010 to 2018, with over one-fifth of adults failing to meet the threshold (2). Physical inactivity represents a significant global public health concern and ranks as the fourth leading cause of mortality (3). Mounting evidence has established a significant association between habitual physical activity and multidimensional neurophysiological adaptations, encompassing neurobiological homeostasis maintenance, augmented emotional regulation capacity, optimized cognitive processing efficiency, functional reorganization of mesolimbic reward pathways (4), circadian entrainment-mediated sleep quality enhancement, hypothalamic-pituitary-adrenal axis modulation governing cortisol dynamics (5), and

prosocial behavioral facilitation through interpersonal neurobiological mechanisms (6). Conversely, insufficient physical activity elevates risks for non-communicable diseases spanning hypertension, type II diabetes mellitus, cardiovascular pathologies, breast/colorectal malignancies, and depressive disorders (7). The prevalence of insufficient physical activity is significantly high in several countries, with rates of 40% in the United States, 34% in India, 47% in Brazil, and 42% in New Zealand being reported (8). Fortunately, physical activity is a modifiable healthy behavior (9). However, existing research primarily focuses on external strategies such as financial incentives (10), social marketing (11), wearable devices (3), and smartphone apps (12) to promote physical activity. Current research has inadequately addressed the interaction effects between individual characteristics and externally-driven intervention strategies. Emerging evidence suggests that congruence between participants' regulatory focus and externally-framed informational stimuli demonstrates substantial influence on health behavior engagement, including but not limited to: adoption rates of smartwatch-based health applications (13), adherence to nutritional guidelines (14), and consumption patterns of athletic merchandise (15). Consequently, it is crucial from both theoretical and practical perspectives to investigate how to deliver appropriate and tailored information to participants based on their regulatory focus characteristics in order to enhance their adoption of physical activity. This paper investigates the impact of combining individual regulatory focus and exercise information on cognition, emotion, intention, and behavior based on the regulatory fit theory. Specifically, it addresses the following questions: Does the regulatory fit between trait focus and information statement influence individuals' perceived value and willingness to engage in exercise? What are the effects of priming individuals with different state regulatory focuses on cognition, emotion, intention, and behavior? Is there consistency between trait regulatory fit effect and state regulatory fit effect in the domain of exercise?

1.1 Regulatory fit theory

In recent years, the regulatory fit theory has increasingly been applied in the realm of health behavior (13, 16, 17). This theory is rooted in regulatory focus and offers various strategies or information to enhance individuals' awareness of both "gain" and "loss". Regulatory focus refers to two motivational tendencies that individuals exhibit in the process of goal realization: promotion focus and prevention focus (18). Promotion-focused individuals are concerned with achieving ideal goals, especially whether they can progress, grow, and achieve positive results. In contrast, those with a prevention focus are based on the ought goals and pay close attention to preventing harm and avoiding adverse outcomes (19). Regulatory focus involves two different types: chronic focus and situational focus. The former is a personality tendency determined by an individual's growth environment as well as their experience of success or failure,

whereas the latter is a temporary motivation orientation induced by the current task or situation (15).

The conventional perspective, which is based on outcome value, posits that conduct assessment depends on the discrepancy between its benefits and costs—in other words, its result value. A positive result value indicates appropriate behavior. Advances in research have led scholars to discover the process value assessment framework. Building upon this foundation, Higgins proposed the regulatory fit theory (20). The theory of regulatory fit emphasizes the interplay between an individual's regulatory focus and their behavioral strategy in goal pursuit and decision-making. Specifically, a promotion-focused individual adopts a desirability-proximity approach, while a prevention-focused individual employs a vigilance-avoidance strategy. The alignment creates a sense of "rightness" or regulatory fit, which subsequently influences individuals' behavioral cognition. Firstly, regulatory fit has the potential to enhance individuals' perceived value. In Higgins' mug auction experiment, participants who adopted a regulatory focus-consistent strategy exhibited an increase in their monetary valuations of target objects (e.g., coffee mugs). Moreover, the value-enhancement effect induced by regulatory fit extends beyond the immediate context of the original goal-directed behavior (such as canine friendliness ratings), thereby demonstrating a cross-situational generalization (21). Moreover, regulatory fit enhances individuals' experience of heightened emotional valence and strengthens their behavioral intentions. Pfeffer's study revealed that participants with a prevention focus exhibited greater behavioral intention following exposure to negative messages, while those with a promotion focus reported more positive emotions both retrospectively and prospectively after reading positive messages (22). Thirdly, regulatory fit functions as a motivational mechanism driving individuals' engagement in advocacy behaviors, indicating that congruence between an individual's regulatory focus and the strategic framing of task objectives enhances their propensity for goal-congruent proactive engagement. Empirical evidence suggests that when the information frame aligns with the induced situational regulatory focus, sedentary and less active individuals exhibit increased participation in sit-ups, squats, planks, and wall-sits (23). In conclusion, regulatory focus operates in conjunction with behavioral strategies or information frames to produce effects. When there is a fit between regulatory focus and the chosen strategy/frame, individuals' cognition, motivation, and behavior are more likely to be influenced (24).

1.2 The interaction between the regulatory focus and frame effect

The extant literature suggests that regulatory fit and frame effect theories are significant factors in influencing persuasion, behavioral motivation, and decision preference. The framing effect constitutes a cognitive bias wherein equivalent objective information, when differentially contextualized through representational variations (i.e., framing), systematically alters decision outcomes and value assessments in judgmental contexts

(25). It is typically divided into the positive frame, which emphasizes the advantages of adopting the behavior, and the negative frame, which focuses on the losses caused by not implementing the behavior (26). According to the regulatory fit theory (27), the promotion-focused individuals are more sensitive to the positive frame, while those with a prevention-focus are more inclined to accept the negative frame. Higgins postulated that the interaction between trait regulatory focus and information presentation would enhance the persuasive impact of information (13). Wang's study demonstrated that aligning consumers' focus with the advertising information framework can effectively activate their attitudes and purchase intentions (28).

In the field of exercise psychology, only a few studies have explored the effect of regulatory fit on exercise motivation and behavior (29). For example, Pfeffer explored the regulatory fit effect between chronic regulatory focus and the exercise information frame and found that participants with a preventive focus reported stronger behavioral intention after reading the negative message while those with a promotion focus reported more retrospective and prospective positive emotions after reading the positive message (18). Latimer et al. found messages that fitted individuals' regulatory focus led to greater physical activity participation and more positive feelings than non-fit messages (30).

1.3 Current research

Despite compelling evidence for regulatory fit's role in exercise motivation, three critical limitations hinder theoretical refinement and practical implementation. First, the predominant focus on chronic regulatory fit—aligning stable promotion/prevention traits with message framing—fails to address whether situational priming of transient motivational states can produce comparable or amplified effects, leaving the trait-state interplay in exercise behavior unresolved. Second, while laboratory studies demonstrate acute regulatory fit effects on cognitive and intentional outcomes (22, 30), their ecological validity remains questionable given the lack of behavioral tracking in real-world contexts. For instance, Kay and Grimm's (23) single-session paradigm with exercise-naïve individuals cannot confirm effect persistence beyond controlled settings. Third, previous studies have often dichotomized exercise experience into “naïve” and “highly experienced” categories (23), thereby overlooking individuals with moderate exercise engagement—one of the most prevalent yet understudied group in non-athletic populations. The current research focuses on regulatory fit mechanisms within this specific group.

To resolve these interconnected limitations, we conduct a sequential investigation targeting moderate exercisers—a sport university undergraduate cohort representing non-specialized populations. Study 1 establishes baseline effects by replicating chronic regulatory fit's immediate impacts on exercise cognition and intention. Study 2 innovates through dual methodologies: (a) experimental induction of situational regulatory focus to disentangle state-level effects from chronic traits, and (b) seven-

day ecological assessment tracking real-world exercise frequency, duration, and intensity. This design uniquely bridges laboratory precision with ecological validity while testing two critical hypotheses: (1) whether transient motivational states can override habitual trait-based responses, and (2) how regulatory fit mechanisms operate in individuals with established (but non-expert) exercise routines.

2 Study 1: regulatory fit effect between chronic regulatory focus and the information frame

Study 1 aims to conceptually replicate previous studies investigating the immediate effect of regulatory fit between chronic regulatory focus and the exercise information frame on exercise-related cognition, emotion, and intention (18). We expect the exercise information frame that is congruent with one's chronic regulatory focus would bring about higher information value, more positive emotional experience, and more willingness to exercise.

2.1 Methods

2.1.1 Experimental design and procedures

The experimental design incorporated both categorical and continuous independent variables. Information framing (positive/negative) was manipulated as a dichotomous factor, while chronic regulatory focus was measured as a continuous construct. First, participants were instructed to complete the regulatory focus questionnaire. Second, participants received the manipulation of the exercise information frame. They were randomly assigned to read one of two pieces of information with different frames but the same theme and content. Finally, the dependent variables were measured by the persuasive effect questionnaire that taps exercise-related cognition, emotion, and intention.

2.1.2 Participants

We conducted *a priori* power analysis using G*Power 3.1.9.7 to estimate the required sample size (31). Based on effect sizes from regulatory fit studies in exercise contexts [(32): $f = 0.34$ – 0.39 ; (33): $f = 0.34$ – 0.36 ; (23): $f = 0.23$ – 0.42], we conservatively assumed a medium effect size ($f = 0.30$). For a 2×2 factorial ANOVA examining the interaction between regulatory focus and information framing, we set $\alpha = 0.05$, power $(1 - \beta) = 0.80$, and $f = 0.30$. The analysis indicated a target sample of 90. The final cohort comprised 121 non-athlete undergraduate students (48 male, 73 female; $M_{\text{age}} = 22.91$ years, $SD = 3.22$) recruited from a sports university, representing a population characterized by moderate but non-elite physical activity engagement. As detailed in Table 1, baseline assessments confirmed participants' weekly vigorous-intensity, moderate-intensity, and walking activity levels corresponded to normative values for young adults established in global population studies (1), effectively controlling for potential athletic performance confounds.

TABLE 1 Baseline information of participants in Study 1 ($M \pm SD$).

Dependent variable	Information frame	Chronic regulatory focus		<i>F</i>	<i>p</i>
		Promotion focus	Prevention focus		
Age (years)	PF	20.40 ± 1.71	20.66 ± 1.60	0.17	0.67
	NF	20.32 ± 1.67	20.32 ± 1.81		
Height (cm)	PF	173.17 ± 8.70	171.80 ± 8.44	0.62	0.43
	NF	170.52 ± 7.73	171.80 ± 7.33		
Weight (kg)	PF	55.08 ± 7.80	55.73 ± 7.05	0.50	0.47
	NF	56.12 ± 7.93	54.80 ± 7.26		
BMI (kg/m ²)	PF	21.11 ± 3.17	21.63 ± 4.03	0.76	0.38
	NF	20.16 ± 3.11	19.58 ± 3.26		
Walking PA	PF	434.48 ± 100.59	433.20 ± 103.06	0.64	0.42
	NF	450.68 ± 108.26	420.16 ± 86.09		
Moderate PA	PF	939.28 ± 167.11	901.00 ± 145.15	1.56	0.21
	NF	897.48 ± 142.73	934.12 ± 190.61		
Vigorous PA	PF	947.08 ± 203.53	986.20 ± 184.05	0.13	0.71
	NF	882.96 ± 195.04	948.00 ± 184.05		
Total PA	PF	2,320.85 ± 278.67	2,320.40 ± 220.49	0.55	0.45
	NF	2,231.12 ± 273.78	2,302.29 ± 271.61		

PF, positive frame; NF, negative frame; PA, physical activity.

2.1.3 Manipulation of the information frame

We created two pieces of exercise information with different frames but the same content. The positive frame emphasizes positive results (i.e., “Physical activity can raise metabolism, improve physique, boost immunity, and decrease disease incidence”), while the negative frame stresses negative results (i.e., “Absence of physical activity can reduce metabolism, negatively affect body image, diminish immunity, and increase disease incidence”).

2.1.4 Measures

2.1.4.1 Regulatory focus questionnaire

The Chinese version of the regulatory focus questionnaire (see [Supplementary Materials](#)), which has six questions on the promotion focus dimension and four on the prevention focus dimension, was translated and revised by Yao et al. (34). Eight of the questions are scored on a scale ranging from 1 (*never*) to 5 (*always*), while the other two are scored ranging from 1 (*completely wrong*) to 5 (*completely right*). To capture individuals’ dominant regulatory focus, a difference score was calculated by subtracting the prevention focus score from the promotion focus score. This continuous variable reflects the relative strength of regulatory focus, with higher scores indicating a promotion-oriented focus and lower scores indicating a prevention-oriented focus. In this study, Cronbach’s α of the promotion focus dimension and the prevention focus dimension are 0.68 and 0.70, respectively.

2.1.4.2 Persuasive effect questionnaire (PEQ)

The questionnaire was constructed based on three theoretically grounded dimensions—cognitive appraisal, affective response, and behavioral intention—derived from regulatory fit theory and persuasion research (13, 18). These dimensions were operationalized as follows: (1) information value, reflecting participants’ evaluations of the perceived validity, credibility, and persuasive efficacy of exercise-related content; (2) emotional

intensity, quantifying the magnitude of both positive (e.g., pleasure) and negative (e.g., sadness) affective states evoked by the information; (3) behavioral intention, assessing participants’ motivation to engage with exercise recommendations and their commitment to future behavioral modifications (see [Supplementary Materials](#)). All items employed a 5-point Likert-type scale (1 = Extremely inconsistent to 5 = Extremely consistent). Confirmatory factor analysis validated the hypothesized three-factor structure ($\chi^2/df = 1.18$; CFI = 0.99; TLI = 0.99; RMSEA = 0.04; SRMR = 0.05), with psychometric analyses confirming reliability at both subscale (information value: $\alpha = 0.78$; emotional intensity: $\alpha = 0.72$; behavioral intention: $\alpha = 0.85$) and the full-scale level ($\alpha = 0.82$), exceeding conventional thresholds for measurement precision.

2.1.4.3 International physical activity questionnaire (IPAQ)

This questionnaire asked participants to report how much vigorous physical activity, moderate physical activity, and walking physical activity they have done during the last 7 days. The amount of each type of physical activity was calculated as follows: The vigorous physical activity score = 8 × days of vigorous activity × time of vigorous activity per day; the moderate physical activity score = 4 × days of moderate physical activity × time of moderate physical activity per day; the walking physical activity score = 3.3 × walking days × walking time per day; the total physical activity score = the vigorous physical activity score + the moderate physical activity score + the walking physical activity score (35).

2.2 Results

2.2.1 Preliminary analyses

The means and standard deviations ($M \pm SD$) for the negative and positive frames across each variable were as follows: chronic

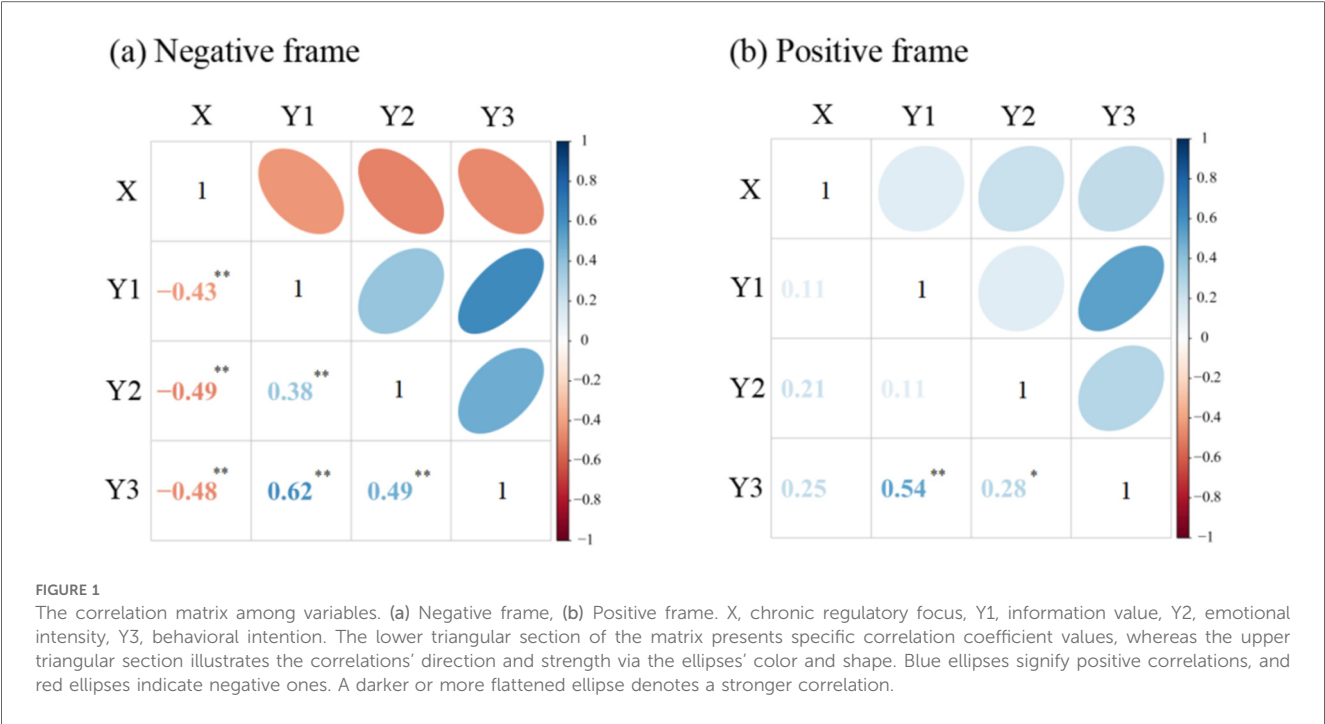


TABLE 2 Moderating model of information frame between chronic regulatory focus and persuasive effect.

Dependent variance	Independent variance	<i>R</i> ²	<i>F</i>	<i>β</i>	<i>SE</i>	<i>t</i>
Information value		0.13	5.69**			
	X			−0.34	0.15	−2.20*
	<i>M</i> _O			−0.12	0.16	−0.77
	<i>X</i> * <i>M</i> _O			0.99	0.31	3.20**
Emotional intensity		0.19	9.30**			
	X			−0.31	0.15	−2.00*
	<i>M</i> _O			−0.33	0.15	−2.08*
	<i>X</i> * <i>M</i> _O			1.31	0.31	4.20**
Behavioral intention		0.15	6.77**			
	X			−0.29	0.18	−1.61
	<i>M</i> _O			−0.28	0.18	−1.48
	<i>X</i> * <i>M</i> _O			1.38	0.36	3.77**

X, chronic regulatory focus; *M*_O, exercise information frame.

**p* < 0.05.

***p* < 0.01.

regulatory focus (0.41 ± 0.53 vs. 0.50 ± 0.49), information value (5.23 ± 0.97 vs. 5.08 ± 0.85), emotional intensity (4.93 ± 0.96 vs. 4.58 ± 0.92), behavioral intention (5.21 ± 1.23 vs. 4.91 ± 0.91), with no statistically significant between-group differences observed (all *ps* > 0.05).

Figure 1 presents the bivariate correlation matrices for both framing conditions. Within the negative framing condition, chronic regulatory focus demonstrated significant inverse associations with information value ($r = -0.43$, $p < 0.01$), emotional intensity ($r = -0.49$, $p < 0.01$), and behavioral intention ($r = -0.48$, $p < 0.01$). Positive correlations emerged between information value and emotional intensity ($r = 0.38$, $p < 0.01$), as well as behavioral intention ($r = 0.62$, $p < 0.01$). Emotional intensity further correlated positively with behavioral intention

($r = 0.49$, $p < 0.01$). Under positive framing, behavioral intention exhibited positive associations with both information value ($r = 0.54$, $p < 0.01$) and emotional intensity ($r = 0.28$, $p < 0.01$).

