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Motivations for physical activity

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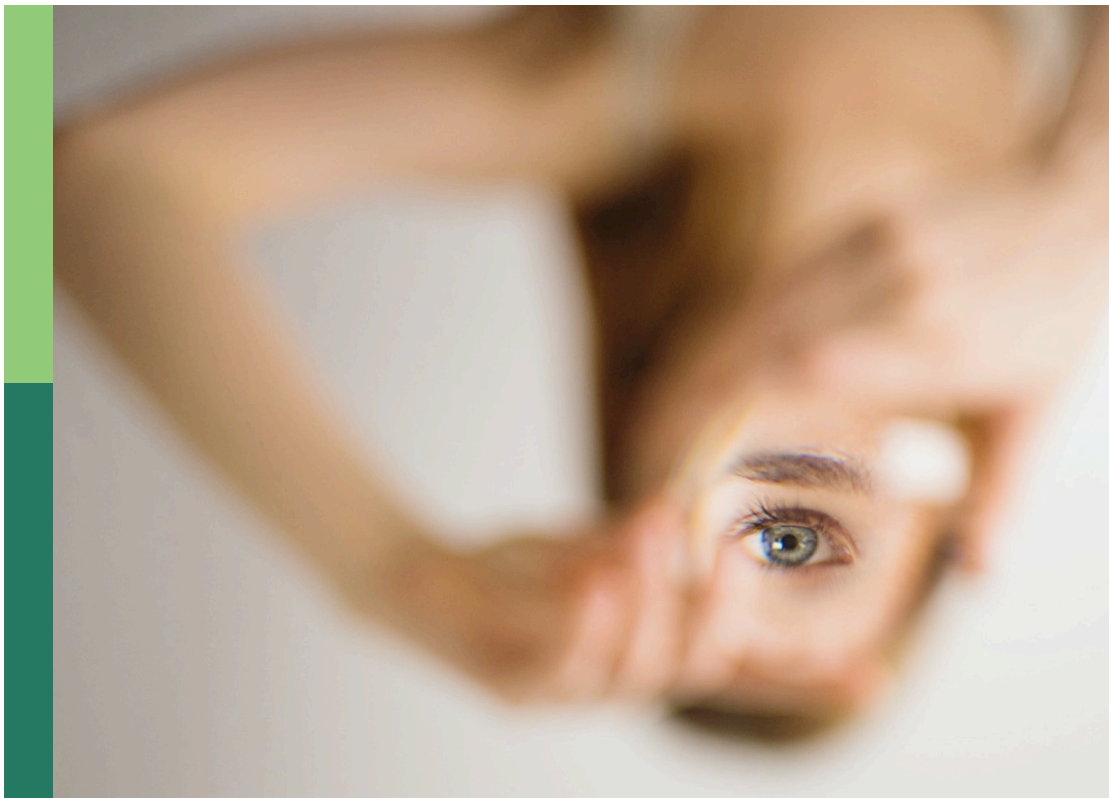

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Motivations for physical activity

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Editorial: Motivations for physical activity

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basic psychological needs (BPN), motivation to physical activity (PA), motivation to sports training, physical activity intervention, Self-Determination Theory (SDT), self-efficacy, Theory of Planned Behavior (TPB), Health Action Process Approach (HAPA)

Editorial on the Research Topic
Motivations for physical activity

Introduction

Engaging in physical activity is a complex and multifaceted phenomenon driven by a variety of motivations. This Research Topic sought to understand the factors that inspire individuals to participate in physical activities (PA). The objective of this Research Topic of articles is to provide fresh perspectives on this subject, thereby offering innovative insights into motivational factors, which is an incredibly promising and relevant domain, especially considering the growing importance of physical activity for health and wellbeing around the world. Addressing the complexity of the motivations behind physical activity can lead to a deeper understanding of exercise-related behaviors and, in turn, inform more effective strategies for promoting active lifestyles.