2.2.2 Regulatory fit effect between chronic regulatory focus and the information frame

Given that chronic regulatory focus (a continuous independent variable) and exercise information frame (a dichotomous independent variable) jointly influence persuasion outcomes (continuous dependent variables), we employed Hayes' PROCESS macro (Model 1) to examine their interactive effects, following established analytical procedures for moderation analysis. As shown in Table 2, chronic regulatory focus significantly predicted information value ($\beta = -0.34$, $p < 0.05$) and emotional intensity

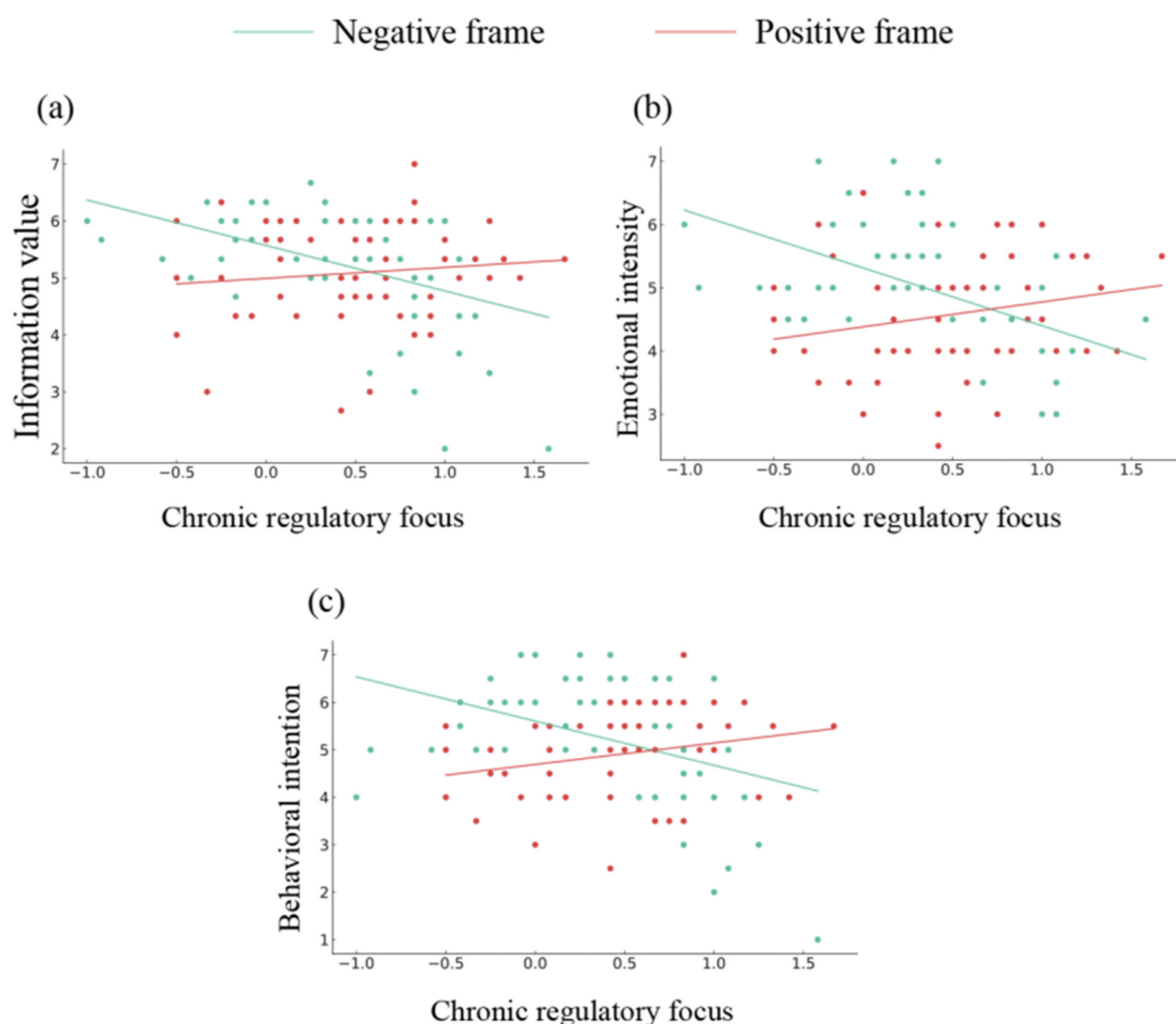


FIGURE 2

Interaction of chronic regulatory focus and exercise information frame predicting regulatory fit effect in Study 1. (a) Information value, (b) Emotional intensity, (c) Behavioral intention.

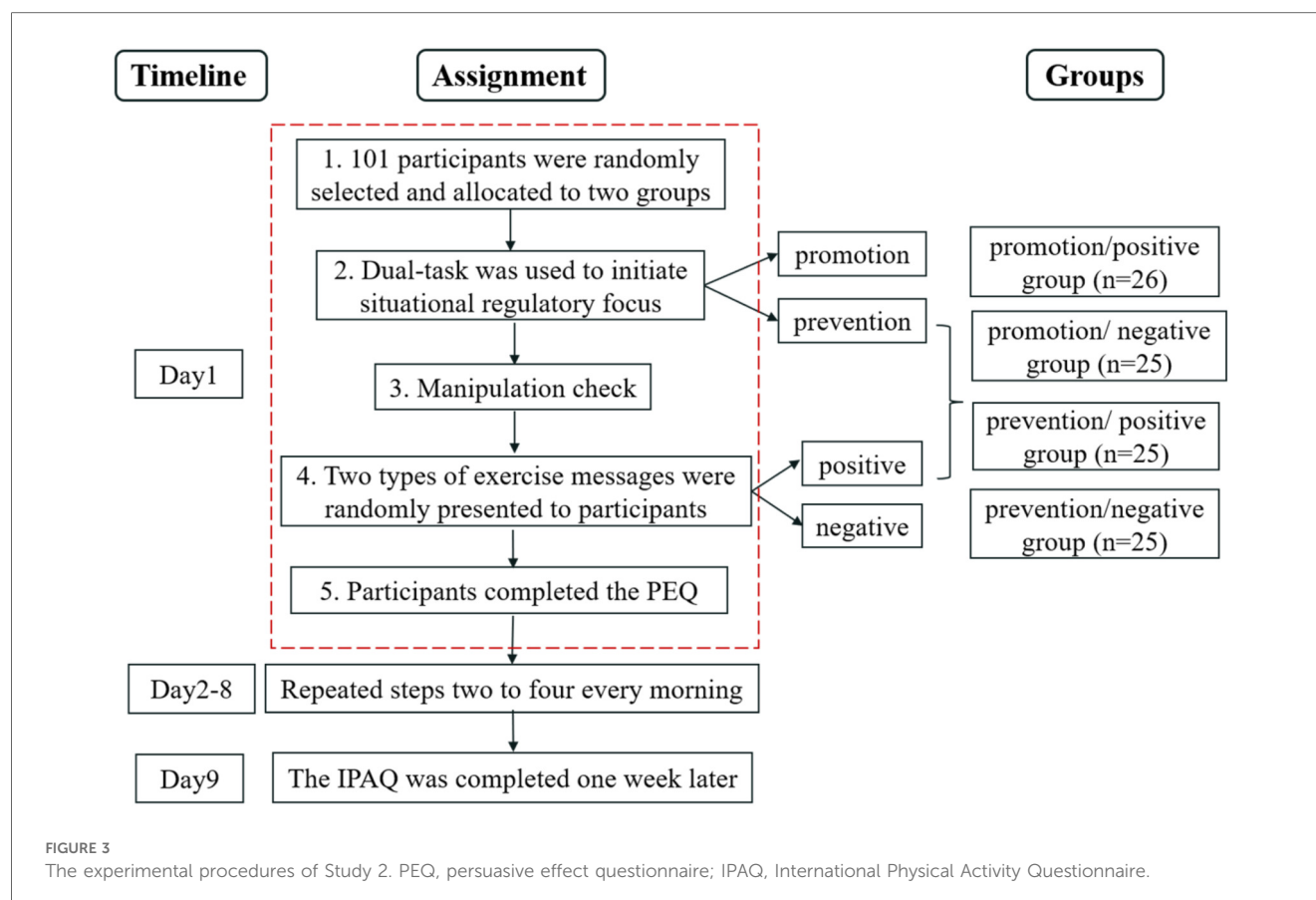
($\beta = -0.31$, $p < 0.05$). The exercise information frame also directly predicted emotional intensity ($\beta = -0.33$, $p < 0.05$). Notably, the interaction between chronic regulatory focus and exercise information frame significantly predicted information value ($\beta = 0.99$, $p < 0.01$), emotional intensity ($\beta = 1.31$, $p < 0.01$), and behavioral intention ($\beta = 1.38$, $p < 0.01$).

Subsequent simple slope analyses demonstrated that chronic regulatory focus exerted significant adverse effects on information value [effect = -0.80 , 95% CI (-1.20 , -0.39)], emotional intensity [effect = -0.91 , 95% CI (-1.31 , -0.51)], and behavioral intention [effect = -0.93 , 95% CI (-1.41 , -0.46)] within the negative framing condition. Notably, these effects failed to attain statistical significance under positive framing conditions. Specifically, prevention-focused participants displayed elevated scores for information value, emotional intensity, and behavioral intention following exposure to negative framing stimuli. Conversely, promotion-focused individuals exhibited comparatively higher scores on these dependent variables when

presented with positive framing, though these associations failed to reach statistical significance. The corresponding results are graphically depicted in Figure 2.

2.3 Discussion

Study 1 found that regulatory fit of chronic regulatory focus and the exercise information frame led to higher evaluation of exercise information, more positive emotional experience, and more willingness to exercise. However, it has been argued that behavioral intention might not always transfer to actual behavior, especially in the exercise domain (19). Therefore, in Study 2, in addition to testing the immediate effect of regulatory fit on information value, emotional intensity, and behavioral intention, we also tracked participants' actual exercise behavior in one week to examine the longitudinal effect of regulatory fit. We also used a dual task to prime



participants' situational regulatory focus to explore whether it has a similar effect as chronic regulatory focus.

3 Study 2: regulatory fit effect of situational regulatory focus and the exercise information frame

3.1 Methods

3.1.1 Experimental design and procedures

We adopted a 2 (situational regulatory focus: promotion vs. prevention) $\times$ 2 (exercise information frame: positive vs. negative) between-subjects design. On day 1, participants were first randomly assigned to be primed by either a promotion focus or a prevention focus. After the manipulation check questionnaire, they received the same manipulation of the exercise information frame shown in Study 1. Finally, they completed the persuasive effect questionnaire that taps exercise-related cognition, emotion, and intention, as shown in Study 1. During day 2 to day 8, they repeated steps two to four every morning in the same manner as on the initial day. On day 9, they were invited to fulfil the IPAQ. The experimental procedure was depicted in Figure 3.

3.1.2 Participants

As in Study 1, *a priori* power analysis using G*Power 3.1.9.7 for a 2 $\times$ 2 factorial design ($\alpha = 0.05$, power = 0.80, $f = 0.30$)

indicated a target sample size of 90. We recruited 101 college students (32 males, 69 females; $M_{age} = 21.23$, $SD = 2.81$) from the same university. As presented in Table 3, baseline demographic profiles confirmed participants' weekly vigorous-intensity, moderate-intensity, and walking activity levels corresponded to normative ranges for young adults documented in global epidemiological research (1), thereby maintaining population representativeness while controlling for athletic performance biases.

3.1.3 Manipulation of situational regulatory focus

The Dual-Task paradigm was employed to initiate the situational regulatory focus (36). The first one was a self-directed task, and the second one was a maze task on paper. In order to prime the promotion focus, participants were instructed to recollect their past or recent hopes or wishes and then complete the maze task. Specifically, there was a rat in the middle of the maze and a piece of cheese at the exit, and participants had to help the rat find the right path to get the cheese. To induce the prevention focus, individuals were required to recall their past or recent responsibilities or obligations and then fulfil the maze task. Specifically, participants needed to guide the rat to find the right path to escape the maze wherein a hungry eagle prowled over it and threatened the rat.

TABLE 3 Baseline information of participants in Study 2 ($M \pm SD$).

Dependent variable	Information frame	Situational regulatory focus		<i>F</i>	<i>p</i>
		Promotion focus	Prevention focus		
Age (years)	PF	20.36 $\pm$ 1.77	21.10 $\pm$ 1.58	1.63	0.20
	NF	20.62 $\pm$ 1.68	20.52 $\pm$ 1.75		
Height (cm)	PF	171.03 $\pm$ 8.29	170.40 $\pm$ 8.90	1.40	0.23
	NF	171.20 $\pm$ 8.68	174.48 $\pm$ 8.31		
Weight (kg)	PF	55.43 $\pm$ 10.14	53.10 $\pm$ 10.47	1.50	0.22
	NF	54.70 $\pm$ 10.76	51.44 $\pm$ 10.41		
BMI (kg/m ²)	PF	20.20 $\pm$ 3.54	20.40 $\pm$ 3.46	0.01	0.90
	NF	20.00 $\pm$ 2.97	20.04 $\pm$ 3.24		
Walking PA	PF	424.66 $\pm$ 95.03	447.16 $\pm$ 86.27	1.38	0.24
	NF	440.37 $\pm$ 96.24	420.68 $\pm$ 95.47		
Moderate PA	PF	893.13 $\pm$ 162.91	914.26 $\pm$ 147.74	1.18	0.27
	NF	990.83 $\pm$ 154.00	945.08 $\pm$ 172.82		
Vigorous PA	PF	913.36 $\pm$ 160.12	927.43 $\pm$ 181.26	0.95	0.33
	NF	935.50 $\pm$ 162.09	1,014.40 $\pm$ 185.12		
Total PA	PF	2,231.16 $\pm$ 248.41	2,288.86 $\pm$ 234.54	0.18	0.66
	NF	2,366.70 $\pm$ 262.25	2,380.16 $\pm$ 325.31		

PF, positive frame; NF, negative frame; PA, physical activity.

3.1.4 Manipulation of the information frame

The information frame manipulation was identical to that used in Study 1.

3.1.5 Measures

As Study 1, we used the PEQ to measure the persuasive effect and the IPAQ to measure physical activity. To do the manipulation check of regulatory focus priming, we used the questionnaire of Pham and Avnet (37) (see [Supplementary Materials](#)). It is composed of 3 questions that scored 7 points, with each having two opposite choices (e.g., I prefer to do whatever I promise to do vs. I prefer to go wherever I want to go). Individuals with lower scores are more inclined to be the prevention focus, while those with higher score are more likely to be the promotion focus.

3.2 Result

3.2.1 Manipulation of situational regulatory focus

The *t* test was used to check the manipulation of situational regulatory focus, which showed a significant difference between the two groups, $M_{\text{promotion focus group}} = 4.69$; $M_{\text{prevention focus group}} = 4.14$, $t(99) = 3.02$, $p < 0.01$, indicating that the manipulation of situational regulatory focus was successful.

3.2.2 Regulatory fit effect of situational regulatory focus and the exercise information frame

3.2.2.1 Preliminary analyses

As shown in [Table 4](#), in the positive frame condition, participants primed with a promotion focus scored higher on information value, emotional intensity, behavioral intention, and physical activity measured by the international physical activity questionnaire than those primed with a prevention focus. In the negative frame condition, the results were just the opposite. We conducted ANOVAs to test the significance, taking situational

regulatory focus and the exercise information frame as independent variables and information value, emotional intensity, behavioral intention, and physical activity measured by the international physical activity questionnaire as dependent variables.

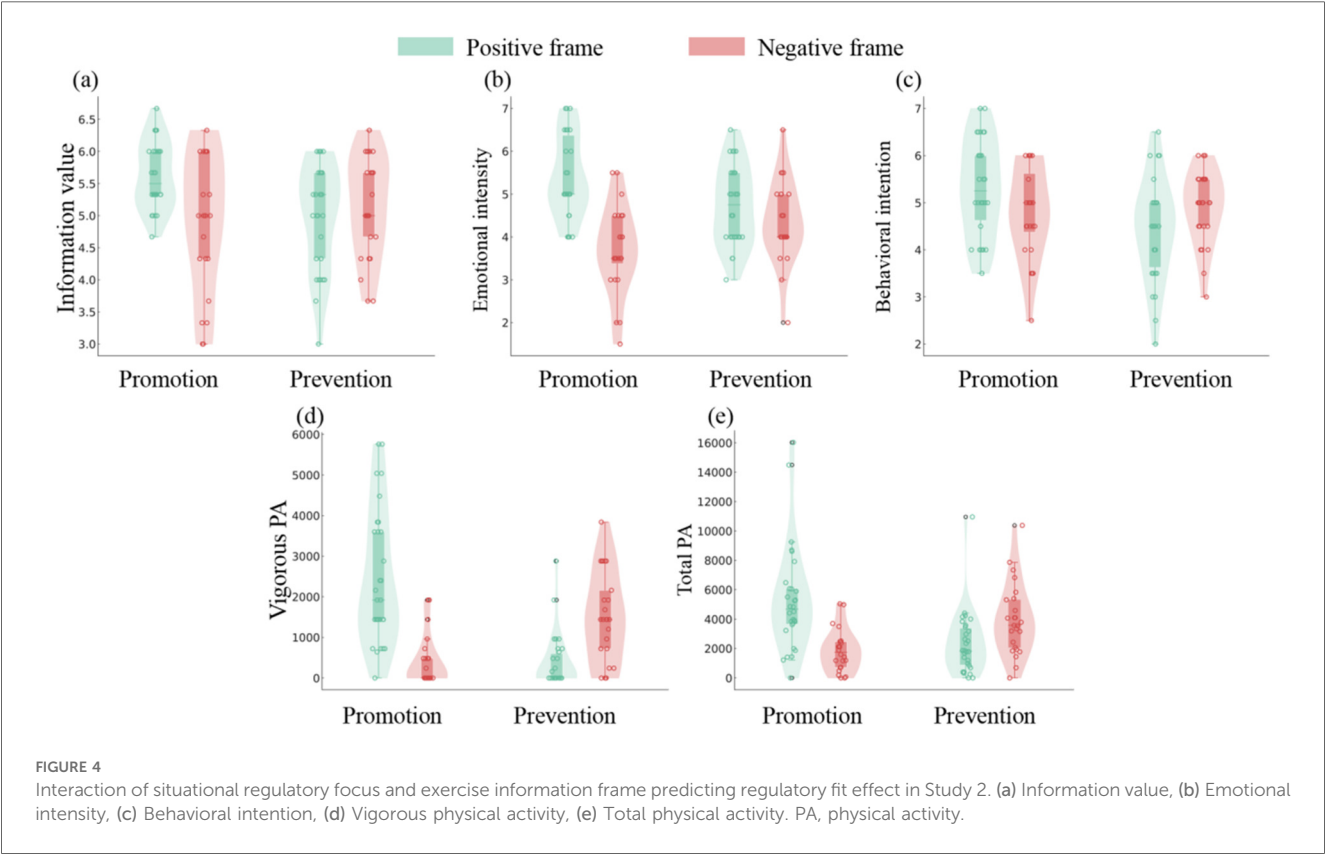
3.2.2.2 Combined effects of situational regulatory focus and message frame on persuasive outcomes and actual physical activity

- (1) Information value: The main effect of situational regulatory focus was significant, $F(1, 97) = 4.58$, $p = 0.04$, $\eta_p^2 = 0.05$. However, the main effect of the exercise information frame was not significant, $F(1, 97) = 1.60$, $p = 0.21$. Importantly, there was a significant interaction between situational regulatory focus and the exercise information frame (see [Figure 4A](#)), $F(1, 97) = 13.16$, $p < 0.01$, $\eta_p^2 = 0.12$.
- (2) Emotional intensity: The main effect of situational regulatory focus was not significant, $F(1, 97) = 0.80$, $p = 0.37$, while the main effect of the exercise information frame was significant, $F(1, 97) = 11.81$, $p < 0.01$, $\eta_p^2 = 0.11$. Furthermore, the interaction between situational regulatory focus and the exercise information frame was significant (see [Figure 4B](#)), $F(1, 97) = 19.65$, $p < 0.01$, $\eta_p^2 = 0.17$.
- (3) Behavioral intention: The main effect of the exercise information frame was not significant, $F(1, 97) = 1.75$, $p = 0.19$, whereas the main effect of situational regulatory focus [$F(1, 97) = 7.63$, $p = 0.01$, $\eta_p^2 = 0.07$] and the interaction [$F(1, 97) = 16.37$, $p < 0.01$, $\eta_p^2 = 0.14$] were significant (see [Figure 4C](#)).
- (4) Vigorous physical activity: The main effect of situational regulatory focus [$F(1, 97) = 4.05$, $p = 0.04$, $\eta_p^2 = 0.04$] and the exercise information frame [$F(1, 97) = 19.56$, $p < 0.01$, $\eta_p^2 = 0.17$] were significant. Moreover, the interaction was also significant (see [Figure 4D](#)), $F(1, 97) = 19.65$, $p < 0.01$, $\eta_p^2 = 0.17$.
- (5) Moderate physical activity: Both the main effect [$F(1, 97)_{\text{regulatory focus}} = 1.06$, $p = 0.31$, $F(1, 97)_{\text{information frame}} = 0.65$,

TABLE 4 Description statistics of variables in Study 2 ($M \pm SD$).

Dependent variable	Information frame	Situational regulatory focus	
		Promotion focus	Prevention focus
Information value	Positive frame	5.69 ± 0.51	4.81 ± 0.87
	Negative frame	4.94 ± 0.89	5.17 ± 0.73
Emotional intensity	Positive frame	5.42 ± 0.99	4.46 ± 0.93
	Negative frame	4.00 ± 0.93	4.64 ± 0.74
Behavioral intention	Positive frame	5.33 ± 1.00	4.16 ± 0.84
	Negative frame	4.86 ± 0.90	5.08 ± 0.97
Walking PA	Positive frame	393.85 ± 264.14	363.80 ± 262.75
	Negative frame	277.20 ± 163.38	411.60 ± 306.55
Moderate PA	Positive frame	951.54 ± 627.23	728.00 ± 347.95
	Negative frame	692.80 ± 467.54	823.20 ± 551.41
Vigorous PA	Positive frame	2,729.23 ± 1,083.12	1,190.40 ± 424.15
	Negative frame	819.20 ± 519.12	1,737.60 ± 866.11
Total PA	Positive frame	4,074.61 ± 1,440.93	2,282.20 ± 579.47
	Negative frame	1,789.20 ± 797.87	2,972.40 ± 1,635.57

PA, physical activity.



- $p = 0.42$] and the interaction [$F(1, 97) = 3.03, p = 0.09$] were not significant.
- (6) Walking physical activity: Neither the main effect [$F(1, 97)_{\text{regulatory focus}} = 1.79, p = 0.18, F(1, 97)_{\text{information frame}} = 0.46, p = 0.05$] nor the interaction [$F(1, 97) = 2.63, p = 0.11$] was significant.
- (7) Total physical activity: The main effect of situational regulatory focus [$F(1, 97) = 2.15, p = 0.15$] and the exercise information frame [$F(1, 97) = 14.74, p = 0.13$] were not significant.

However, the interaction was significant (see Figure 4E), $F(1, 97) = 51.27, p < 0.01, \eta_p^2 = 0.35$.

Further simple-effects analyses showed that under the positive frame, promotion-focused participants scored significantly higher on information value [$F(1, 97) = 16.95, p < 0.01, \eta_p^2 = 0.15$], emotional intensity [$F(1, 97) = 14.69, p < 0.01, \eta_p^2 = 0.13$], behavioral intention [$F(1, 97) = 23.23, p < 0.01, \eta_p^2 = 0.19$], vigorous physical activity [$F(1, 97) = 51.25, p < 0.01, \eta_p^2 = 0.34$],

TABLE 5 Situational regulatory fit effect in Study 2 (M ± SD).

Independent variables	Fit	Non-fit	t	p	d
Information value	5.44 ± 0.67	4.88 ± 0.88	3.59	0.00	0.72
Emotional intensity	5.04 ± 0.96	4.23 ± 0.95	4.25	0.00	0.85
Behavioral intention	5.21 ± 0.86	4.51 ± 0.93	3.92	0.00	0.78
Vigorous PA	2,243.14 ± 1,094.21	1,004.80 ± 505.23	7.33	0.00	1.47
Moderate PA	888.62 ± 588.94	710.40 ± 408.27	1.76	0.08	0.35
Walking PA	402.55 ± 282.97	320.50 ± 220.91	1.62	0.11	0.32
Total PA	3,534.31 ± 1,398.95	2,035.70 ± 733.67	6.72	0.00	1.35

and total physical activity [$F(1, 97) = 38.23, p < 0.01, \eta_p^2 = 0.28$] than those primed with a prevention focus. When faced with the negative frame, participants primed with a prevention focus scored significantly higher on emotional intensity [$F(1, 97) = 6.20, p = 0.01, \eta_p^2 = 0.06$], vigorous physical activity [$F(1, 97) = 17.60, p < 0.01, \eta_p^2 = 0.15$], and total physical activity [$F(1, 97) = 16.06, p < 0.01, \eta_p^2 = 0.14$] than those primed with a promotion focus. Put it differently, participants primed with a promotion focus scored significantly higher on information value [$F(1, 97) = 12.30, p < 0.01, \eta_p^2 = 0.11$], emotional intensity [$F(1, 97) = 31.41, p < 0.01, \eta_p^2 = 0.24$], behavioral intention [$F(1, 97) = 3.90, p = 0.05, \eta_p^2 = 0.04$], vigorous physical activity [$F(1, 97) = 78.11, p < 0.01, \eta_p^2 = 0.44$], and total physical activity [$F(1, 97) = 61.41, p < 0.01, \eta_p^2 = 0.38$] after reading the positively framed message than after reading the negatively framed message. Participants primed with a prevention focus scored higher on behavioral intention [$F(1, 97) = 14.27, p < 0.01, \eta_p^2 = 0.13$], vigorous physical activity [$F(1, 97) = 6.25, p = 0.01, \eta_p^2 = 0.06$], and total physical activity [$F(1, 97) = 5.46, p = 0.02, \eta_p^2 = 0.05$] after receiving the negative frame than after receiving the positive frame.

We divided participants into the regulatory fit group (promotion focus/positive frame group and prevention focus/negative frame group) and the regulatory non-fit group (promotion focus/negative frame group and prevention focus/positive frame group) to further verify the overall regulatory fit effect. The t test results showed a significant difference between the fit group and the non-fit group on all dependent variables except walking physical activity and moderate activity, as shown in Table 5.

3.2.2.3 Mediation analysis: linking Fit to exercise via persuasive outcomes

To examine the mediating role of persuasive outcomes in the regulatory fit-physical activity relationship, we conducted mediation analyses using Model 4 of the PROCESS macro for SPSS. The analytical protocol involved: (1) operationalizing regulatory fit as a dummy-coded independent variable (Non-fit = 1, Fit = 2), (2) standardizing and aggregating three persuasive measures (information value, emotional intensity, and behavioral intention) to form a composite mediator (persuasion effect index), and (3) separately analyzing standardized vigorous physical activity (VPA) and total physical activity (TPA) scores as dependent variables. Model 1 revealed significant mediation pathways for VPA (Table 6). Regulatory fit exerted both direct [$\beta = 0.51, p < 0.01, 95\% \text{ CI } (0.34, 0.67)$] and indirect effects

TABLE 6 Bootstrap test on the indirect effects of depression on relapse.

Model	Effect	Effect value	SE	LLCI	ULCI
Model 1	Direct effect	0.51	0.08	0.34	0.67
	Indirect effect	0.07	0.03	0.01	0.15
	Total effect	0.58	0.07	0.43	0.73
Model 2	Direct effect	0.39	0.09	0.21	0.57
	Indirect effect	0.05	0.04	0.01	0.14
	Total effect	0.45	0.08	0.27	0.62

LLCI, the lower limit of the confidence interval; ULCI, the upper limit of the confidence interval; Model 1, regulatory fit → persuasion effect → vigorous PA; Model 2, regulatory fit → persuasion effect → total PA. All variables in the model were standardized and then put into the regression equation.

through persuasive outcomes [$\beta = 0.07, p < 0.05, 95\% \text{ CI } (0.01, 0.15)$]. The total effect reached statistical significance [$\beta = 0.58, p < 0.01, 95\% \text{ CI } (0.43, 0.78)$], indicating partial mediation of the regulatory fit-VPA relationship by persuasive outcomes. Parallel analysis for TPA in Model 2 demonstrated similar mediation patterns with attenuated effects (Table 6). We observed a significant direct effect [$\beta = 0.39, p < 0.01, 95\% \text{ CI } (0.21, 0.57)$] and indirect pathway through persuasion [$\beta = 0.05, p < 0.05, 95\% \text{ CI } (0.01, 0.14)$]. The total effect remained significant [$\beta = 0.45, p < 0.01, 95\% \text{ CI } (0.27, 0.62)$], confirming partial mediation in the regulatory fit-TPA association.

4 Discussion

In this study, the regulatory fit theory was applied to explore the psychological benefits of matching regulatory focus (chronic/situational) with corresponding exercise information frame. Two experiments showed that individuals were inclined to evaluate the exercise information more positively, show higher emotional intensity, and be more willing to engage in physical activity when the exercise information frame matched with either their chronic or situational regulatory focus. More importantly, the results in Study 2 also revealed an enduring effect of regulatory fit on exercise behavior, showing regulatory fit led to more engagement in vigorous physical activity in the following week.

The current investigation advances regulatory fit theory in exercise behavior through four distinct contributions. First, the majority of current research on physical activity promotion primarily relies on external intervention methods, with limited integration of individual characteristics and advocacy information. However, it is imperative to amalgamate these two factors in research endeavors. This study investigated the impact of

regulatory focus as a representation of individual characteristics and an information framework for physical activity on perceived value and participation intention under both separate and interactive mechanisms. Second, although regulatory focus can be both chronically salient and situationally activated, most studies paid attention to only one form of regulatory focus when testing the effect of regulatory fit on exercise-related variables. Our two studies found that these two forms of regulatory focus had very similar effect on exercise-related cognition, emotion, and intention. The effect sizes (partial $\eta^2 = 0.11$ – 0.17) were consistent with those reported in previous research on regulatory fit [(31): $f = 0.34$ – 0.39 (32); $f = 0.34$ – 0.36 (23); $f = 0.23$ – 0.42], underscoring the well-established impact of aligning individuals' motivational orientations with message framing. Third, not only did we examine the immediate effect of regulatory fit, but we also tracked participants' actual behavior for one week and investigated the enduring effect of regulatory fit, which provides greater ecological validity. The results revealed notably stronger effects for vigorous physical activity ($\eta^2 = 0.17$) and total physical activity ($\eta^2 = 0.35$), exceeding the typical effect sizes observed in laboratory-based motor tasks. Similarly, Spiegel et al. (38) demonstrated that participants exposed to regulatory-fit-compatible messaging exhibited significantly greater behavioral improvements (e.g., a 21% increase in fruit and vegetable intake) compared to non-fit conditions over one week. These findings provide preliminary support for the translational potential of regulatory fit. However, these effects were only tested over a one-week period. Future research is needed to determine whether the benefits of regulatory fit can be sustained over longer durations. Fourth, our findings reveal robust regulatory fit effects in moderately active individuals, challenging Kay and Grimm's (23) assertion that such effects predominantly benefit exercise-naïve populations. This discrepancy stems from key methodological differences: Unlike prior studies categorizing exercise experience dichotomously (low vs. high), our focus on undergraduates with habitual yet non-elite activity patterns identified a transitional cohort retaining motivational plasticity—a population overlooked in earlier frameworks. Participants' routine exposure to physical activity in academic environments may have amplified their sensitivity to identity-aligned message framing. Crucially, our use of situational priming (rather than chronic regulatory focus measures) likely disrupted habitual tendencies, enabling fit-driven motivation even in moderately active individuals. Longitudinal tracking of vigorous physical activity, a behavior requiring conscious effort rather than routine habituation, further heightened sensitivity to regulatory fit effects. These insights underscore the need for future studies to adopt gradient-based stratification (naïve/moderate/elite) to clarify boundary conditions of regulatory fit.

It is intriguing why regulatory fit has such beneficial effect. According to the regulatory fit theory, regulatory focus acts as a “filter” that makes individuals more sensitive to corresponding information (39). When regulatory focus and the information frame achieve regulatory fit, individuals' ventromedial prefrontal cortex would be activated, which makes them more favorable to the advocacy message (40) and helps them process information more fluently (38). Furthermore, regulatory fit could also

improve individuals' sense of identity and correctness (41), enhancing concentration and experience value in decision-making (42). As a result, regulatory fit is advantageous for individuals in terms of cognition, emotion, intention, and behavior. Notably, recent theoretical advancements integrate regulatory focus theory (RFT) with self-determination theory (SDT) through the Need-Support Model (NSM), offering a nuanced perspective on how regulatory fit operates (43). SDT posits that autonomy, competence, and relatedness are fundamental psychological needs that drive motivation and well-being. The NSM bridges RFT and SDT by proposing that regulatory focus interacts with need satisfaction: Promotion-focused individuals exposed to gain-framed messages (e.g., “exercise enhances immunity”) experience heightened perceptions of autonomy (“I freely choose to exercise”), competence (“I can achieve fitness goals”), and relatedness (“exercise connects me to others”). This inflated need satisfaction elevates information valuation, triggers positive emotions (e.g., excitement), and reinforces intentions by framing vigorous activity as self-actualization rather than obligation. Conversely, prevention-focused individuals receiving loss-framed messages (e.g., “inactivity increases disease risk”) mitigate threats to autonomy (“I must exercise to avoid harm”) and competence (“I can prevent risks”), thereby preserving cognitive acceptance. By maintaining relatedness through perceived social responsibilities (e.g., “exercise fulfills family duties”), external pressures are transformed into controllable goals, reducing anxiety and stabilizing behavioral intentions. This dual-pathway mechanism—enhancing need satisfaction for promotion-focused individuals and minimizing need frustration for prevention-focused individuals—explains how regulatory fit sustains motivation across cognitive, affective, and behavioral domains. Such integration underscores the NSM's value in elucidating how motivational orientations and need-supportive environments jointly shape engagement in health behaviors and beyond.

Therefore, individuals can take advantage of the regulatory fit effect when engaging in physical activity. For instance, health management professionals and policymakers can effectively target individuals' regulatory focus to provide personalized physical activity information, thereby fostering individual exercise preferences. On one hand, data analysis can be utilized to construct an individual profile and discern their more stable trait regulatory focus. On the other hand, situational factors can stimulate the state regulatory focus of individuals. To promote physical activity among individuals with a promotion focus, it is recommended to encourage or induce positive mental associations following exercise in order to establish a positive body image or state. Conversely, for individuals with a preventive orientation, they should be guided to envision the physical characteristics resulting from lack of exercise and enhance their motivation to engage in physical activities by avoiding negative images. Once the regulatory fit is achieved, it will enhance motivation and enthusiasm for exercise, increase persistence in engaging in sports behavior, and maximize the persuasive impact of sports information.

It has to be noted that this study found insignificantly weak effect of regulatory fit on moderate physical activity and walking

activity. Moderate physical activity refers to activities that induce a slightly faster heartbeat, such as lifting light objects and cycling at a regular speed. Walking is defined as moving from one place to another for recreation and exercise. The insignificance of the difference in these activities between the fit and non-fit groups may be attributed to a ceiling effect, such that moderate physical exercise and walking are common activities for college students' daily lives, especially for our participants who were from a sport university.

Finally, there are some limitations in our study. First, the measurement of exercise behavior needs to be improved. Although we utilized a subjective approach to monitor exercise behavior, potential issues remain. For instance, the international physical activity questionnaire relies on subjective recall, which may be influenced by memory bias, social desirability bias, emotional motivation and other factors that could compromise the scale's reliability and validity. More accurate and portable assessments could be used in follow-up research to measure objective exercise behavior. Second, the current research did not test chronic and situational regulatory focuses simultaneously, which requires a much larger sample size to achieve adequate statistical power. It is intriguing for future research to explore which form of regulatory fit is more dominant when individuals' chronic regulatory focus and situationally activated focuses are discrepant. Third, the homogeneity of our sample (university students with habitual yet non-elite activity patterns) may constrain the ecological validity of findings. Future studies should prioritize diversified recruitment strategies and incorporate measures of sociocultural and motivational covariates to enhance generalizability.

5 Conclusion

When there is a fit between the exercise information frame and regulatory focus, individuals tend to evaluate the exercise information more positively, show more positive emotions, are more willing to take part in exercise, and may engage in more actual physical activity. This study broadens the scope of the regulatory fit theory's applicability, promotes the development of sports and exercise research topic, and provides guidance for the practice of physical activity.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/vj2gm/?view_only=a12a3b0df1be4e73981d92bde5f13d26.

Ethics statement

The studies involving humans were approved by the ethics committee of School of Psychology, Beijing Sport University. The

studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CS: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft. YG: Data curation, Writing – original draft. JL: Data curation, Writing – original draft. GZ: Conceptualization, Project administration, Supervision, Writing – review & editing. JD: Conceptualization, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fspor.2025.1564917/full#supplementary-material>

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Association between exercise self-efficacy and physical activity in elderly individuals: a systematic review and meta-analysis

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Objective: In an aging population, the problem of insufficient physical activity among the elderly is increasingly recognized. Exercise self-efficacy, a critical determinant of physical activity in this demographic, has garnered increasing attention recently. This review focuses on healthy older adults, systematically reviewing the research progress on the relationship between exercise self-efficacy and physical activity in later life. It analyzes the correlation between the two factors and their influencing factors, and explores the mechanism of exercise self-efficacy in promoting physical activity among the elderly.

Methods: In accordance with the standards set by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, an extensive literature search was conducted across five electronic databases: Web of Science, PubMed, ProQuest, Scopus, and EBSCOhost. The search period spanned from January 1, 2000, to October 20, 2024. A rigorous quality assessment was performed on the selected studies, with methodological and outcome data extracted via a standardized data extraction form. The meta-analysis of the included studies was conducted via Stata 18 software, along with tests for between-study heterogeneity and an evaluation of publication bias.

Results: The literature screening process yielded 19 studies that provided data on the correlation between physical activity and exercise self-efficacy. These studies employed Pearson correlation analysis (15 studies), multiple regression analysis (6 studies), and structural equation modeling (SEM) (4 studies). A random-effects model was used to pool the effect sizes, revealing an average correlation coefficient of $r = 0.412$ ($p < 0.001$). The average standardized coefficient for the effect of exercise self-efficacy on physical activity was $\beta = 0.386$ ($p < 0.001$), and the average path coefficient for the effect of physical activity on exercise self-efficacy was $\gamma = 0.481$ ($p < 0.001$).

Conclusion: A significant positive correlation was found between exercise self-efficacy and physical activity among elderly individuals, with a moderate degree of influence of exercise self-efficacy on physical activity participation. Conversely, physical activity also positively impacts exercise self-efficacy in elderly individuals. These findings provide a theoretical basis for encouraging elderly individuals to engage in physical activities and enhance their quality of life. Future research should further investigate the roles of various influencing

factors and develop targeted intervention strategies to promote more active participation in physical activities among elderly individuals.

KEYWORDS

exercise self-efficacy, physical activity, elderly, correlation, meta-analysis

1 Introduction

The aging of the global population has brought the issue of insufficient physical activity among the elderly to the forefront. Studies indicate that appropriate physical activity can significantly enhance the health and well-being of older adults, prevent chronic diseases, and improve quality of life (Sun et al., 2013). However, many elderly individuals exhibit low levels of physical activity due to various factors. According to the 2020 World Health Organization (WHO) guidelines, only a fraction of older adults engage in regular physical exercise, particularly in multicomponent activities focused on functional balance and strength training (WHO, 2020). Consequently, strategies to increase physical activity levels in elderly individuals have become a research priority. In this context, exercise self-efficacy, as a pivotal psychological factor in promoting physical activity among elderly individuals, has gained attention. Exercise self-efficacy reflects an individual's confidence in participating in and adhering to physical exercise, a concept rooted in Bandura's self-efficacy theory, which emphasizes that individual behavior is influenced by beliefs about one's capabilities and anticipated outcomes (Bandura and Wessels, 1997). This systematic review focuses on individuals aged 60 and above to align with the World Health Organization's definition of older adults and to address the unique health challenges faced by this population. This systematic review aims to uncover the psychological motivation mechanisms underlying elderly individuals' participation in physical activity by examining the association between exercise self-efficacy and physical activity, providing a scientific basis for developing effective intervention strategies to enhance physical activity engagement and overall health in elderly individuals.

While the association between self-efficacy and physical activity has been extensively studied in adolescents and adults, few review studies have focused on the elderly population. For example, Craggs et al. (2011) noted in their review on determinants of physical activity change in children and adolescents that self-efficacy was related to physical activity changes in older children. Similarly, in their review on physical fitness, exercise self-efficacy, and quality of life in adulthood, Medrano-Ureña et al. (2020) found that the majority of studies reported a significant correlation between exercise self-efficacy and physical activity. This research bias may have led to an underestimation of the importance of self-efficacy in strategies to promote physical activity among elderly individuals. Given the distinct physiological and psychological developmental stages of adolescents and adults, their mechanisms of self-efficacy formation and function may significantly differ from those of elderly individuals. Physical activity participation in the elderly is often influenced by physiological constraints, chronic diseases, and changes in social roles, making it crucial to conduct research specific to the elderly to understand their unique needs and challenges in physical activity.

Previous research has fallen short in addressing the relationship between self-efficacy and the general healthy population, with a majority of studies focusing on pathological groups. For example,

Hamidi et al. (2022) reported a significant association between self-efficacy and physical activity in diabetic patients. Similarly, Selzler et al. (2020) noted a positive correlation between self-efficacy and functional exercise capacity as well as physical activity in individuals with COPD, although the strength of this association is influenced by the choice of measurement tools. Current review studies predominantly focus on general self-efficacy, with limited attention given to exercise self-efficacy, potentially overlooking its unique role in facilitating physical activity. General self-efficacy pertains to an individual's overall confidence in facing challenges, whereas exercise self-efficacy is more specific, relating to the confidence level in engaging in sports activities (Bandura, 1997). Given that exercise self-efficacy directly impacts the selection, persistence, and effort invested in sports activities (McAuley et al., 2006), research targeting this domain is essential for developing precise intervention strategies for promoting physical activity among elderly individuals.

The innovation of this study lies in the fact that it is the first systematic review and meta-analysis specifically focusing on healthy elderly individuals to explore the bidirectional relationship between exercise self-efficacy and physical activity. Previous reviews, such as those by Selzler et al. (2020) and Hamidi et al. (2022), primarily targeted clinical populations (e.g., individuals with chronic obstructive pulmonary disease or diabetes mellitus), whereas this study focuses on healthy older adults. Furthermore, it is the first to integrate effect sizes from various statistical methods, including correlation coefficients, regression coefficients, and path coefficients from structural equation modeling. This methodological innovation allows for the quantification of between-study variations in results, providing more robust scientific evidence for developing interventions to promote physical activity among elderly individuals.

This systematic review aims to examine the association between exercise self-efficacy and physical activity in elderly individuals, uncover the psychological mechanisms underlying their participation in physical activity, and provide a scientific basis for developing targeted interventions to enhance physical activity engagement, improve health outcomes, and address the global challenge of aging populations.

2 Method

2.1 Literature search strategy

This study adheres to the PRISMA 2020 Statement (Page et al., 2021) and systematically documents the entire literature search process. The search covered five databases: Web of Science, PubMed, ProQuest, Scopus, and EBSCOhost, with the search period ranging from January 1, 2000, to October 20, 2024. The search criteria were set to include documents in which the title or abstract contained 'physical activity' OR 'exercise' OR 'circuit training' OR 'resistance training' OR 'aerobic training' OR 'leisure-time activity' OR 'sport participation' OR

'exercise therapy' OR 'sports' OR 'physical fitness' OR 'swimming' OR 'walking' OR 'water exercise' OR 'power training' OR 'muscle stretching exercise' AND 'exercise self-efficacy' OR 'self-efficacy' OR 'self-efficacy beliefs' OR 'self-efficacy levels' AND 'elderly' OR 'senior citizens' OR 'aged 80 and above' OR 'octogenarian' OR 'nonagenarian' OR 'centenarian'.