Including a wide range of target populations, such as college students, older adults, and people affected by the COVID-19 pandemic, is crucial to ensure that the findings have relevance and applicability in diverse contexts. In addition, consideration of social, cultural, and environmental factors reflects the interdisciplinary and multifaceted nature of physical activity and human behavior in general. With this Research Topic, we hope to offer valuable insights into the complex domain of motivations for physical activity and underline the importance of individual characteristics, social and cultural factors, and environmental influences in shaping exercise behaviors. Our goal was also to highlight research findings that have implications for the promotion of physical activity in diverse populations, including college students, older adults, and those affected by the COVID-19 pandemic. Three areas of motivation for PA have been identified:

Factors increasing motivation to engage in physical activity

An integrated theoretical perspective that blended the Health Action Process Approach (HAPA) and the Theory of Planned Behavior (TPB) was applied in a cross-sectional study conducted by Meng et al. to investigate psychosocial factors determining the initiation and maintenance of physical exercise behaviors in Chinese individuals with substance use disorders (SUD). An extensive set of variables was explored, including task self-efficacy (TSE), maintenance self-efficacy (MSE), recovery self-efficacy (RSE), outcome expectations (OE), action planning (AP), coping planning (CP), social support (SS), subjective norms

(SN), attitude behavior (AB), behavioral intention (BI), perceived behavioral control (PBC), and risk perception (RP). The structural model revealed several associations that provide valuable scientific guidance for improving physical exercise adherence among individuals with SUD.

Motivational differences between men and women and among individuals with varying relationship statuses were investigated in a study focused on determining the most effective exercise program among three types of social interaction: people exercising in fitness alone, in aerobic groups, and with a personal trainer (Vuckovic and Duric). The findings indicated that individuals who exercised alone were primarily motivated by intrinsic factors, such as enjoyment and stress management. On the other hand, health-related motives, such as avoiding ill health, were most commonly associated with exercising with a personal trainer, particularly among females and those in a relationship.

The study conducted by Gabay et al. aimed to investigate the contextual variables and factors that influence adherence to physical activity among veteran, novice, and dropout trainees in Israel. The findings suggest that individuals with varying ages, gender, and levels of physical training experience have unique and diverse goals for their training, and there is no single goal that is suitable for everyone. By identifying the most critical factors that may impact adherence to physical activity, self-efficacy can be increased simultaneously.

A cross-sectional study investigated the part played by physicians in encouraging physical activity among pregnant women in Poland (Laudańska-Krzemińska and Krzysztoszek). According to the WHO recommendations for physical activity, 41% of women adhered to these guidelines before becoming pregnant. Among pregnant women who were physically inactive, poorer wellbeing was reported. Regrettably, healthcare professionals do not often provide education and motivation to pregnant women regarding physical activity.

A systematic review (Sun et al.) was conducted employing a socio-ecological framework to identify factors that serve as either facilitators or obstacles to engaging in physical activity (PA) among pregnant women. The study revealed that higher levels of education, knowledge, and skills, as well as access to mass media, had a positive influence on PA in pregnant women. Conversely, lower levels of education, inadequate knowledge and skills, low income, pregnancy discomforts, limited time, safety concerns, and societal perceptions of PA during pregnancy were identified as significant barriers. Furthermore, significant others, including family members, colleagues, friends, and partners, can either support or hinder PA. It is essential to offer accessible information and resource systems to pregnant women to foster a healthy lifestyle during pregnancy. Additionally, interventions should aim not only at pregnant women but also their families.

Motivation to participate in different sport disciplines

The prospective study by Honório et al. investigated the anthropometric characteristics and other relevant variables associated with physical performance in a sample of Portuguese U-17 soccer players during 10 months of soccer training. Results indicated significant enhancements in the levels of anthropometric and physical fitness variables, such as leg power, speed, bone mass, muscle mass, and fat mass. These findings suggest that soccer is a multifaceted collective sport that fosters the development of various capacities, including power, agility, joint flexibility, and muscle development, in a harmonious manner.

The impact of coach-delivered verbal encouragement on the physiological and psychological responses was investigated in four sessions of small-sided games (SSGs) among male basketball players from Tunisia (Khayati et al.). The results indicated significant benefits of coach-delivered verbal encouragement on both the physical and psychophysiological responses of adolescent athletes, including increased physical enjoyment, positive mood state, lower heart rate, and higher physical activity intensity level. Therefore, it is recommended that coaches incorporate verbal encouragement strategies to enhance sports performance.