This study only included English—language peer-reviewed literature published from January 1, 2000 to October 20, 2024. This period saw key development in studying the relationship between elderly exercise self-efficacy and physical activity. Significant progress was made in theory construction, measurement tool development, and research—method innovation. This ensured the included literature's theoretical, methodological, and tool—related advancement and scientific rigor, offering high—quality data for the systematic review and meta—analysis. Limiting the literature—source platform and time—span boosted data reliability and authority, enhancing the research results' generalizability and academic worth.

The research team's English proficiency enabled accurate data extraction and ensured the reliability of the study's findings. English, as the main language of international academic exchange, encompasses a vast number of high-quality research results. However, this choice of excluding non-English studies might limit the general applicability of the research outcomes. Future research could enhance the comprehensiveness of its results by incorporating studies in multiple languages.

2.2 Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) participants aged 60 years and older, with an average age exceeding 65 years; (2) studies that included an assessment of exercise-related self-efficacy; (3) research involving an evaluation of physical activity; (4) quantitative analysis of the association between exercise-related self-efficacy and physical activity; (5) studies that were cross-sectional, longitudinal, or long-term; and (6) publications in English.

The exclusion criteria were as follows: (1) This study only included healthy elderly individuals, excluding those with specific diseases such as cardiovascular disease or diabetes. The subjects were defined as individuals without major chronic diseases or health issues; (2) studies not published in peer-reviewed journals; (3) studies with a sample size less than 50; (4) studies that did not provide data on the association between exercise-related self-efficacy and physical activity; and (5) review or regression analysis articles. To ensure the rigor and relevance of this systematic review and meta-analysis, specific inclusion and exclusion criteria were established. We focused on individuals aged 60 years and older with an average age exceeding 65 years, as this population represents the senior demographic with distinct physiological and psychological characteristics regarding physical activity participation. Studies involving specific disease populations such as those with cardiovascular conditions or diabetes were excluded because these groups may have unique restrictions and motivations for physical activity that differ from the general healthy elderly population.

Cross-sectional, longitudinal, and long-term studies were included to capture the complex temporal relationships between exercise self-efficacy and physical activity. Cross-sectional studies provide a snapshot of the association at a single point in time, while

longitudinal and long-term studies allow for the examination of causal relationships and changes over time. Only peer-reviewed studies were considered to guarantee the scientific quality and credibility of the included research, as the peer-review process involves rigorous evaluation of study design, data collection, and analysis methods by experts in the field.

Studies with samples of less than 50 were excluded for statistical reasons. Small samples are more likely to have sampling errors, which can make effect size estimates inaccurate and lower statistical power. While removing such studies helps ensure the meta—analysis results on the exercise self-efficacy and physical activity relationship are reliable and valid, it might also exclude studies with extreme results, affecting funnel plot symmetry. It is important to acknowledge that the exclusion of studies with a sample size less than 50 may have influenced the results of this meta-analysis. While this criterion was applied to reduce statistical heterogeneity and enhance the reliability of the findings, it is possible that some studies with smaller sample sizes but potentially significant results were excluded. This could have affected the symmetry of the funnel plot and potentially introduced bias. Future research should consider incorporating studies with smaller sample sizes to provide a more comprehensive understanding of the relationship between exercise self-efficacy and physical activity in elderly individuals.

After de-duplication of the retrieved literature, two researchers independently screened the studies on the basis of the inclusion and exclusion criteria. Initially, a preliminary screening was conducted through titles and abstracts to identify potentially relevant studies for full-text review. While confirming studies for full-text review, a meticulous examination of the reference lists of the obtained full-text articles and other systematic reviews was subsequently conducted to ensure that no eligible studies were missed. Finally, the included studies were identified by consensus between the two researchers. In the case of discrepancies in the screening results, a third researcher made the final decision.

2.3 Data extraction

Data were extracted independently by two authors on the basis of the inclusion criteria, with any discrepancies resolved through consultation. The extracted information included the following: (1) author names and publication year; (2) study location; (3) type of study design; (4) methods for assessing exercise self-efficacy; (5) methods for assessing physical activity; (6) statistical analysis techniques; (7) measures of association (e.g., correlation coefficients, standardized coefficients); (8) key findings of the studies.

2.4 Quality assessment of the literature

In this study, one reviewer assessed the quality of the included studies, and another reviewer verified the assessment. The Risk of Bias in Non-randomized Studies—of Exposure [ROBINS - E (Higgins et al., 2024)] tool was used for the risk - of - bias assessment. ROBINS-E assesses the risk of bias in non-randomized exposure studies across multiple dimensions: confounding control (D1), exposure measurement accuracy (D2), participant selection (D3), post-exposure intervention effects (D4), missing data handling (D5),

outcome measurement reliability (D6), and selective outcome reporting (D7). Each dimension's risk of bias was rated as low (+), of some concern (/), or high (−). This comprehensive evaluation helps researchers identify and measure potential study biases, enhancing the reliability and validity of the findings.

2.5 Statistical analysis

Each study included in this review provided data on the association between exercise self-efficacy and physical activity in elderly individuals, along with the sample size. For longitudinal studies, we selected baseline association data for analysis; for studies that used different assessment tools, we conducted a meta-analysis to combine the association data. The meta-analysis was performed using Stata 18 software, and the converted effect sizes were analyzed. We used a fixed effects model ($I^2 < 50\%$ and $p > 0.05$) or a random effects model ($I^2 \geq 50\%$ or $p < 0.05$) based on the results of the heterogeneity test. The level of heterogeneity was assessed using the I^2 index and categorized as low ($I^2 \leq 25\%$), moderate ($25\% < I^2 \leq 50\%$), or high ($I^2 > 50\%$) (Liu et al., 2023; Higgins et al., 2003). To detect publication bias, we performed Egger's test and presented the analysis results in funnel plots.

3 Results

3.1 Study selection process

After the initial and full-text screening, 19 studies were included for analysis (see Figure 1). All of them satisfied the inclusion criteria and offered relevant data on the relationship between exercise self-efficacy and physical activity. The database search initially yielded 4,603 potentially relevant articles. After removing duplicates, 2,536 unique articles were screened by title and abstract, with 2,385 being excluded on the basis of the inclusion criteria. A full-text review was conducted for the remaining 151 articles, resulting in the exclusion of 136 articles for various reasons. The primary reasons for exclusion were as follows: 73 articles lacked original data, 45 studies focused on specific populations (e.g., patients with diseases, veterans), and 18 studies did not involve exercise-related self-efficacy. A total of 19 articles met all the inclusion criteria from January 2000 to October 2024.

3.2 Basic characteristics of the included studies

Table 1 provides a comprehensive summary of the fundamental details of the 19 studies included in this review. Of the 19 studies incorporated in this review, 68.42% (13 studies) utilized a cross-sectional design, while 31.58% (6 studies) employed a longitudinal design. Regarding the geographical distribution, 57.89% (11 studies) were conducted in the United States, with the remaining 42.11% (8 studies) carried out in the United Kingdom, Spain, Germany, Korea, Indonesia, and Chinese Taipei. The sample sizes of these studies varied, ranging from 71 to 884 participants. Among these studies, 15 conducted

correlation analysis and reported correlation coefficients (r). Six studies further employed multiple regression analysis, presenting standardized coefficients (β) and standard errors (SE). Furthermore, four studies employed structural equation modeling and reported path coefficients (γ) with their 95% confidence intervals. The PRISMA flow diagram (Figure 1) illustrates the process of study selection and the reasons for excluding studies.

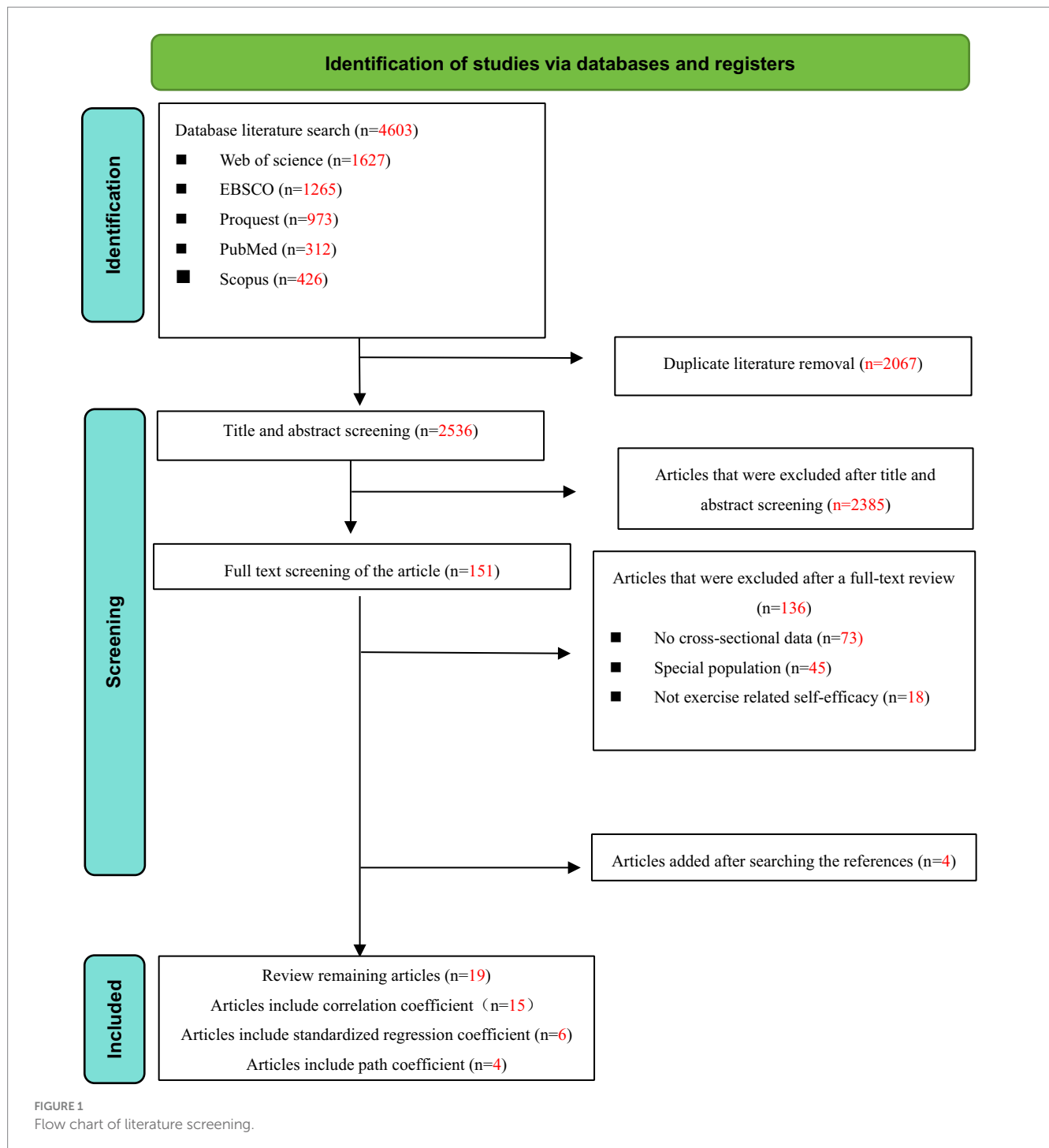
3.3 Quality assessment of the included studies

The risk of bias assessment results obtained using the ROBINS-E (Higgins et al., 2024) tool. The studies selected for the review showed variability in the different quality assessment domains.

Results – Six studies were found to have a low risk of bias across all analyzed domains. Most studies were judged to have some concerns, due to reasons such as incomplete adjustment for all confounders, issues with exposure measurement, participant selection, post-exposure interventions, missing data, outcome measurement, and selective reporting of results. The overall certainty of the evidence for any specific outcome was not determined, as no indication was provided in the supplied data. For other unmentioned outcomes, we also did not determine the certainty of the evidence due to insufficient information to assess it based on the given data (see Table 2).

3.4 Assessment tools for physical activity in elderly populations

This study incorporated six different tools to evaluate the frequency and energy expenditure of physical activities among elderly individuals. The Physical Activity Scale for the Elderly (PASE) (Washburn et al., 1993) was utilized in nine studies, providing a comprehensive assessment of daily activities, leisure, and exercise over the past week. Additionally, the Godin Leisure Time Exercise Questionnaire (GLTEQ) (Godin and Shephard, 1985) was applied in four studies, two of which also employed the PASE. The GLTEQ assesses leisure-time physical activity by documenting the frequency and duration of light to vigorous exercise over a year. One study used the Community Health Activities Model Program for Seniors questionnaire (CHAMPS) (Stewart et al., 2001), which spans a range of physical activities from walking to vigorous exercise. The Global Physical Activity Questionnaire (GPAQ) (Armstrong and Bull, 2006), developed by the World Health Organization (WHO), was used in one study to evaluate physical activity across work, travel, and leisure domains. Similarly, the Physical Activity Index from the College Alumnae Questionnaire (PAI-CAQ) (Paffenbarger et al., 1978) was used in one study to assess physical activity levels. Furthermore, two studies employed Actigraph accelerometers to collect objective data on physical activity (Hendelman et al., 2000). An additional four studies (Perkins et al., 2008; Warner et al., 2011; Mullen et al., 2012; Ainsworth et al., 2000) assessed physical activity through inquiries or reports on exercise frequency. These tools offer a multifaceted approach to evaluating physical activity in elderly populations, including the quantification of activity frequency and energy expenditure (see Table 3).



3.5 Assessment of exercise self-efficacy in elderly individuals

The studies included in this review primarily employed four tools to assess the self-efficacy of elderly individuals in engaging in physical activities. The Exercise Self-efficacy scale (ESE) (McAuley, 1993) was used in 10 studies and is widely applied to evaluate individuals' self-efficacy in maintaining exercise participation. The ESE consists of nine items that measure the confidence level of maintaining a 20-min exercise routine three times a week, despite challenges such as adverse weather, boredom, and physical

discomfort. Additionally, two studies utilized the Self-Efficacy for Walking scale (WSE) (McAuley et al., 2000), which focuses on assessing participants' belief in their walking ability, particularly their ability to successfully complete walks of increasing duration from 5 to 40 min at a moderate pace. The Barriers Self-Efficacy scale (BSE) (McAuley, 1992) was employed in three studies to evaluate individuals' perceived ability to overcome common barriers to exercise, with the aim of understanding participants' confidence in maintaining a 40-min exercise routine three times a week over the next 2 months. Finally, the Physical Self-Efficacy scale (PSE) (Bosscher et al., 1993), which includes 10 statements about physical

TABLE 1 Summary of the included literature.

Number	Author, year	Study design	Country	Sample size	Age (years) mean (SD) [range]	Percentage girls (%)	Instruments used(PA)	Instruments used(ES)	Analysis	Association indicators	Conclusion
1	Langan and Marotta (2000)	CS	US	228	>60	66.2%	PAI-CAQ	PSE	multiple regression	$\beta = 0.19$ ($p < 0.05$) $R^2 = 0.036$	The results of the analysis identified physical activity as the only significant predictor of physical self-efficacy, accounting for 3.6% of the variance in the PSE scores.
2	Laffrey (2000)	CS	US	71	60–87(71.37)	100%	PAQ	S-E	correlations multiple regression	$r = 0.5$ ($p < 0.01$) $\beta = 0.36$ ($p < 0.01$)	Exercise self-efficacy is significantly and positively related to physical activity levels among older Mexican American women, suggesting that enhancing self-efficacy may contribute to promoting greater physical activity engagement in this population.
3	Brassington et al. (2002)	LS	US	103	>65(70.18)	65%	Exercise intervention	SEE	correlations multiple regression	$r = 0.46$ ($p < 0.01$) $\beta = 0.37$ ($p < 0.001$)	Improving exercise self-efficacy and helping older adults achieve health-related goals are key to promoting exercise adherence.
4	McAuley et al. (2003)	LS	US	174	60–75(66)	74.1%	PASE	BSE ESE	SEM	$\gamma = 0.42$	Self-efficacy is a key factor in predicting older adults' long-term adherence to physical activity and can be enhanced through social support, exercise-related affect, and exercise frequency.
5	McAuley et al. (2005)	LS	US	152/126	60–75(66.7)	72%	PASE	ESE	bivariate correlations	12-month: $r = 0.28$ 60-month: $r = 0.09$	Physical activity and self-efficacy were related at 1 year, but the relationship between changes in these variables over time was non-*significant. However, the lack of association may be attributed to the manner in which self-efficacy and physical activity were assessed in the present study.
6	McAuley et al. (2007)	LS	US	174	>60 (66.7)	71.8%	PASE	ESE	bivariate correlations	$r = 0.32$	Being more efficacious and reporting more positive affect at Year 2 were significantly associated with higher levels of activity at both Years 2 and 5.
7	Morris et al. (2008a)	LS	US	137	(69.6)	100%	PASE	BSE	correlation matrix SEM	Baseline: $r = 0.261$ 6-month: $r = 0.360$ $\gamma = 0.26$ (B)	As hypothesized, self-efficacy was directly associated with physical activity.
8	Perkins et al. (2008)	CS	Spain and US	108(53/55)	63–92 (76.7)	58.3%	Exercise frequency inquiry	ESE	multiple regression	Spain: $\beta = 0.391$ US: $\beta = 0.486$ ($p < 0.05$)	The finding that self-efficacy is significantly associated with participation in physical activity replicates previous studies that found greater self-efficacy of physical activity led to a higher likelihood of participating in physical activity.

(Continued)

TABLE 1 (Continued)

Number	Author, year	Study design	Country	Sample size	Age (years) mean (SD) [range]	Percentage girls (%)	Instruments used(PA)	Instruments used(ES)	Analysis	Association indicators	Conclusion
9	Morris et al. (2008b)	CS	US	136	63–75 (69.7)	100%	Actigraph accelerometer	ESE	bivariate correlations multiple regression	$r = 0.42$ $\beta = 0.29$	Among older women, self-efficacy, functional limitations and street connectivity demonstrated independent contributions to physical activity behavior.
10	Harris et al. (2009)	CS	UK	238	≥ 65	47.9%	Actigraph accelerometer	ESE	linear regression	Moderate ($p < 0.05$) 1,108 (267 to 1949) High ($p < 0.05$) 1885 (139 to 3,631)	The independent effects of exercise self-efficacy and exercise control on PA levels highlight their roles as potential mediators for intervention studies.
11	Grant-Savella (2010)	CS	US	197	60–96(71.5)	55.3%	PASE	SEE	correlations	$r = 0.18$ ($p < 0.05$)	Enhancing older adults' self-efficacy may boost their frequency and duration of physical activity participation, thereby elevating their overall physical activity levels.
12	Paxton et al. (2010)	CS	US	196	66–82 (74)	75%	GLTEQ	BSE WSE	correlations	$r = 0.61$	Older adults who participate in physical activity may enhance their self-efficacy beliefs for physical activity and improve their mental health.
13	Warner et al. (2011)	LS	German	309	65–85 (73.3)	42%	Exercise frequency inquiry	ESE	correlations multiple regression	$r = 0.40$ $\beta = 0.65$ $R^2 = 0.28$	Support received from friends and exercise self-efficacy were specified as predictors of exercise frequency while baseline exercise, sex, age, and physical functioning were controlled for. In addition to main effects of self-efficacy and social support, an interaction between social support and self-efficacy emerged.
14	Mullen et al. (2012)	CS	US	884	>65 (74.8)	77%	Walking behavior inquiry	WSE	correlations SEM	$r = 0.26$ $\gamma = 0.36$	Walking more frequently and for longer duration was positively associated with beliefs in capabilities of walking incrementally further distances.
15	Mudrak et al. (2016)	CS	Czech	546	≥ 60 (68)	79.2%	GLTEQ PASE	BSE	correlations SEM	LTEQ/LPASE $r = 0.284$ PASE/LPASE $r = 0.234$ $\gamma = 0.808$	Physical activity predicted self-efficacy, which in turn predicted global QOL through mental and physical health status.
16	Miller et al. (2019)	CS	Australia	586	65–96 (72.5)	70.6%	CHAMPS	ESE	bivariate correlations	$r = 0.44$	Exercise behavior (measured as calories per week) is significantly correlated with exercise self-efficacy.
17	Juwita and Damayanti (2022)	CS	Indonesia	106	≥ 60 (74.4)	60%	GPAQ	ESE	bivariate correlations	$r = 0.6$	There is a significant correlation between self-efficacy and physical activity in the elderly with a value of $r = 0.6$, which indicates a positive direction and a strong correlation level.

(Continued)

TABLE 1 (Continued)

Number	Author, year	Study design	Country	Sample size	Age (years) mean (SD) [range]	Percentage girls (%)	Instruments used (PA)	Instruments used (ES)	Analysis	Association indicators	Conclusion
18	Lee and Fan (2023)	CS	Taiwan	183	≥65 (74.4)	70.73%	PASE	A modified version of a previous scale	bivariate correlations	$r = 0.29$	Self-rated health and self-efficacy were the significant variables in physical activity for middle-aged and elderly individuals. In addition, neighborhood environment and the interaction between self-efficacy and the neighborhood environment were significant variables in middle-aged adults.
19	Dawe et al. (2024)	CS	US/ITA	726	≥65 (72.57)	51.1%	GLTEQ	ESE	Spearman correlation	$r = 0.531$	Exercise Self-efficacy has shown a large positive correlation with the leisure score index.

C, Cross-sectional study; LS, Longitudinal study; SEM, Structural Equation Model testing; PAI-CAQ, Physical Activity Index from the College Alumnus Questionnaire; PAQ, Physical Activity Questionnaire; S-E, Self-Efficacy (S-E) questionnaire; LTPA, Leisure Time Physical Activity; PASE, Physical Activity Scale for the Elderly; ESE, Exercise Self-Efficacy scale; WSE, Self-Efficacy for Walking; PSE, Physical Self-Efficacy scale; BSE, Barriers Self-Efficacy scale; SEE, Self-Efficacy for Exercise Scale; GLTEQ, Godin Leisure Time Exercise Questionnaire; QOL, quality of life; CHAMPS, Community Health Activities Model Program for Seniors questionnaire; GPAQ, Global Physical Activity Questionnaire.

capabilities, was used in two studies, with respondents indicating their agreement or disagreement on a 5-point Likert scale.

3.6 Meta-analysis

3.6.1 Meta-analysis of the correlation between physical activity and exercise self-efficacy in elderly individuals

Among the 19 studies included, 15 provided data on the correlation between physical activity and exercise self-efficacy in elderly individuals. To standardize the analysis, Spearman’s rho (ρ) coefficients reported in the literature were converted to Pearson’s r coefficients via the following formula: $r \approx 6 \sin(\pi\rho/6)/\pi$. These coefficients were then transformed into Fisher’s Z scores for meta-analysis, along with the calculation of standard errors (SE) and 95% confidence intervals (CI) (Borenstein et al., 2011; Szczuka et al., 2021).

A random-effects model was used to conduct the meta-analysis on the correlation coefficients (r values) and their 95% CIs. The results revealed a pooled effect size of 0.412, with a 95% CI ranging from 0.326 to 0.497, indicating a significant overall correlation. The heterogeneity test yielded a chi-square value of 101.45 with 14 degrees of freedom and a p value less than 0.0001, suggesting significant heterogeneity among studies. The I-squared value of 86.2% indicates that 86.2% of the variability in effect sizes can be attributed to heterogeneity between studies. Moreover, the z test for an effect size of zero yielded a value of 9.40 with a p value less than 0.0001, further confirming the statistical significance of the findings (see Figure 2).

Converting the pooled Fisher’s Z scores and 95% CIs back to Pearson’s r , the average correlation coefficient was found to be 0.390, with a 95% CI ranging from approximately 0.315 to 0.460. Therefore, the average correlation between physical activity and exercise self-efficacy in elderly individuals is 0.390, with a 95% CI of 0.315 to 0.460.

3.6.2 Meta-analysis of the impact of exercise self-efficacy on physical activity in the elderly

Among the 19 studies included, six employed multiple regression analysis to provide effect sizes (standardized coefficients β) of exercise self-efficacy on physical activity in elderly individuals. The 95% confidence intervals were calculated via the following formula: 95% CI = $\beta \pm 1.96 \times SE$. A random-effects model was used to conduct the meta-analysis on the standardized coefficients β and their 95% CIs.

The results indicate a pooled effect size of 0.386, with a 95% CI ranging from 0.221 to 0.551, suggesting a significant positive impact of exercise self-efficacy on physical activity in elderly individuals. The heterogeneity test yielded a chi-square value of 31.00 with 5 degrees of freedom and a p value less than 0.0001, indicating significant heterogeneity among studies. The I-squared value of 83.9% suggested that 83.9% of the variability in effect sizes was due to heterogeneity between studies. Furthermore, the z test for an effect size of zero yielded a value of 4.58 with a p value less than 0.0001, further confirming the statistical significance of the findings (see Figure 3).

In summary, exercise self-efficacy has a moderate positive impact on physical activity in elderly individuals, with a standardized coefficient of 0.386. This implies that for every standard deviation increase in exercise self-efficacy, there is an average increase of 0.386 standard deviation units in physical activity levels among elderly individuals.

TABLE 2 The risk of bias in non-randomized studies—of exposures (ROBINS-E) assessment tool (for follow-up studies).

Study	D1	D2	D3	D4	D5	D6	D7	Overall risk of bias
Langan and Marotta (2000)	/	+	+	+	+	/	+	/
Laffrey (2000)	+	+	/	+	+	+	+	+
Brassington et al. (2002)	/	/	+	/	+	/	+	/
McAuley et al. (2003)	/	/	/	+	/	+	/	/
McAuley et al. (2005)	+	+	/	+	/	+	+	/
McAuley et al. (2007)	+	+	/	+	+	/	+	/
Morris et al. (2008a)	+	+	/	+	/	+	+	/
Perkins et al. (2008)	+	+	/	+	+	/	+	/
Morris et al. (2008a, 2008b)	+	+	/	+	+	+	+	+
Harris et al. (2009)	+	+	+	+	+	+	+	+
Grant-Savella (2010)	+	/	/	+	+	/	+	/
Paxton et al. (2010)	+	+	/	+	+	/	+	/
Warner et al. (2011)	+	+	+	+	+	/	+	+
Mullen et al. (2012)	+	/	+	+	+	/	+	/
Mudrak et al. (2016)	+	/	+	+	+	+	+	+
Miller et al. (2019)	+	+	+	+	+	/	+	+
Juwita and Damayanti (2022)	+	+	/	+	+	/	+	/
Lee and Fan (2023)	+	+	/	+	+	/	+	/
Dawe et al. (2024)	+	+	+	+	+	/	+	+

D1: Risk of bias due to confounding. D2: Risk of bias arising from measurement of the exposure. D3: Risk of bias in selection of participants into the study (or into the analysis). D4: Risk of bias due to post-exposure interventions. D5: Risk of bias due to missing data. D6: Risk of bias arising from measurement of the outcome. D7: Risk of bias in selection of the reported result. Judgement. +: Low risk of bias. /: some concerns. -: High risk of bias.

TABLE 3 List of physical activity assessment tools for elderly individuals.

Evaluation tool	Full name	Author, year
PASE	Physical Activity Scale for the Elderly	Washburn et al. (1993)
GLTEQ	Godin Leisure Time Exercise Questionnaire	Godin and Shephard (1985)
PAI-CAQ	Physical Activity Index from the College Alumnus Questionnaire	Paffenbarger et al. (1978)
GPAQ	Global Physical Activity Questionnaire	Armstrong and Bull (2006)
CHAMPS	Community Health Activities Model Program for Seniors questionnaire	Stewart et al. (2001)
Actigraph accelerometer	Actigraph-provided ActiLife Monitoring System	Hendelman et al. (2000)

3.6.3 Meta-analysis of the impact of physical activity on exercise self-efficacy in elderly individuals

Among the 20 studies included, four utilized structural equation modeling (SEM) to assess the impact of physical activity on exercise self-efficacy in elderly individuals, providing effect sizes in the form of path coefficients (γ). Standard errors (SE) and 95% confidence intervals (95% CI) were calculated via path coefficients and sample sizes with the following formulas: $SE = \gamma / \sqrt{n}$, $95\% CI = \gamma \pm 1.96 \times SE$. A random-effects model was employed for the meta-analysis of the path coefficients γ and their 95% CIs.

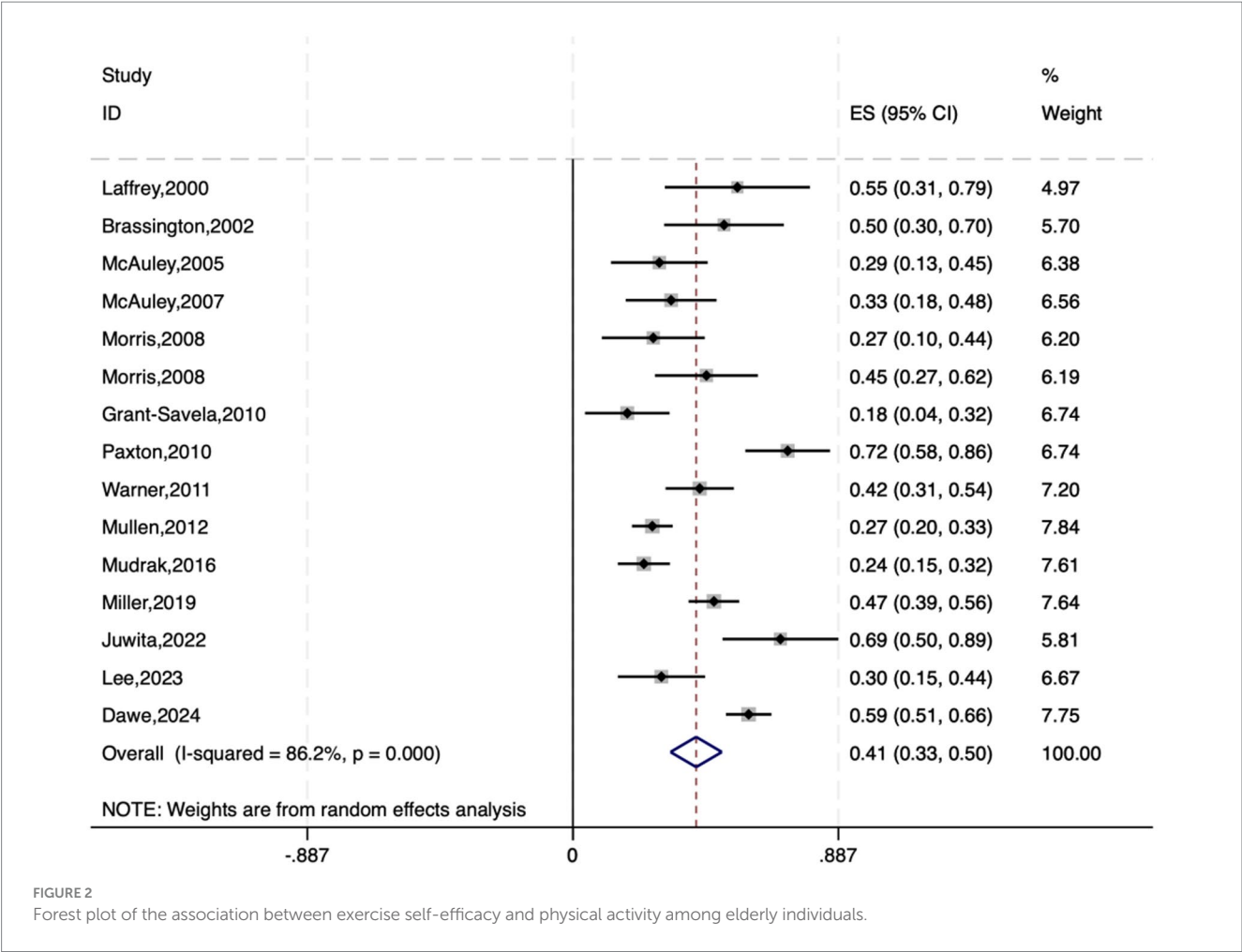
The results revealed a pooled effect size of 0.481, with a 95% CI ranging from 0.211 to 0.750, indicating a significant positive impact of physical activity on exercise self-efficacy in elderly individuals. The heterogeneity test yielded a chi-square value of 14.59 with 3 degrees of freedom and a p value less than 0.01, suggesting significant heterogeneity among studies. The I-squared value of 79.4% indicates

that 79.4% of the variability in effect sizes is due to heterogeneity between studies. Moreover, the z test for an effect size of zero yielded a value of 3.49 with a p value less than 0.0001, further confirming the statistical significance of the findings (see Figure 4).

In summary, physical activity in elderly individuals has a moderate positive impact on exercise self-efficacy, with an average path coefficient of 0.481. These findings suggest that an increase in the level of physical activity among the elderly is associated with a corresponding increase in their exercise self-efficacy, with an estimated increase of approximately 48.1% in the activity level.

3.7 Subgroup analysis

To investigate the impacts of different physical activity assessment tools on the results, a subgroup analysis was conducted. Specifically, the data were divided into three subgroups on the basis of the use of



the PASE, GLTEQ, and other assessment tools. These tools included the PASE (6studies), GLTEQ (3 studies), and other tools, such as the Actigraph accelerometer (7studies), which were used to analyze the associations between physical activity and exercise self-efficacy in elderly individuals.

The subgroup analysis revealed that the pooled effect size for the PASE was 0.237 (95% CI: 0.184 to 0.290), that for the GLTEQ was 0.510 (95% CI: 0.236 to 0.785), and that for the other assessment tools was 0.461 (95% CI: 0.353 to 0.569). The *p* values for all three subgroups were less than 0.001, indicating a significant effect across studies. Heterogeneity tests revealed that the I-squared values for the PASE, GLTEQ, and other tools were 0.0, 96.1, and 80.5%, respectively, indicating significant heterogeneity within each subgroup (see Figure 4).

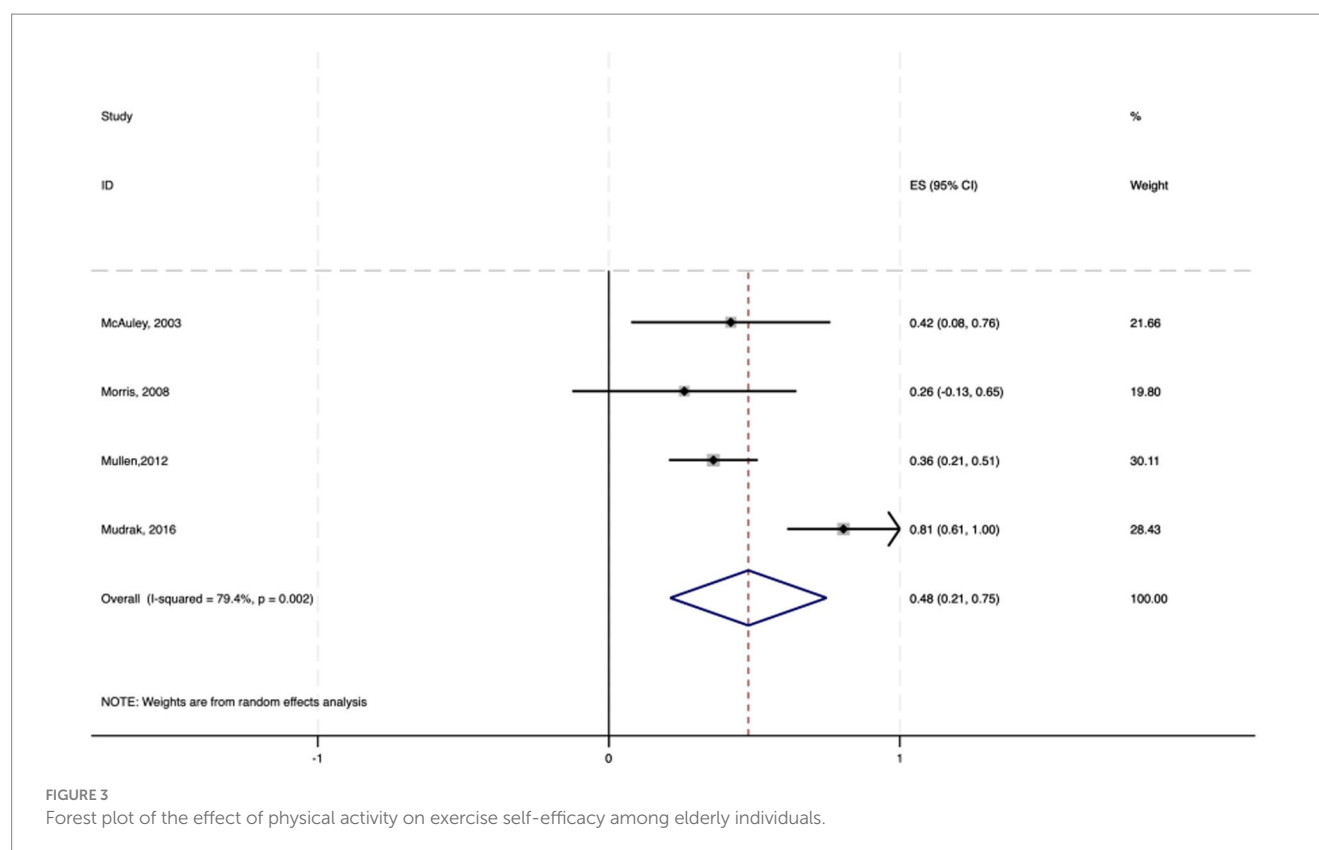
After converting the Fisher's *z* scores and 95% CIs back to correlation coefficients and their 95% CIs, the correlation coefficient between PASE and exercise self-efficacy was found to be 0.232 (95% CI: 0.182 to 0.282), that between the GLTEQ score and exercise self-efficacy was 0.470 (95% CI: 0.231 to 0.656), and that between other tools and exercise self-efficacy was 0.431 (95% CI: 0.339 to 0.514). Therefore, the average correlation coefficients between the PASE, GLTEQ, and other tools with exercise self-efficacy were 0.232, 0.470, and 0.431, respectively.

3.8 Publication Bias assessment

Publication bias in the included studies was examined via funnel plots and Egger's test. The symmetry of the funnel plots (Figure 5) and the intercept coefficient *p* values from Egger's test (Table 4) for different types of effect sizes (statistical correlation data *r*, standardized coefficient β , and path coefficient γ) were 0.613, 0.471, and 0.517, respectively. These findings suggest that there is no publication bias in the statistical correlation data *r*. Additionally, there is insufficient evidence to indicate the presence of small sample effects or publication bias for the standardized coefficient β and path coefficient γ .

4 Discussion

By adhering to PRISMA guidelines, it aims to comprehensively and transparently outline the current evidence regarding this relationship in older adults. Our analysis of 19 high—quality studies (both cross—sectional and longitudinal) shows a significant positive link between exercise self—efficacy and physical activity. Exercise self—efficacy positively affects physical activity and vice versa. These results highlight their bidirectional relationship, offering a theoretical basis for promoting physical activity and enhancing the quality of life in older adults.



To further explore this association, we conducted subgroup analysis on the basis of different physical activity assessment tools, such as the PASE scale and GLTEQ. The findings indicated a positive correlation between physical activity and exercise self-efficacy within all subgroups, validating the effectiveness of the assessment tools. However, heterogeneity tests among subgroups highlighted significant differences between studies, which may be attributed to variations in sample characteristics, research design, and measurement tools. Previous research has highlighted the limitations of traditional assessment tools. For instance, McAuley et al. (2005) and Harris et al. (2009) pointed out these limitations and recommended the use of more refined evaluation methods.

Furthermore, we performed a publication bias assessment, with neither funnel plots nor Egger's test indicating bias, thereby enhancing the reliability of our results. These findings provide empirical evidence for understanding the role of exercise self-efficacy in promoting physical activity among elderly individuals and offer guidance for future research directions and methodologies.

This review makes an important breakthrough compared to previous studies. Early studies often focused on clinical populations (e.g., individuals with chronic obstructive pulmonary disease or diabetes) or younger groups. In contrast, this review demonstrates that the bidirectional relationship between self-efficacy and physical activity is also prevalent in healthy elderly populations and is not affected by disease-related factors. Unlike Medrano-Ureña et al. (2020), who emphasized a unidirectional path in adults, this review leverages longitudinal and structural equation modeling meta-analyses to provide more robust empirical support for Bandura (1997)

interactional theory. It underscores the importance of designing interventions that target both self-efficacy and physical activity simultaneously.

4.1 The specificity and objectivity of the assessment tools

The study employed multiple tools to measure physical activity and exercise self-efficacy, including the Physical Activity Scale for the Elderly (PASE) and the Godin Leisure Time Exercise Questionnaire (GLTEQ). These tools differ significantly in measurement precision, time frame, and subjectivity. For instance, the PASE focuses more on daily activities, while the GLTEQ emphasizes leisure-time physical activity. Despite their respective advantages and limitations, both tools are widely used in their respective fields and have established reliability and validity.

To further verify this association, we performed a subgroup analysis across different tools. All subgroups showed a positive correlation, indicating these tools' validity in measuring the relevant variables. Yet, the heterogeneity testing between subgroups revealed significant study-to-study differences. This might stem from the tools' specificity—related biases, such as those between self-reported and objectively measured data. McAuley et al. (2005) and Harris et al. (2009) highlighted the limitations of traditional tools. By incorporating multidimensional assessment tools like SEM and accelerometers, this study partly addresses their criticisms. However, there's still a need to develop more specific and objective tools tailored to the physiological and psychological characteristics of elderly individuals to reduce bias and enhance measurement precision.