The study by Leduc et al. tested basic psychological need satisfaction among Canadian collegiate athletes, focusing on their interactions with team identification and leader-member exchange (LMX) perceived quality. The results demonstrated a positive association between team identification and the satisfaction of the needs for competence and relatedness. Additionally, satisfaction with the needs for competence and autonomy was shown to be positively related to LMX quality. Furthermore, LMX quality was found to moderate the relationship between team identification and the satisfaction of the needs for competence and relatedness, emphasizing the significant role played by team identification and LMX quality in satisfying the basic psychological needs of collegiate athletes.

The international study of motivational drivers and a sense of belonging among Chinese Martial Arts (CMAs) practitioners was conducted using the Self-Determination Theory (SDT) by Cao and Lyu. The motivation for practicing CMAs was found to consist of enjoyment, mastery, physical condition, psychological condition, and appearance. The persistence in practicing CMAs was positively related to motivation for practicing CMAs, sense of belonging, affiliation, competition ego, and others' expectations. International instructors of CMAs should focus on fostering the development of physical, mental, aesthetic, and moral qualities of CMAs practitioners, together with virtues and etiquette. By doing so, instructors can help practitioners discover enjoyment in their practice, achieve competency in their skills, and ultimately enhance their overall performance.

The motivation for participating in Brazilian Jiu-Jitsu (BJJ) was examined in accordance with the Self-Determination Theory (Tarver and Levy). The primary motives that emerged were interest/enjoyment, competence, and fitness, while appearance and social motivations were found to be less pronounced in BBJ players from the USA. It was observed that competence and interest/enjoyment motivators had a significant impact on competitive BJJ players, regardless of their years of experience in the sport. The results of this study could be helpful for coaches, sports clinicians, and sports psychologists in developing training programs that are tailored to the motivations of BJJ players.

A novel approach for assessing and applying motivation to physical activity

A mixed-methods study was performed in Norway to evaluate the adoption, acceptability, and sustained use of digital interventions to encourage physical activity among inactive adults (Manskow et al.). The participants in the randomized controlled trial received a wearable activity tracker along with the personalized metric Personal Activity Intelligence (PAI) on a mobile app. Furthermore, two groups received access to online training, and one group also had access to online social support. The study results indicated that PAI was the most effective intervention, with satisfactory usability and positive effects on motivation and behavior change, leading to high adoption and sustained use.

A four-month randomized controlled trial was carried out among healthy adults in Singapore to investigate the effectiveness of hedonic vs. cash incentives in promoting physical activity (Finkelstein et al.). The study revealed that both the cash and hedonic incentive groups showed an increase in mean daily steps without any significant differences. These results imply that either type of incentive can be implemented to increase physical activity among inactive adults.

The Behavioral Regulation in Exercise Questionnaire (BREQ-3) was validated in a sample of German-speaking young adults (Cocca et al.). The 22-item BREQ-3 questionnaire, which encompasses six factors, demonstrated good fit and moderate to high internal consistency in the German-speaking population. Additionally, the BREQ-3 proved to be invariant across genders. Consequently, the BREQ-3 can be considered a scientifically valid instrument for assessing certain social aspects of exercise behaviors in future studies.

We hope that this Research Topic of articles will result in new insights that can inform policies, programs, and interventions aimed at promoting physical activity and ultimately contribute to the improvement of the health and quality of life of individuals around the world.

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Brazilian Jiu Jitsu players' motivations to train

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Combat sports, such as Brazilian Jiu Jitsu (BJJ), require intense physical, mental, and emotional tasking within its training. With the degree of difficulty ingrained within the sport, many participants that once were intrigued by the sport may lose this interest and enjoyment if their goals are not met. The purpose of this study was to examine the relative strength of sport motivations among BJJ players. Participants included 228 BJJ athletes varying in levels of sport participation experience. Grounded in Self-Determination Theory, participants were assessed on five motives for sport participation including: fitness, appearance, competence, social, and interest/enjoyment. Motives related to interest/enjoyment, competence, and fitness, were rated relatively higher; and appearance and social were rated relatively lower regarding participants' motivation for BJJ participation. Analyses were also conducted related to athletes' years of experience and competitive level of participation (i.e., hobbyist or non-competitor to those who compete on a regular basis) There was a significant effect of competence and interest/enjoyment motivators among competitive BJJ players, regardless of years of experience in the sport. Findings from this study could aid coaches, sport clinicians, and sport psychologists in working with BJJ players by focusing their training on the motivators that are most appealing to these athletes.

KEYWORDS

sport participation, self-determination theory, martial arts, combat sports, exercise motivation

Introduction

Brazilian Jiu Jitsu (BJJ) is a grappling combat sport that mainly utilizes chokeholds and joint locks. Over the past 30 years, interest in BJJ participation has grown tremendously. While BJJ is a prominent sport in Brazil, it has garnered attention and interest worldwide (Andreato et al., 2017). This rise has been found in a multitude of countries such as the United Kingdom where the number of BJJ gyms has grown exponentially from 12 in 2009 to a staggering 320 in 2020 (Sugden, 2021).

Motivation is the force that drives people to initiate and sustain their effort toward their goals (Liu et al., 2015). It is instrumentally critical to sport participation in athletes because it is a pivotal element in determining the actions and efforts that they take within their sport (Ryan and Deci, 2000; Rintaugu et al., 2014; Vink and Raudsepp, 2018). Sport practitioners have found motivation to be one of the most difficult and misconstrued concepts to define within psychology (Williams and Krane, 2015). This is a result of many biological and environmental determinants that influence motivation for each athlete. Motivation is defined as "a combination of an individual's desire to take action, also known as their drive, and the direction in which these said actions are aimed" (Weinberg and Gould, 2007, p. 52). Motivation can partly be determined by the variation of an athlete's behavioral patterns as well as the quantity and quality of their motivation (Duda, 2001, 2005). For example, it has been found that athletes who are more

intrinsically motivated are more likely to continue their participation in their sport (Sarrazin et al., 2002), especially if they are participating in an athlete-centered (as opposed to outcome focused) climate—one that is perceived as caring, autonomy-supportive, empowering, and task-involving (Fry and Moore, 2019).

Motivation can be impacted by several internal and external factors that an athlete may experience. The relation between the athlete and these factors is of vital importance for the well-being of athletes because of the impact it may have on the athlete's motivation, which in turn influences an athlete's ability to achieve the desired level of performance for their sport (Ryan and Deci, 2000). Research findings indicate athletes experience more satisfaction and joy from their sport participation when it is perceived as intrinsically motivating, or for the enjoyment of participation (Deci and Ryan, 2000). However, separable rewards such as athletic scholarships and professional sports careers have the potential to hinder this intrinsic motivation (Deci, 1971). While these derivatives of motivation have been analyzed through many theories, multiple researchers and sport practitioners have utilized self-determination theory to access the motivation of athletes.

Self-determination theory (SDT) bases its origins off the seminal work of Deci and Ryan (1985). It is a macro theory of human motivation that differentiates between different types of motivation depending on the motives, goals, and actions that influence the motivation. SDT further categorizes these different reasons for an athlete's actions on a continuum of behavioral regulations with some having elements of both intrinsic and extrinsic motivation (Ryan and Deci, 2000; Amorose et al., 2016). Intrinsic actions are considered those in which an athlete engages in an activity for the pleasure and satisfaction derived from the activity itself. Extrinsically motivated athletes engage in an activity to attain some separable outcome such as for a medal, fame, or financial reward. The extent to which extrinsic motivation is self-determined allows this motivation to be explained along a continuum (Vansteenkiste et al., 2010; Taylor, 2015). This continuum places these motivations from the most extrinsic (external regulation) to the most intrinsic (intrinsic regulation).