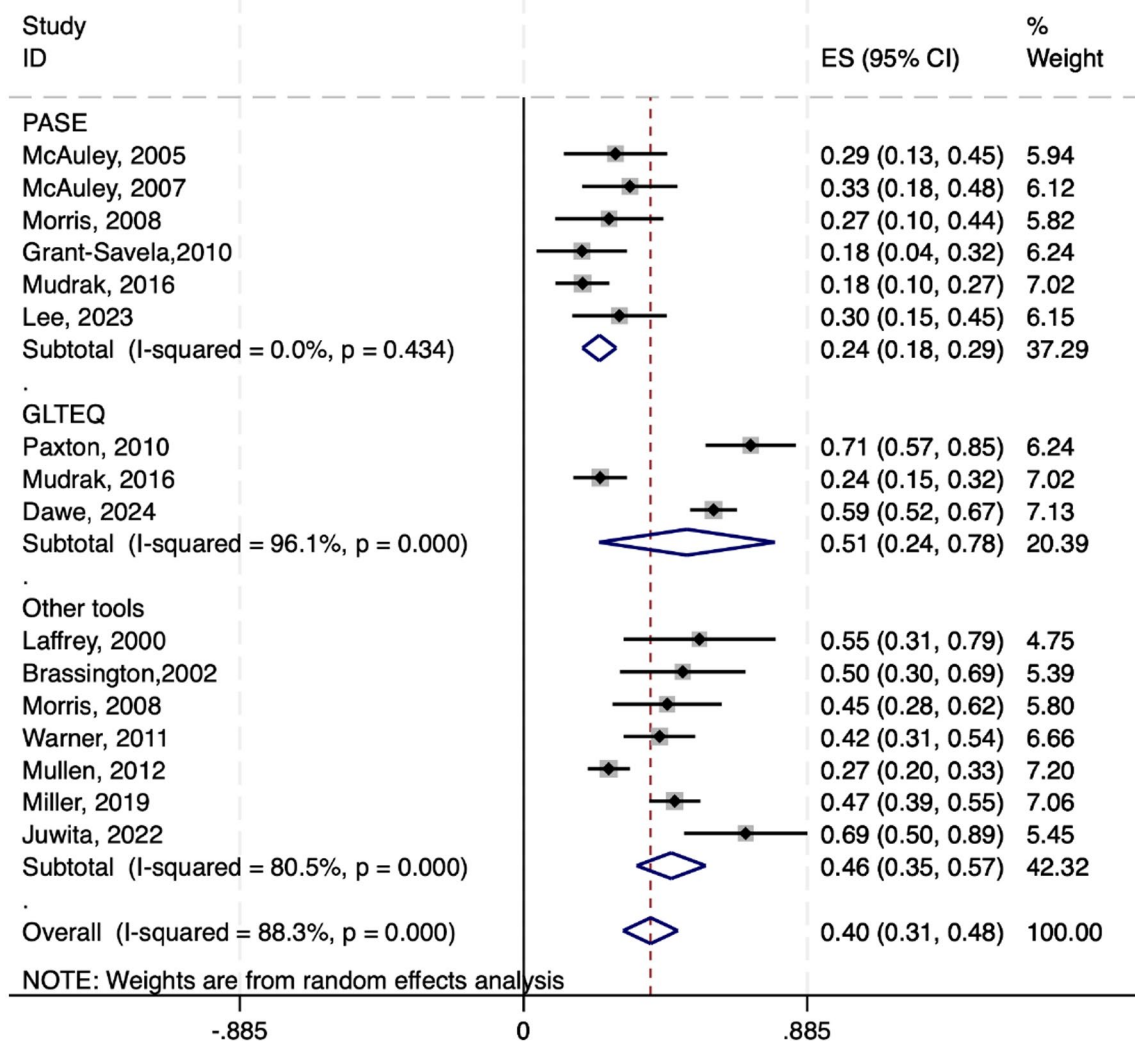


FIGURE 4
Forest plot of the subgroup analysis based on different physical activity assessment tools.

4.2 Mechanisms underlying the association between physical activity and exercise self-efficacy in elderly individuals

The meta-analysis of correlation coefficients revealed a moderate positive relationship between physical activity and exercise self-efficacy among the elderly (average correlation coefficient $r = 0.412$, $p < 0.001$), suggesting that elderly individuals who actively engage in physical activity tend to have greater exercise self-efficacy. This finding aligns with previous review studies on patients with chronic obstructive pulmonary disease (COPD) (Selzler et al., 2020) and diabetes mellitus (DM) (Hamidi et al., 2022), which also revealed a link between increased self-efficacy and increased levels of physical activity.

Additionally, a meta-analysis of six studies using multiple regression analysis showed a significant positive link between exercise self-efficacy and physical activity levels in the elderly (average standardized coefficient $\beta = 0.386$, $p < 0.001$). The results of this study underscore the pivotal role of exercise self-efficacy in promoting

physical activity in elderly individuals, which is consistent with Bandura (1977) self-efficacy theory. Elderly individuals with high exercise self-efficacy are more likely to participate in and adhere to physical exercise, as they believe that they can overcome challenges such as physical discomfort and poor weather. This positive mindset and behavioral pattern combination aids in overcoming physical and psychological barriers, thereby enhancing physical activity levels. This perspective is supported by several studies, including those by Lee and Fan (2023) and Perkins et al. (2008), which indicate that exercise self-efficacy is a significant factor in promoting the participation of elderly individuals in physical and social activities.

Furthermore, the meta-analysis of structural equation model data revealed a significant relationship between increased physical activity and increased exercise self-efficacy in elderly individuals (average path coefficient of 0.481, $p < 0.001$). These findings suggest that physical activity can enhance exercise self-efficacy in elderly individuals, which may be related to the positive health impacts of physical activity. Research by Mullen et al. (2012) shows that physical activity not only improves physical function but also reduces functional limitations,

thereby promoting the development of exercise self-efficacy. Paxton et al. (2010) also highlighted the role of mental health in this process. Also, the slight asymmetry in Figures 2, 6 may hint at publication bias. But Egger's test had a p value > 0.05 , indicating no significant bias. This minor asymmetry might stem from study diversity, varying sample sizes, and different measurement tools. Overall, there is a positive feedback loop between physical activity and exercise self-efficacy in elderly individuals: physical activity enhances self-efficacy, which in turn promotes more physical activity. This

bidirectional relationship suggests that interventions to promote physical activity in the elderly should consider both enhancing exercise self-efficacy and encouraging active participation in physical activities to create a virtuous cycle. These findings provide important theoretical and practical support for improving the quality of life of elderly individuals.

4.3 Other factors associated with physical activity and exercise self-efficacy

The association between physical activity and exercise self-efficacy in elderly individuals is influenced by various factors, including social support, the neighborhood environment, cultural differences, and occupational involvement. Social support, a frequently cited factor in the literature, plays a significant role in the physical activity participation and exercise self-efficacy of elderly individuals. Research by Orsega-Smith et al. (2007) indicates that social support from friends is significantly associated with perceived physical self-efficacy and long-term physical activity (LTPA) among elderly individuals. Warner et al. (2011) further suggested that the interaction between exercise self-efficacy and social support enhances the frequency and persistence of physical exercise in elderly individuals.

The neighborhood environment is also a crucial factor. Morris et al. (2008b) reported that satisfaction with the neighborhood environment and perceived functional status are key predictors of exercise self-efficacy and subsequent physical activity behaviors. Lee and Fan (2023) emphasized the interactive relationship between the neighborhood environment and exercise self-efficacy, confirming its positive impact on promoting physical activity.

Cultural differences cannot be overlooked. Dawe et al. (2024) revealed variations in the associations between exercise self-efficacy and physical activity across different cultural contexts. Occupational background is another significant factor. Juwita and Damayanti (2022) reported that elderly individuals who continue to be occupationally involved exhibit higher levels of physical activity and confidence in their exercise capabilities.

4.4 Limitations and recommendations for future research

This study offers robust evidence for the relationship between exercise self-efficacy and physical activity, yet some limitations warrant attention. First, the majority of the included studies focused on the elderly population in the United States. This geographic concentration may affect the generalizability of the findings to other regions. The social and cultural context in the United States, such as the emphasis on individualism and the availability of specific physical

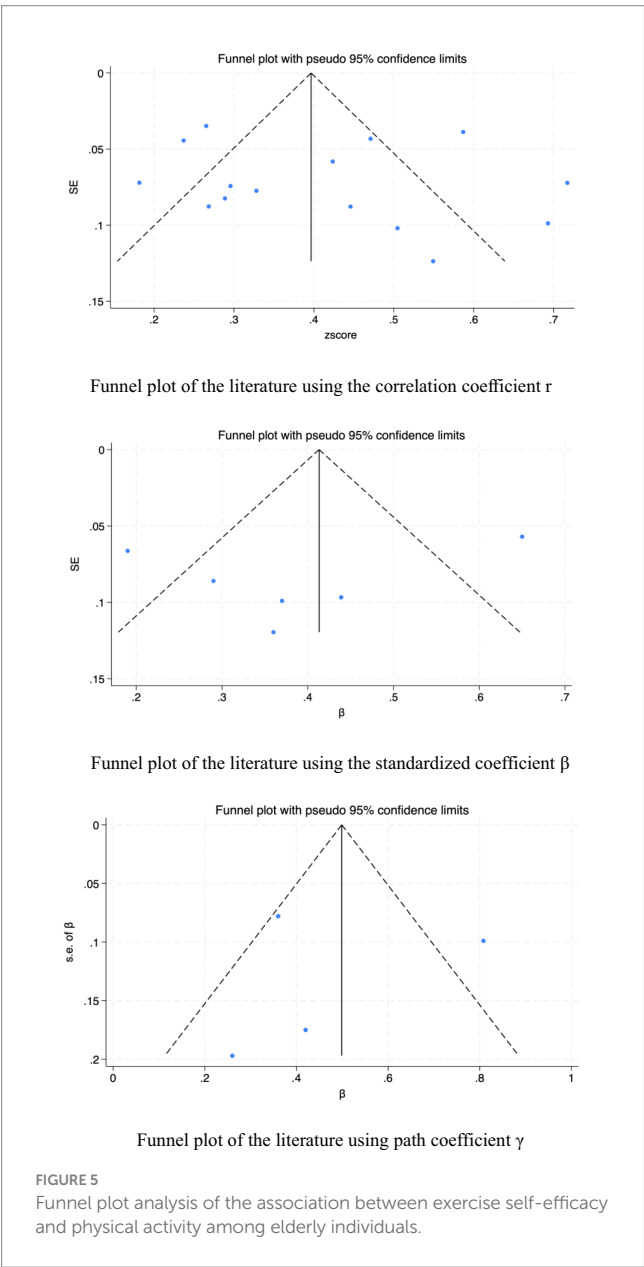
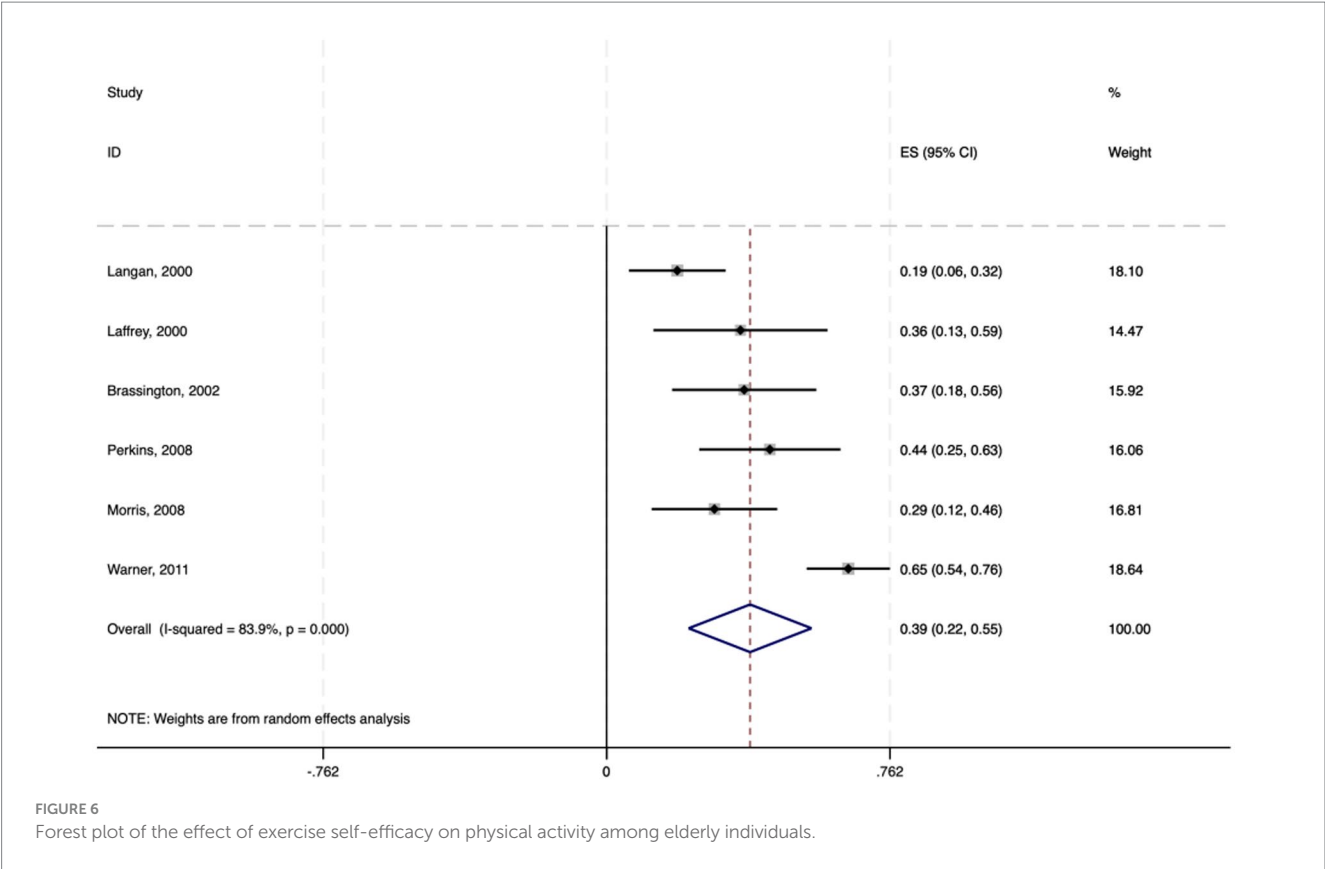


TABLE 4 Results of the publication bias test.

Data Type	P value of slope	P value of bias	Is there publication bias?
Correlation data r	$p = 0.012$	$p = 0.613$	No
Standardized coefficient β	$p = 0.116$	$p = 0.471$	No
Path coefficient γ	$p = 0.137$	$p = 0.517$	No



activity resources, might influence how exercise self-efficacy is developed and how it relates to physical activity behaviors. In contrast, elderly individuals in European or Asian countries may be influenced by different cultural values, community structures, and healthcare systems. For instance, in some Asian cultures, there may be a greater emphasis on group-based physical activities and family support, which could interact with exercise self-efficacy in unique ways. Therefore, future research should extend the investigation to more diverse geographical and cultural settings to enhance our understanding of the universal and context-specific factors that shape the relationship between exercise self-efficacy and physical activity in elderly populations worldwide.

Additionally, since 2000, it's been crucial to consider the evolving concepts and practices regarding physical activity in the elderly. During this time, there's been a growing recognition that physical activity offers benefits beyond the physiological, emphasizing psychological factors like exercise self-efficacy. However, events like the COVID-19 pandemic may have significantly altered physical activity patterns and self-efficacy perceptions in the elderly. The pandemic restricted outdoor activities and changed social interactions, likely affecting how the elderly engage in physical activity and perceive their ability to do so. Future research could explore the specific impacts of such global events on the relationship between exercise self-efficacy and physical activity in the elderly, complementing the long-term trends summarized in this study.

The exclusion of the Embase database from this study may have limited the retrieval of articles published in biomedical journals. Future systematic reviews should include Embase to improve the

comprehensiveness of evidence synthesis. The assessment tools used in this study have insufficient specificity and objectivity. For instance, physical activity is often measured via self-report tools like the PASE and GLTEQ, which are prone to subjective bias. Although accelerometer-based methods can offer more reliable data, their small sample sizes limit the representativeness of the findings. Future research should develop more specific and objective assessment tools to reduce bias and increase the sample size when using accelerometer-based methods, enhancing the representativeness and reliability of the results.

In our research, we define elderly individuals as those aged 60 and above, with an average age of 65 and above. This definition is in line with the WHO's standard and aims to capture trends related to early-stage aging. However, this approach may include participants who have not yet experienced obvious functional decline. Although the requirement for an average age of 65 and above reduces the impact of younger outliers, future research could conduct more stratified analyses by narrowing the age range (e.g., 60–69 and 70–above). This would clarify how the relationship between exercise self-efficacy and physical activity changes across different stages of old age. The limitation of this study only selecting English literature may lead to the research scope not being comprehensive enough, failing to cover important research results in other languages, and thus affecting the universality of the research conclusions. In addition, since the conduct of the study may have certain regional and group characteristics, its results may not fully represent the characteristics of special regional groups. To this end, future research should consider including multilingual literature to ensure the comprehensiveness and

universality of the research. At the same time, it is recommended to expand the sample range and increase attention to the elderly in special regions, so as to improve the representativeness and applicability of the research results.

Also, the assessment tools lack specificity and objectivity. For instance, physical activity is mainly measured via self-reported tools (e.g., PASE, GLTEQ), prone to subjective bias. While accelerometer-based measurements (as in [Harris et al., 2009](#)) offer more reliable data, their small sample sizes reduce representativeness. Moreover, excluding studies with fewer than 50 participants might introduce bias by removing extreme results. Future research should verify findings across different sample sizes and combine multiple measurement tools to minimize bias from a single instrument. Finally, this review excluded individuals with chronic illnesses, yet many older adults do have underlying conditions, which may affect the generalizability of the findings. Future research should further investigate the impact of chronic diseases on the relationship between exercise self-efficacy and physical activity to gain a more comprehensive understanding of the exercise behaviors of the elderly population.

4.5 Heterogeneity and its potential sources

The meta-analysis revealed substantial heterogeneity among the studies. Although the random-effects model accounted for between-study variability, the high heterogeneity warranted a more in-depth analysis of its sources. The primary potential factors are as follows:

4.5.1 Differences in study designs

The included studies show marked methodological differences, comprising 13 cross-sectional and 6 longitudinal studies. Cross-sectional studies capture associations at a single time point, while longitudinal studies explore temporal relationships. For instance, [McAuley et al. \(2005\)](#) reported that correlations significantly weakened over time ($r = 0.28$ at 12 months, $r = 0.09$ at 60 months), which suggests that differences in study design may be a significant source of heterogeneity.

4.5.2 Cultural and geographical differences

The studies cover several countries, including the US, Germany, South Korea, and Indonesia, which have significant differences in cultural norms and the accessibility of sports facilities. For example, [Dawe et al. \(2024\)](#) pointed out cultural differences in self-efficacy between participants from the US and Italy. [Juwita and Damayanti \(2022\)](#) emphasized that socioeconomic barriers in Indonesia might affect the elderly's physical activity. These factors may influence the strength of the link between exercise self-efficacy and physical activity.

4.5.3 Differences in measurement tools

The characteristics of physical activity assessment tools vary. They include self-report tools like the PASE and GLTEQ, and objective measurement tools such as the Actigraph accelerometer. Subgroup analysis shows that the pooled effect sizes for the PASE ($r = 0.232$) and GLTEQ ($r = 0.470$) differ significantly. This indicates that tool-specific biases (e.g., self-reported vs. objective measurements) may

introduce heterogeneity. Similarly, exercise self-efficacy measurement tools also vary. Examples are the general-exercise ESE and the walking-specific WSE. These differences may further increase between-study variability.

4.5.4 Disparities in sample characteristics

Differences in the age ranges (60–96 years), gender distribution (with a female percentage of 42–100%), and health status (such as working versus retired individuals) of study samples can moderate the strength of associations. For example, [Morris et al. \(2008b\)](#) focused exclusively on a female cohort, while [Lee and Fan \(2023\)](#) incorporated a mixed-gender sample, reflecting the diverse dynamics of different populations.

4.5.5 Differences in statistical methods

Studies have employed a variety of analytical methods, including Pearson correlations, multiple regression, and structural equation modeling (SEM). Path coefficients derived from SEM [such as $\gamma = 0.808$ from [Mudrak et al., 2016](#)] are often larger than effect sizes from regression models. This might be because SEM can incorporate latent variables and measurement errors.

4.5.6 Temporal and contextual changes

The time span of studies ranges from 2000 to 2024, which introduces temporal heterogeneity. Societal changes, like the COVID-19 pandemic, may have altered physical activity patterns and self-efficacy perceptions in later studies. However, the current dataset has insufficient exploration of such impacts.

This study offers strong evidence on the relationship between exercise self-efficacy and physical activity, but the following limitations should be noted. Firstly, high heterogeneity implies that unmeasured moderators (such as cultural norms and measurement tool biases) may mask the true effect size. Secondly, the studies are predominantly from Western countries (from the US and Europe), which limits the generalizability of the results to resource-poor regions. Thirdly, the reliance on self-reported physical activity measures (such as the PASE and GLTEQ) may introduce recall bias. Although accelerometer-based studies provide more objective data, their small sample sizes limit their representativeness. Future research should prioritize longitudinal designs, culturally adapted tools and stratified analyses to explore the sources of heterogeneity, and develop more precise and standardized measurement tools to enhance the reliability and comparability of the findings.

5 Conclusion

This study confirmed a significant positive correlation between exercise self-efficacy and physical activity in elderly individuals, with a moderate positive impact of exercise self-efficacy on physical activity levels among elderly individuals. Conversely, physical activity also positively influences exercise self-efficacy. These findings provide a theoretical basis for promoting physical activity among elderly individuals to increase their quality of life. Future research should further investigate the roles of various influencing factors and develop targeted intervention strategies to encourage more active engagement in physical activities among elderly individuals.

Author contributions

LX: Formal analysis, Writing – original draft, Writing – review & editing. WM: Conceptualization, Data curation, Validation, Writing – original draft. KD: Data curation, Writing – review & editing. YH: Data curation, Writing – review & editing. AL: Data curation, Writing – review & editing. HW: Data curation, Resources, Writing – original draft. HC: Project administration, Writing – review & editing. WQ: Data curation, Formal analysis, Writing – original draft. RG: Methodology, Project administration, Software, Writing – review & editing. GQ: Methodology, Visualization, Writing – review & editing. XW: Methodology, Validation, Writing – review & editing. CL: Supervision, Funding acquisition, Resources, Project administration, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Personality traits can predict which exercise intensities we enjoy most, and the magnitude of stress reduction experienced following a training program

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Introduction: The aim of this study was to determine if personality can predict physical fitness, enjoyment of exercise by intensity, and engagement in an exercise program in the general population.

Methods: Participants were assigned to either an 8-week home-based cycling and strength training intervention or a resting control group.

Results: Personality traits were strong predictors of baseline fitness levels, and of enjoyment of different exercise intensities. For example, conscientiousness predicted greater general fitness and more weekly hours of physical activity, whereas extraversion and neuroticism predicted higher VO_{2peak} and poorer heart rate recovery, respectively. Extraversion also predicted greater enjoyment of highest intensity activities, whereas neuroticism predicted lower enjoyment of activities which required sustained effort. Importantly, those who scored high on neuroticism benefited the most from potential stress-reducing effects of aerobic training.

Discussion: These findings provide insight into how personality can determine engagement with physical activity, and the degree to which one enjoys different forms of exercise, thus aiding the development of tailored exercise programs.

KEYWORDS

Big Five, physical activity, neuroticism, exercise tailoring, fitness

Introduction

The World Health Organisation (WHO) physical activity recommendations indicate that healthy adults should complete at least 150 min of activity (i.e., strength, endurance, mixed) per week ([Physical activity, n.d.](#)); however, only 22.5% of adults and 19% of adolescents worldwide achieve these goals ([Guthold et al., 2018](#)). Accordingly, physical inactivity is becoming one of the leading risk factors for poor physical and mental health across the lifespan ([Farooq et al., 2020](#)), and there is a growing need for effective ways to encourage participation in physical activity. Understanding how individual personality traits relate to physical activity engagement may help strengthen the efficacy of such interventions and shape physical

education practice in schools to promote positive affect and enjoyment during exercise (Reed and Buck, 2009; Posadzki et al., 2020).

Personality has been shown to impact health behavior uptake and thus the onset of disease and comorbidities. For example, neuroticism has been associated with maladaptive life choices and an increased prevalence of cardiovascular disease (Kim, 2022). Notably, when a person who scores high on neuroticism also exhibits high conscientiousness, they are more likely to engage in healthy behaviors (Graham et al., 2020). Similarly, although extraversion has been associated with smoking and heavy drinking, this trait is also associated with more physical activity; thus, these individuals tend to exhibit a higher incidence of cardiovascular disease but not metabolic syndrome (Kim, 2022). Therefore, understanding the effect of personality on physical activity behaviors can inform public health research and increase the effectiveness of physical activity-related interventions. There is a large body of literature outlining the effects of personality on performance in athletic populations (Egloff and Jan Gruhn, 1996; Allen et al., 2013) and additional studies on exercise adherence in clinical populations (Daley, 2002; Kruger et al., 2018).

The available literature that explores the above relationship has focused primarily on the Big Five personality traits (i.e., extraversion, conscientiousness, agreeableness, neuroticism, and openness) (McCrae and Costa, 1997) which are the most used in the field of sport and exercise psychology. Extraversion has been related to greater levels of physical activity (Rhodes and Pfaeffli, 2012) and greater engagement in organized sport (Engels et al., 2022); conscientiousness has been associated with greater commitment towards physical activity (Rhodes et al., 2005) and more active lifestyles (Conner and Abraham, 2001); agreeableness was shown to relate to positive experience in sport (Sutin et al., 2016); and neuroticism has been largely associated with a reduced willingness to exercise which is potentially related to engagement anxiety (Courneya and Hellsten, 1998; Engels et al., 2022). This anxiety sometimes leads to physical inactivity (Rhodes and Pfaeffli, 2012; Sutin et al., 2016). Apart from openness, the Big Five personality traits have been consistently associated with some aspect of engagement in physical activity, and this suggests that personality predicts one's willingness and commitment to partake in regular physical activity.

The above associations have been largely assessed via cross-sectional self-reported questionnaires on physical activities which risk exposure to recall bias. Perceived levels of fitness and physical activity are notoriously difficult to measure using subjective questionnaires (Shephard, 2003). Although there are numerous cross-sectional studies relating personality to sporting success (Laborde et al., 2020), these typically focus on the performance of athletic populations and are not necessarily generalizable to the wider population. The relationships reported thus far call for further research to corroborate these findings through more objective measurements, immediate recall, and longitudinal designs to test the effects of exercise interventions on various personality types. Determining whether personality traits can predict engagement in exercise programs will help behavioral professionals target areas of need, design tailored sessions and interventions to promote positive affect and enjoyment with exercise, and ensure long term behavior changes (Reed and Buck, 2009; Posadzki et al., 2020).

Therefore, this study aimed to (i) identify relationships between personality and baseline fitness levels, (ii) determine whether personality influenced enjoyment of specific forms of exercise, and

(iii) determine whether personality influenced the outcomes of a training intervention. Accordingly, we expect that individuals' scores on extraversion, neuroticism, conscientiousness and agreeableness, but not openness, will be directly related to these outcomes.

Methods

Participants

Participants were recruited from the general public via email newsletters (i.e., company- and university-wide emails) and social media advertisements (i.e., via LinkedIn, Facebook, etc.). A total of 232 participants had expressed interest in participating in this study (i.e., university students: 33, emergency workers, police or health services: 134; other: 65), of which 132 attended the laboratory for pre-intervention testing. Participants were then match-randomised into an intervention and a control group by age, birth sex, BMI, and $\text{VO}_{2\text{peak}}$. Of these, 86 completed the entire study protocol. Reasons cited by participants for leaving the study included illness ($n = 2$), surgery ($n = 3$), and/or general unavailability or loss of contact ($n = 41$). Participants were excluded from the study if they presented any physical illness or injury that prevented them from safely taking part in physical activity, determined via the physical activity readiness questionnaire (PAR-Q). The sample included here was determined adequate to detect statistically significant changes (mean change 5 ± 5 , power 0.80, $\alpha = 0.05$). All participants provided informed consent prior to being enrolled in the study and ethical approval was granted by the University College London Research Ethics Committee (13985/004). This study was conducted in line with guidelines presented in the Declaration of Helsinki. Data will be made available on request.

Study measures

Prior to attending the laboratory sessions, participants completed an online questionnaire which included demographic information, the Perceived Stress Scale 10 items (PSS-10) (Cohen and Williamson, 1988), and a modified version of the Big Five Inventory 10 item (BFI-10) (Rammstedt and John, 2007). The former is a widely implemented, 10-item scale designed to assess individuals' perceived stress. The latter is a 10-item scale used to assess personality traits (i.e., Extraversion, Agreeableness, Conscientiousness, Emotional Stability, and Openness) wherein each trait is represented by 2 questions. Here, we included a third Agreeableness item ("Is considerate and kind to almost everyone") as recommended by Rammstedt and John to improve the measurement of this personality trait (Rammstedt and John, 2007). Factor analysis demonstrated that this 11th item exhibited a loading of 0.89 onto the Agreeableness factor, confirming its appropriateness in the scale. The PSS-10 has been widely recognized for its reliable assessment of perceived stress and Cronbach's alpha levels have been reported between 0.65 and 0.93 (Roberti et al., 2006). In contrast, studies employing the BFI-10 reported Cronbach's alpha scores between 0.14 and 0.71 (Kwon and Park, 2016; Abdul Aziz et al., 2024); however, BFI-10 has demonstrated acceptable test-retest reliability and correlates well with the BFI-44 (Rammstedt and John, 2007).

Study design

Participants then attended the laboratory for baseline fitness testing (i.e., $\text{VO}_{2\text{peak}}$) and were match-randomized to either an intervention or resting control group based on their age, gender, and baseline fitness level following the above-mentioned baseline assessments. The intervention group were provided with a home-based 8-week cycling and strength training plan, whereas participants assigned to the control condition were asked to maintain their normal lifestyle and were provided a plan of weekly 10-min stretching exercises. These were provided as a form of engagement for the control group, but these individuals were not monitored. During the laboratory tests, and during week 1 of the training period, participants were asked to rate their enjoyment of each training session from 1 to 7 (i.e., 1 being not enjoyable and 7 being extremely enjoyable). After the 8-week intervention, all participants completed the PSS-10 questionnaire a second time and attended the laboratory for post-intervention testing (Figure 1).

Laboratory testing

Prior to maximal exercise testing, body composition was estimated using bioelectrical impedance on a Tanita MC980MA (Tanita Corporation, Tokyo, Japan). Participants then undertook three strength tests completed on the same day, separated by 4 min of rest between each test. These tests included: press-ups (i.e., maximum number of press-ups on hands and toes, not knees, in 1 min); countermovement jumps with hands on hips on a force plate (Hawkin Dynamics Inc., Maine, USA); and plank (i.e., on elbows and forearms and toes) to failure. Following strength exercise testing, participants completed the 'Lab low intensity session,' rested for 30 min, and then completed the $\text{VO}_{2\text{peak}}$ test. The Lab low intensity session was only completed once at pre-or post-intervention testing and when participants completed this session was determined via random order generator. Participants rated their session enjoyment (i.e., 1–7 as above) immediately after the low intensity session, and immediately after the $\text{VO}_{2\text{peak}}$ test.

Lab low intensity session

The exercise session required participants to complete 15 min of low-intensity cycling (i.e., rating of perceived exertion (RPE) of 4) on a stationary cycle ergometer (Corval OEM, Lode BV Medical Technology, Groningen, The Netherlands), while heart rate (Polar H9, Polar, Finland) and breath-by-breath gas exchange (Vyntus CPX Metabolic Cart, Vyaire Medical Inc., USA) were monitored, respectively. The researchers controlled the required exercise intensity by adjusting the load on the ergometer to maintain a constant RPE of 4 out of 10 using the visual OMNI scale (Robertson and Noble, 1997). Intensity was adjusted as needed for each participant.

$\text{VO}_{2\text{peak}}$ test

The $\text{VO}_{2\text{peak}}$ test was conducted using the same cycle ergometer and physiological monitoring equipment as the low intensity session. Participants completed 3 min of loadless cycling prior to the onset of a ramp protocol which continued for the remainder of the test. The workload was increased by either 15 or 25 W/min depending on the participant's self-reported training level. Participants were instructed to maintain a constant cadence of between 60 and 70 rpm during testing. Verbal encouragement by the researchers was not provided in order to obtain accurate assessments of participants' own motivation to exercise. Participants were instead updated on the test time every 2 min with a neutral tone of voice. Researchers did not otherwise engage with participants during testing. The $\text{VO}_{2\text{peak}}$ test was terminated upon volitional exhaustion, or if the participant's cadence dropped below 60 rpm for 30 s, or twice within a 45 s period. Participants completed a recovery phase pedaling for 3 min at a workload of 25 W. Heart rate recovery (HRR) was monitored as the change in heart rate from the time of reaching its maximum value to 120 s into recovery. $\text{VO}_{2\text{peak}}$ and peak respiratory exchange ratios (RER_{peak}) were determined following data smoothing via averaging every 7-breaths as the highest values obtained during testing, and the anaerobic threshold was determined using the v-slope method, respectively (Beaver et al., 1986).

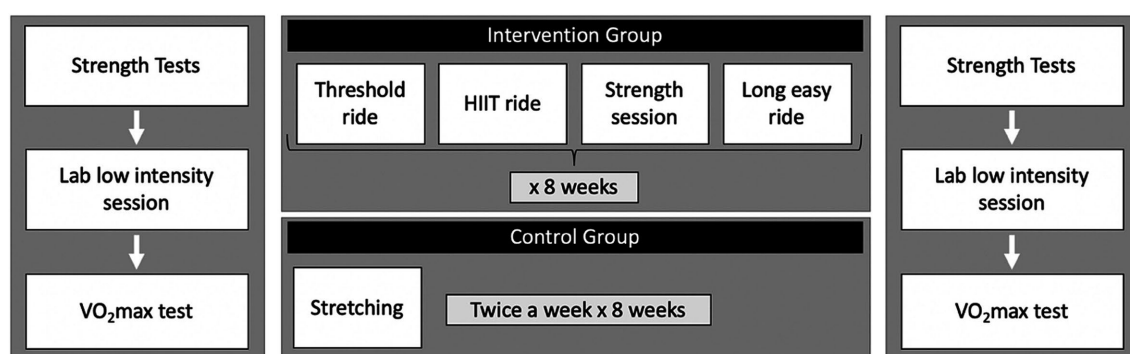


FIGURE 1

Study Design demonstrating the order in which exercise sessions were carried out. Participants rated how much they enjoyed their session after each lab task and after each home-based session in week 1 only.

Exercise intervention sessions

Participants were provided with a Polar H9 (Polar, Finland) chest strap to monitor their heart rate during exercise sessions across the 8-week intervention via the Polar Beat app 3.5.0 (Polar, Finland). Exercise-related thresholds were used to determine five heart rate zones which were individual to the participant using Polar Flow (Polar, Finland) on participants' phones. To determine the zones, heart rate (HR) values corresponding to the aerobic threshold (VT1), anaerobic threshold (VT2), and peak HR were extracted from the VO_{2peak} test and inputted into the Polar Beat application, which utilized these values as reference points to delineate the five participant-specific zones. Specifically, lower-intensity zones were determined relative to the aerobic threshold, moderate-intensity zones were positioned between the aerobic and anaerobic thresholds, and high-intensity zones were determined in relation to the anaerobic threshold and peak HR.

The intervention consisted of a cycling program which included three endurance sessions (Easy long, Threshold, High intensity interval training (HIIT)) as well as one strength session per week. During the first week of the training program participants were asked to log their session enjoyment during each session. The 'Easy long ride' consisted of 50 min of cycling at an intensity inducing a heart rate within zone 2; the 'Threshold ride' consisted of cycling at variable intensities over the course of the ride period and included 15 min within zone 2, 5 min within zones 3–4, and 5 min within zone 2; last, the 'HIIT ride' consisted of cycling for 10 min at an intensity where heart rate would fall within zone 2 as well as 4, 2 min rides completed at maximal effort with 2 min of active recovery (i.e., slow cadence pedaling), and 5 min of cycling at an intensity to achieve a heart rate in zone 2. The intensity of each session gradually increased over the course of the 8-week intervention. Finally, the 'Strength session' consisted of body weight exercises including squats, lunges, press-ups, sit-ups, calf raises, and glute bridges completed for 3 sets with 8 repetitions in each set. Progression and regression versions of each exercise were provided where participants were instructed to adjust the level of difficulty to target an RPE of 8 over the course of the 8-week intervention. Participants were asked to continue to log their perceived enjoyment after each aerobic and strength session during this time.

Data analysis

All statistical analyses were conducted in RStudio (Posit | The Open-Source Data Science Company, n.d.). Data were checked for normality using the Shapiro–Wilk test. As the personality trait distribution was not normally distributed, non-parametric analyses were used. Demographic comparisons between groups were checked through independent t-tests or Mann Whitney U tests. Pre-post intervention changes were assessed using a mixed model ANOVA and multiple linear regressions (backward elimination) were implemented to examine relationships between personality traits and physical variables or enjoyment. Logistic regressions by backward elimination were implemented in the same manner to predict adherence likelihoods. All five personality traits, age, and gender were included in the full models where variables with the lowest AIC were removed in turn until all variables met $p < 0.05$. The α level was set to $p < 0.05$ in all tests.

Results

Demographic overview

One hundred and thirty-two participants (56 female) attended baseline fitness testing in the laboratory (Table 1) and were match-randomized to intervention ($n = 78$) and control ($n = 54$) groups by age, birth sex, BMI, and VO_{2peak} , such that these values did not differ between groups at baseline testing. Of these, 86 participants completed both pre-and post-testing for the control ($n = 25$) and intervention ($n = 51$) groups. Drop-outs were due to injury, illness, and loss of contact.

Females had a higher body fat percentage ($p < 0.001$), lower VO_{2peak} ($p < 0.001$), lower peak power output ($p < 0.001$), and completed fewer press-ups in 1 min than males ($p < 0.001$). In terms of personality traits, females scored higher than men on ratings of extraversion ($p = 0.035$), agreeableness ($p < 0.001$), neuroticism ($p = 0.002$) and openness ($p = 0.041$). Age was positively correlated with conscientiousness ($p = 0.001$) and negatively correlated with neuroticism ($p < 0.001$) (Table 2).

TABLE 1 Mean $\pm$ SD for main baseline physical fitness indicators and personality traits.

	Score ≥ 1	All ($n = 132$)	Female ($n = 56$)	Male ($n = 76$)
Age		38 $\pm$ 13	35 $\pm$ 13	39 $\pm$ 12
Fat %		21.9 $\pm$ 6.6	25.9 $\pm$ 5.6 ***	19.3 $\pm$ 5.9
VO_{2peak} (ml/min/kg)		38.8 $\pm$ 9.6	35.4 $\pm$ 8.7	41.3 $\pm$ 9.5 ***
Power output (w)		255 $\pm$ 77	199 $\pm$ 58	295 $\pm$ 62 ***
Press-ups (n/60s)		23 $\pm$ 17	11 $\pm$ 10	31 $\pm$ 15***
Extraversion	58%	0.9 $\pm$ 2.0	1.4 $\pm$ 2.0 *	0.6 $\pm$ 2.0
Conscientiousness	74%	1.7 $\pm$ 1.9	2.1 $\pm$ 1.8	1.5 $\pm$ 1.9
Agreeableness	69%	1.4 $\pm$ 1.5	2.0 $\pm$ 1.3 ***	0.9 $\pm$ 1.4
Neuroticism	29%	−0.6 $\pm$ 2.0	0 $\pm$ 1.9 **	−1.1 $\pm$ 1.9
Openness	77%	1.6 $\pm$ 1.6	2.0 $\pm$ 1.6 *	1.4 $\pm$ 1.6

Significant differences between females and males are denoted as *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$.

TABLE 2 Means, standard deviations and spearman correlations between personality traits and age ($n = 132$).

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6
1. Age	37.65	13.09						
2. Sex	NA	NA	0.15					
3. Extraversion	0.92	2.04	0.16	−0.19*				
4. Neuroticism	−0.61	1.99	−0.31***	−0.28**	−0.20*			
5. Conscientiousness	1.73	1.88	0.28**	−0.16	0.22**	−0.25**		
6. Agreeableness	1.37	1.45	−0.01	−0.33***	0.08	−0.09	0.10	
7. Openness	1.61	1.62	0.06	−0.16	0.33***	−0.20*	0.23**	0.21*

Point biserial correlations for sex (Female = 0, Male = 1). * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

As for study groups, participants in the control and intervention group did not differ according to their ratings of extraversion (control 0.8 ± 2.1 , intervention 1.0 ± 2.0), neuroticism (control -0.3 ± 2.0 , intervention -0.8 ± 1.9), conscientiousness (control 1.6 ± 1.7 , intervention 1.8 ± 2.9), agreeableness (control 1.4 ± 1.3 , intervention 1.3 ± 1.5) nor openness (control 1.5 ± 1.5 , intervention 1.7 ± 1.7) ($ps > 0.16$).

Pre-intervention measurements

To determine if personality traits predicted fitness measures, stepwise multiple linear regressions using backward elimination were conducted for each variable. All five traits, age, and gender were included in the full model (Table 3). Of the five personality traits, only extraversion was predictive of having higher VO_{2peak} , anaerobic threshold, and peak power output, $Fs(2,123) > 11.96$, $ps < 0.001$, $R^2_{adj} > 0.13$, respectively (Figure 2). Conscientiousness predicted press-up completion, longer plank times, more weekly hours of physical activity, and lower body fat percentage, $Fs(3,121) > 4.03$, $ps < 0.046$, $R^2_{adj} > 0.02$, respectively. Neuroticism only predicted poorer HRR, $F(1,69) = 9.98$, $p = 0.002$, $R^2_{adj} = 0.11$ (Figure 3). Openness and agreeableness were not predictive in any model for baseline fitness variables. Muscle mass was only predicted by age and sex, $Fs(2,125) > 128.8$, $ps < 0.001$, $R^2_{adj} = 0.67$.

Participants who were part of an endurance club ($n = 45$) were more extraverted ($p = 0.039$) and more conscientious ($p = 0.007$) than those who were not. However, following backward elimination during logistic regression, only conscientiousness remained as a significant predictor of this factor (OR: 1.28, $p = 0.021$).

Exercise enjoyment

Participants who scored higher in neuroticism reported less enjoyment of the low intensity laboratory session and the threshold ride, $Fs(1,53) > 4.27$, $ps < 0.009$, $R^2_{adj} = 0.15$. In contrast, higher extraversion predicted enjoyment of the VO_{2peak} test and the HIIT sessions, $Fs(1,125) > 5.10$, $ps < 0.026$, $R^2_{adj} > 0.03$, respectively, whereas openness predicted less enjoyment of the threshold ride and the HIIT rides. Agreeableness predicted more enjoyment of the easy long ride, $F(2,49) = 6.08$, $p = 0.004$, $R^2_{adj} = 0.17$ (see Table 4).

Personality effects on program adherence and participation

Participants in the intervention group who scored higher on neuroticism were less likely to record their HR data required for research monitoring throughout the 8 weeks of training (OR: 0.73). This was independent of whether participants attended the laboratory for post intervention testing. Extraverted participants were less likely to attend post-intervention testing (OR: 0.70), whereas openness predicted a greater likelihood to attend (OR: 1.42).