The sport of BJJ relies heavily on positioning, leverage, and technique, and relies less on physical attributes such as size, strength, speed, and quickness (Gracie and Danaher, 2003). With the focus of the sport resting heavily on the acquisition of submission holds and positions, BJJ requires a keen level of competence to not only defeat an opponent, but to also elude an opponent that is aiming to place a player in an uncompromising position (Ovretveit et al., 2018). A mishap in applying a technique could create an unwelcoming experience for a non-competent BJJ player. While BJJ provides an opportunity for athletes to gain competence in a new sport, it also allows athletes to learn techniques to utilize in their everyday lives as well. BJJ has long been regarded as a great self-defense art that provides competence in using leverage to defend oneself (Jeon, 2020).

Although many BJJ athletes begin their training out of sheer interest in the sport, some continue to participate in part to the social connections that they make within their gym. BJJ athletes have noted that the social environment and connections made during their training have had a significant impact on their comfortability within their gym as well as providing many mental health benefits such as positive coping, resilience, and perseverance (Reusing, 2014; Chinkov and Holt, 2016; Mickelsson, 2021; Sugden, 2021). Research has also found that social connections to others deemed as vital to a BJJ athlete's gym is correlated with a higher probability of continued participation as well as stronger feelings of connectedness to others (Rodrigues et al., 2019). These social connections and environment that BJJ players participate in foster a therapeutic, comforting, and encouraging environment to thrive (Willing et al., 2019).

BJJ athletes may also find encouragement to engage in their sport from extrinsic motivators as well, such as the physical appearance and fitness benefits that BJJ can provide. BJJ has been found to improve cardiovascular functioning, strength, bone mineral density, flexibility, and nutrition, as well as reduce blood pressure and body fat (Burke et al., 2007; Tsang et al., 2008; Boguszewski et al., 2014; Kim et al., 2014). These benefits may also aid in enhancing BJJ athletes' physical appearance as well. Research has even shown that it is possible to experience these benefits with as little as 2 h of BJJ training per week (Lorenco-Lima et al., 2020).

Motivation for BJJ players may also come from the achievement of belt progression. Within BJJ, players progress through a belt ranking consisting of the colors white, blue, purple, brown, and black, to designate their skill level within the sport. While this progression can provide motivation, it may also lead to higher dropout rates among players. For example, a blue belt within a gym, while still considered a relative novice within the sport, may have additional expectations bestowed upon them with their first belt promotion. Blue belts may feel that they must be better than all white belt practitioners while also being competitive against more advanced belts (Ovretveit et al., 2018). These expectations can lead to negative outcomes and behaviors such as performance-avoidance tendencies. With these heightened expectations, many blue belts may feel that they can no longer perform at a desired level, which may lead to drop out. With the multitude of motivators that can draw athletes to BJJ, there is a dearth of research that investigates what motivators BJJ athletes value most.

Current study

The purpose of the current study was to examine the relative strength of sport motivations among Brazilian Jiu Jitsu players consisting of both intrinsic and extrinsic motivators. We posited and tested the following hypotheses:

> *H1:* BJJ athletes would rate the intrinsic motivators of interest/enjoyment, competence, and social significantly higher than the extrinsic motivators of fitness and appearance. Rationale: The physical and high cardio nature of BJJ creates a difficult environment for training and participation. Therefore, BJJ athletes could be more likely to find motivators that enhance motivation outside of receiving awards and praise.

> *H2:* The number of years BJJ training and competitive level of BJJ participation (i.e., hobbyist, competitive hobbyist, regular amateur competitor, elite amateur competitor, and professional athlete) would be positively related to intrinsic motivators of interest/enjoyment, competence, and social but not for the extrinsic motivators of fitness and appearance. Rationale: The researchers posit those participants that have engaged in BJJ participation longer and who competed more regularly would

> espouse more intrinsically oriented motivators than those who have participated for a significantly less amount of time or competed less.
>
> *H3:* Participants who regularly engaged in BJJ competition (i.e., amateur, elite amateur and professional athletes) would rate the intrinsic motivators of interest/enjoyment, competence, and social higher than those BJJ players that participated primarily for enjoyment and fitness (i.e., hobbyists and competitive hobbyists).