Intervention outcomes

Our results demonstrated group by time interactions for VO_{2peak} , peak cycling power, total press-ups, and plank time, $Fs(1,87) > 5.7$, $ps < 0.02$, $\eta_p^2 > 0.06$, where only the intervention group exhibited pre-post improvements in these measures ($ps < 0.001$). No changes were observed for RER_{peak} and BMI (Table 5). Within the sample, and regardless of personality type, we observed a significant increase in weekly hours of exercise, VO_{2peak} , peak power output, number of press-ups, and plank duration in the intervention group ($ps < 0.02$).

Multiple linear regression models were used to predict intervention outcomes by personality traits on the intervention group and the relationships between personality and program adherence are also explored (see Supplementary material). Here, more conscientious participants exhibited smaller improvements in peak power output over the course of the intervention, $F(1,49) = 4.89$, $p = 0.032$, $R^2_{adj} = 0.07$; however, they reported that they had been asked to exercise fewer hours per week during the intervention compared to their usual weekly hours (although this effect trended toward significance; $p = 0.06$). Extraversion predicted an increase in RER_{peak} on the second laboratory visit, $F(1,48) = 6.70$, $p = 0.013$, $R^2_{adj} = 0.10$. Furthermore, participants who scored high on neuroticism reported a greater decrease in stress after the intervention, $F(1,49) = 9.94$, $p = 0.003$, $R^2_{adj} = 0.15$ (Figure 4). When adjusting for low, medium or high levels of neuroticism in a mixed model ANOVA, neuroticism was related to self-reported stress, $F(2, 127) = 21.7$, $p < 0.001$, and there was a significant intervention group by neuroticism level interaction, $F(2,127) = 3.59$, $p = 0.031$. In decomposing this interaction, perceived stress differed between low and the high neuroticism groups ($t = 2.56$, $p = 0.012$). Finally, a multiple linear regression by backward

TABLE 3 Multiple linear regression output for each component of baseline physical fitness following backward elimination.

	Estimate	95% CI [LL, UL]	<i>p</i>	df	<i>F</i>	<i>R</i> ²	<i>R</i> ² _{adj}
DV: VO _{2peak}							
Extraversion	1.15	[0.36, 1.93]	0.006				
Sex (male)	6.83	[3.60, 10.10]	<0.001				
Regression			<0.001	2, 120	13.38	0.15	0.13
DV: anaerobic threshold							
Extraversion	1.40	[0.74, 2.05]	<0.001				
Sex (male)	4.57	[1.84, 7.30]	0.002				
Regression			<0.001	2, 120	11.33	0.16	0.14
DV: peak power output							
Extraversion	8.06	[3.01, 13.11]	0.003				
Age	0.98	[0.18, 1.78]	0.018				
Sex (male)	99.56	[79.70, 120.40]	<0.001				
Regression			<0.001	3, 119	35.4	0.47	0.46
DV: heart rate recovery							
Neuroticism	−2.19	[−3.58, −0.81]	0.003	1, 66	9.54	0.13	0.12
DV: press-ups							
Conscientiousness	2.17	[0.91, 3.36]	<0.001				
Age	−0.29	[−0.47, −0.11]	0.001				
Sex (male)	23.32	[18.74, 27.90]	<0.001				
Regression			<0.001	3, 118	33.13	0.48	0.44
DV: plank time							
Conscientiousness	3.97	[0.06, 7.89]	0.046	1, 122	4.06	0.03	0.02
DV: PA weekly hours							
Conscientiousness	0.62	[0.22, 1.22]	0.002				
Sex (male)	2.15	[0.64, 3.66]	0.014				
Regression			0.001	2, 106	7.20	0.12	0.11
DV: body fat %							
Conscientiousness	−0.56	[−1.10, −0.01]	0.039				
Age	0.20	[.12, 0.28]	<0.001				
Sex (male)	−7.76	[−9.80, −5.62]	<0.001				
Regression			<0.001	3, 124	23.43	0.36	0.35
DV: muscle mass							
Age	0.18	[0.09, 0.27]	<0.001				
Sex (male)	17.96	[15.61, 20.30]	<0.001				
Regression			<0.001	2, 125	128.8	0.67	0.67

The full models included all Big Five personality traits, age and sex. Full models included all Big Five personality traits + Sex + Age, predictors were removed via backward elimination until all variables were significant (*p* < 0.05).

elimination revealed that post-intervention stress was predicted by the level of baseline stress and baseline VO_{2peak} (*ts* > −2.15, *p* = <0.035), but not post-intervention VO_{2peak}.

Discussion

This study aimed to determine whether personality traits were associated with physical fitness, and whether they could predict

engagement with a home-based exercise program and its outcomes. Below we outline key findings and how they related to personality scores.

Main study outcomes

Baseline fitness

Extraversion and conscientiousness predicted baseline fitness outcomes, but neuroticism did not. Instead, neuroticism did predict a poorer HRR following laboratory testing, independent of fitness. Such

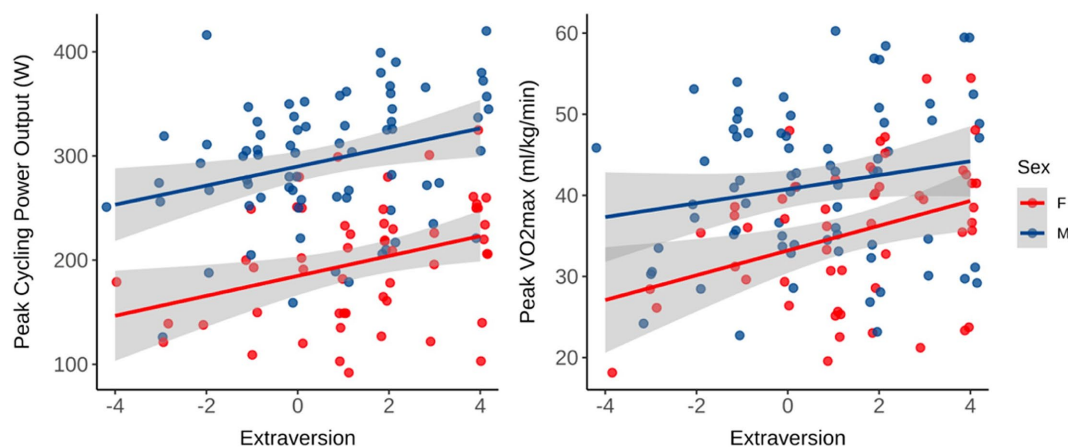


FIGURE 2

Regressions of extraversion on VO_{2peak} ($R^2 = 0.15$, $p < 0.001$) and Peak cycling power output ($R^2 = 0.16$, $p < 0.001$) on a cycling VO_{2peak} test. Birth sex ($n = 132$, female = 56) was also a significant predictor in both models ($p < 0.001$), see Table 3.

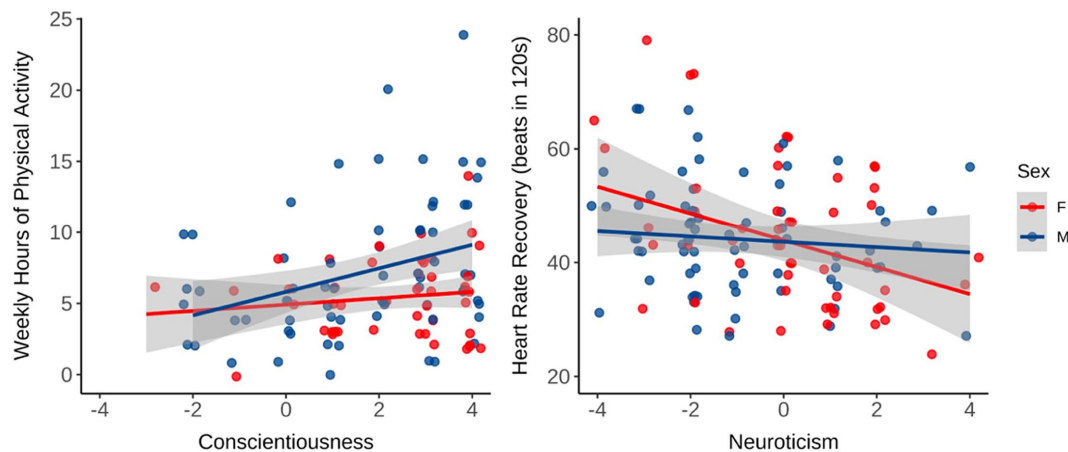


FIGURE 3

Regressions of conscientiousness on self-reported weekly hours of physical activity ($R^2 = 0.12$, $p = 0.001$), and of neuroticism on HRR after a VO_{2peak} test ($R^2 = 0.13$, $p = 0.003$). Gender was a significant predictor in the conscientiousness model ($p = 0.014$) but not in the neuroticism model; ($n = 132$, female = 56), see Table 3.

findings are consistent with neurotic sub-facets of anxiety and rumination (Watson and Casillas, 2003). In line with the literature, openness and agreeableness were not predictive of any baseline fitness measurements.

Session enjoyment and program adherence

Participants scoring high on extraversion enjoyed high intensity sessions the most and predicted a lower likelihood that participants would return for post-intervention testing. Individuals scoring high on neuroticism enjoyed light exercise sessions where they were not being watched (i.e., at-home light intensity sessions as opposed to the 'lab low intensity' cycling session), or sessions that did not require a lengthy sustained vigorous effort. Neuroticism did not predict dropout rates, but did predict a lower likelihood of self-monitoring heart rate on the online research platform. Those scoring high on openness rated strenuous exercise lower than other activities and this group was more likely to return for post intervention testing. Conscientiousness and

agreeableness did not predict strong preferences of either intensity, and conscientiousness did not predict any of the adherence variables.

Intervention outcomes

The most notable outcome from the intervention was decreased stress only in those participants who scored high in neuroticism. This effect was predicted by higher baseline VO_{2peak} but was not related to improvements in fitness. In addition, conscientiousness did not predict greater improvements in peak cycling power output, and extraversion did not predict greater fitness improvements following the program. Therefore, it may be precarious to assume that personality traits influence the *magnitude* of fitness benefits gained from a home-based exercise program. However, it does appear that exercise programs may benefit specific personalities in different ways, as discussed in more detail below. For example, participants who scored highly on extraversion have been shown to be more likely to engage in sport (Engels et al., 2022), and performance is further

TABLE 4 Multiple linear regression outputs predicting enjoyment of each exercise session with personality traits following backward elimination.

	Estimate	CI [LL, UL]	<i>p</i>	df	<i>F</i>	<i>R</i> ²	<i>R</i> ² _{adj}
DV: enjoyed stretching							
Neuroticism	0.18	[0.03, 0.33]	0.023	1, 32	5.58	0.15	0.12
DV: enjoyed strength session							
Sex (male)	0.10	[−0.04, 0.24]	0.18	1, 50	1.99	0.04	0.03
DV: enjoyed lab low intensity session							
Neuroticism	−0.25	[−0.42, −0.08]	0.005	1, 43	8.74	0.17	0.15
DV: enjoyed easy long ride							
Agreeableness	0.24	[0.01, 0.27]	0.049	1, 42	4.11	0.09	0.07
DV: enjoyed threshold ride							
Neuroticism	−0.19	[−0.35, −0.03]	0.024	1	1.29		
Openness	−0.25	[−0.40, −0.09]	0.005	1	5.13		
Sex (male)	−0.63	[−1.21, −0.05]	0.031	1	4.73		
Regression			0.015	3, 51	3.85	0.18	0.14
DV: enjoyed high intensity interval ride							
Extraversion	0.21	[0.01, 0.43]	0.031	1	0.68		
Openness	−0.40	[−0.65, −0.15]	0.004	1	9.10		
Regression			0.012	1, 46	4.89	0.18	0.14
DV: enjoyed lab VO _{2peak} test							
Extraversion	0.13	[0.02, 0.25]	0.039	1, 117	4.32	0.04	0.03

The full models included all Big Five personality traits, age and sex.

TABLE 5 Comparison of pre- and post-test changes in physical variables for the Intervention and Control groups.

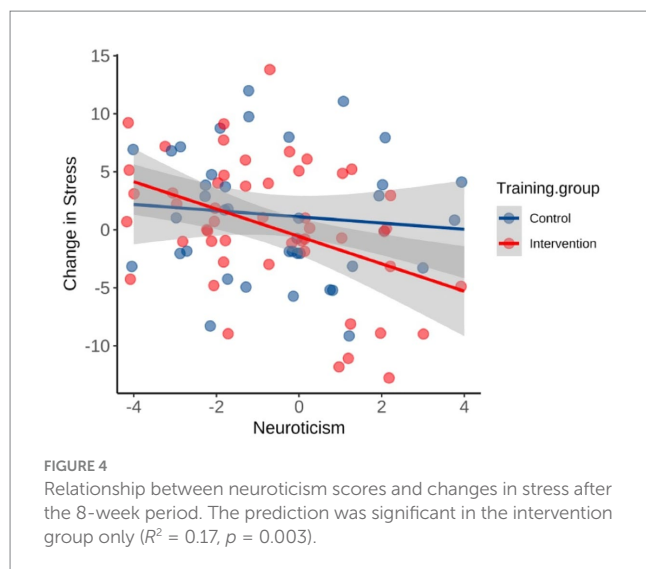
	Control (<i>n</i> = 35)		Intervention (<i>n</i> = 51)	
	Pre	Post	Pre	Post
VO _{2peak} (ml/kg/min)	31.9 ± 11.6	40.2 ± 12.0	38.7 ± 8.40	41.4 ± 7.81***
Peak power output (W)	241 ± 92	243 ± 109	265 ± 66	280 ± 56***,†
RER _{peak}	1.19 ± 0.09	1.21 ± 0.09	1.18 ± 0.07	1.17 ± 0.08
Press ups (n)	26 ± 18	23 ± 18	24 ± 12	32 ± 14***
Plank time (s)	125 ± 53	125 ± 57	136 ± 59	170 ± 73***,†††
BMI	23.2 ± 3.5	22.9 ± 3.4	25.1 ± 4.1	25.1 ± 4.0
Change in PA hours (self-reported rating −2 to 2)		0.0 ± 0.9		0.5 ± 0.9 *

Significantly higher than Pre-value within group **p* < 0.05, ****p* < 0.001. Significantly higher than control group within timepoint †*p* < 0.05, †††*p* < 0.001.

predicted by higher scores of extraversion in athletic populations (McAuley et al., 2022). According to Eysenck’s (1976) biological theory of arousal, extraverts possess a lower resting state of arousal than introverts and therefore seek greater stimulation (Stelmack, 1990). This biological basis of extraversion underpins most of the findings reported in this study. That is, extraversion was predictive of greater enjoyment only of the VO_{2peak} and HIIT sessions (i.e., the highest exercise intensities). The mechanisms which explain greater engagement of extraverts are also largely related to the findings pertaining to neuroticism in this study.

Neuroticism has been associated with low engagement in physical activity (Rhodes and Smith, 2006) due to a higher association with perceived stress (Dunker et al., 2020) and greater focus on the fear of failure (Courneya and Hellsten, 1998). However, once other extrinsic factors are considered, this relationship appears

to be weak (Rhodes and Pfaeffli, 2012). Graham et al. (2020) highlight the effects of “healthy neuroticism,” defined as an interaction between high neuroticism and high conscientiousness, and its significant association with greater engagement in physical activity. Therefore, the relationship between the broader trait of neuroticism and sport participation is complex and may require greater scrutiny of how sub-facets of the trait, and their interactions with other traits, predict attitudes towards specific forms of physical activity. The existing literature does indicate that neuroticism is associated with poorer cardiovascular recovery and highlights its deleterious effects on cardiac health in this population (Chida and Hamer, 2008). The Objective Self Awareness Theory (Duval and Wicklund, 1972) highlights the effects of an audience on increased introspection, prompting a comparison of the real self to the ideal self. Considering the higher emotional instability associated with



neuroticism, it is possible that HIIT may be more tolerable than a long continuous vigorous session, where anxiety, worry and negative self-talk are more likely to impact performance (Altamura et al., 2019). In fact, enjoyment of physical activity has been associated with feelings of perceived competence in individuals with high neuroticism, who may prefer tasks that facilitate self-efficacy (Engels et al., 2022).

When considering conscientiousness, individuals who scored highly on this trait are more likely to be strongly motivated by health-protective behaviors (Conner and Abraham, 2001) and are more likely to translate intention to behavior (Rhodes et al., 2005). In exercise contexts, participants with high reward-dependence were found to be more likely to complete a 6-month training program (De Panfilis et al., 2008), and it is therefore unsurprising that conscientiousness was the only trait that did not predict enjoyment of any particular session on the program. This group might engage in physical activity largely for health purposes, where enjoyment might play a smaller motivational role compared to the reward of achieving their intended health or performance goals (Rhodes et al., 2005).

Openness is largely associated with intellect and curiosity and is characterized by high degrees of reflection and introspection (Connelly et al., 2014). Although this trait is sometimes related to adopting problem-solving coping mechanisms and to greater commitment in sporting contexts (Allen et al., 2013), it is generally not considered relevant to exercise engagement or performance. In a meta-analysis of 33 studies, Rhodes and Smith (2006) found that openness was not associated with any measure of engagement in physical activity, and according to Engels et al. (2022), openness is the only trait that does not relate to enjoyment of exercise. Therefore, the strong negative predictions of openness on enjoyment of higher intensity activities in this study are a new finding that somewhat contradicts current literature. It should be noted that the existing studies were based on recall questionnaires only, and did not measure the effects of exercise intensities on exercise enjoyment, as is reported here. It is worth noting, however, that openness has been associated with greater body awareness (Ferentzi et al., 2017), perhaps indicating that open-minded individuals may have a stronger tendency to focus on their sensations, leading to a higher likelihood of perceiving high levels of exertion as threatening if combined with neurotic traits.

Finally, in terms of agreeableness, two meta-analyses totaling 27 samples independently concluded that, once adjusting for other personality traits, there is no relationship between agreeableness and physical activity or sedentary behaviors (Rhodes and Smith, 2006; Sutin et al., 2016). This study supports these findings.

Strengths and limitations

This study adds to literature on the direct relationship between personality, fitness, and exercise engagement in a healthy population, and provides good ecological validity for the reported associations. However, conducting lab-based tests with an interventional element did generate bias in the sample, where more than 70% of those who volunteered for the study were found to be open-minded, conscientious and emotionally stable. Sport participation history was not considered in this study. In line with the developmental hypothesis, potential changes in personality might arise through participation in sport determined by one's upbringing or life events (Rhodes et al., 2005). Understanding the cyclical relationship between phenotypic and genotypic traits in exercise could provide a bases for physical activity promotion throughout childhood. Moreover, the present study sample were not explicitly asked about their motivation to participate in exercise. Rather, this was only ascertained via their performance during the study. The inclusion of this parameter would provide a more complete understanding of why participants performed the way they did. Last, the Big Five personality traits were implemented in this study without consideration of sub-traits or other personality factors, such as grit or anxiety. This may be relevant in the context of physical activity and is worth future research. The literature does not currently present an 'exercise personality' questionnaire which further constrains current research to rely on broader and more generalizable trait analyses. Nonetheless, this paper indicates that specific traits can strongly predict physical activity behaviors. Accordingly, the development of personality psychometrics that are more relevant to exercise engagement may prove useful in providing tailored recommendations for individuals.

Implications and future directions

These results highlight that, although fitness was improved across personality types—for those who did complete the program - differences in enjoyment and adherence by personality traits suggest that tailoring exercise programs according to personality could potentially maximize these benefits. For example, the fact that extraversion predicted higher baseline scores on peak power output and $\text{VO}_{2\text{peak}}$, greater enjoyment of high intensity home sessions, and greater effort to exhaustion in post-intervention lab tests (RER_{peak}) suggests that extraverted individuals might particularly welcome the inclusion of high intensity aerobic sessions in a program. In contrast, while participants who scored high on neuroticism were less likely to monitor their heart rate during their sessions, they were just as likely to complete the program and return to the lab for post-intervention testing. These individuals exhibited a particularly strong reduction in stress following the exercise program. This suggests that individuals in this group might appreciate being given space for independence and privacy during an exercise program. Further studies could

investigate if training plans that facilitate autonomy might be more welcomed by those who score highly on neuroticism, therefore supporting greater adherence for those less likely to engage in physical activity. Therefore, these results demonstrate a strong potential for the development of tailored programs according to personality traits. Research which identifies the optimal exercise-personality pairing should therefore be explored to support the development of effective exercise adherence strategies for behavior change, particularly in less active groups.

Conclusion

In this study sample of members of the general public, the Big Five personality traits were strong predictors of existing physical activity behaviors, baseline fitness levels, and enjoyment of the differing prescribed exercise intensities. Group level improvements in fitness were observed regardless of personality profiles. Of note, neuroticism specifically predicted a significant reduction in self-reported stress, providing an encouraging outlook on the individualized stress-reducing effects of physical exercise. Overall, results provide insights into how personality traits influence exercise related behaviors, exercise enjoyment, and its long-term effects. These results demonstrate the potential utility of monitoring personality traits in future exercise studies and might aide the design of training programs tailored to participant's needs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the University College London Research Ethics Committee (13985/004). All participants provided informed consent prior to being enrolled in the study. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

FR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft,

Writing – review & editing, Project administration, Visualization. BT: Writing – original draft, Writing – review & editing. CX: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. PB: Conceptualization, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2025.1587472/full#supplementary-material>

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