Materials and Methods

Participants

This study included 228 BJJ players. Most participants resided within the United States with 165 (72.4%) followed by Canada with 12 (5.3%); the United Kingdom with 10 (4.4%); Ireland with seven (3.1%); Australia with six (2.6%); Germany had four (1.8%); and Sweden with three (1.3%). Three countries (Northern Iran, the United Arab Emirates, and Thailand) had two (0.9%) while 15 countries (Poland, Pakistan, Norway, Switzerland, Ukraine, Italy, South Africa, Luxembourg, Belgium, Singapore, New Zealand, Romania, France, Austria, and Netherlands) had one (0.4%). Regarding race, the majority of participants ($n = 183$; 80.3%) identified as White, followed by Asian or Asian American ($n = 18$, 7.9%), Hispanic ($n = 13$, 5.7%), Interracial ($n = 12$, 5.3%), and African American or Black ($n = 2$, 0.9%). Regarding sex, the majority of participants identified as male ($n = 186$, 81.6%); with 40 (17.5%) identifying as women, and two (0.9%) identifying as other. Participants were asked to disclose their ages within set ranges. The majority of participants fell within the 25–34 age range with 86 (37.7%) followed by the 35–44 age range with 68 (29.8%), the 45–54 age range with 40 (17.5%), the 18–24 age range with 28 (12.3%) and the 55–64 age range with six (2.6%). All recruitment messages and studies measures were presented solely using the English language; thus the possible sample was limited to those who could read English.

Procedures

The study was reviewed and approved for human subjects by the authors' Institution Review Board (UTK IRB-20-05816-XM). This current study is based on a sub-set of data collected as part of larger investigation of combat sport athletes exercise behavior, mental health, and exercise motivation. Participants were recruited through social media groups such as Facebook and other combat sport web groups. Permission from administrators of these social media groups and websites was granted prior to research solicitation. The posts included a link to the secured survey within the Survey Monkey. The survey began with an informed consent statement, and participants indicated their consent to participate by checking the "I agree" button (this is the only required response needed to submit the survey). Next, participants were asked to respond to the questionnaires. Participation was voluntary and anonymous.

Instrumentation

The participants first filled out a demographic form as a part of the survey. The demographic asked for non-identifying demographic information such as the participants' current age, sex, race, country of origin, and region (if country of origin was the US). This information from this demographic form was used as descriptive data for this study.

Level of participation

Participants were asked to indicate their level of participation within BJJ within the survey. This information was garnered by having participants mark one of the following levels of participation: hobbyists (i.e., train exclusively for recreation and fitness), competitive hobbyists (i.e., train mostly for recreation and fitness, but occasionally compete in BJJ), amateur athletes (i.e., train for the purposes of regularly competing as an amateur BJJ player), elite amateur athletes (i.e., train to compete at highest level of amateur competition—for example, Olympic, national, and/or international competition); and professional combat sport athletes. Regarding competitive level of participation, 60 (26.3%) were hobbyists; 97 (42.5%) participants identified as competitive hobbyists, 49 (21.5%) as amateur athletes, 17 (7.5%) as elite amateur athletes, and 5 professional combat sport athletes (2.2%). For the purposes of assessing meaningful comparisons among level groups, we reallocated participants into one of three groups: hobbyists ($n = 60$, 26.3%); competitive hobbyists ($n = 97$, 42.5%), and competitors (i.e., those train to regularly compete in BJJ at the amateur, elite amateur, and professional levels—$n = 71$, 31.1%).

Motivation

The Motives for Physical Activity Measure-Revised (MPAM-R; Ryan et al., 1997) was used to assess the strength of motives for athletes' participation in BJJ. The five motives measured are: (1) fitness—being physically active out of the desire to be physically healthy and to be strong and energetic; (2) appearance—being physically active in order to become more physically attractive, to have defined muscles, to look better, and to achieve or maintain a desired weight; (3) competence—being physically active because of the desire just to improve at an activity, to meet a challenge, and to acquire new skills; (4) social—being physically active in order to be with friends and meet new people; and (5) interest/enjoyment—being physically active just because it is fun, makes you happy, and is interesting, stimulating, and enjoyable. The scale has been used to predict various behavioral outcomes, such as attendance, persistence, or maintained participation in some sport or exercise activity, or to predict mental health and well-being. This scale was created on the foundations of Self-Determination Theory and the basic psychological needs of competence, relatedness, and autonomy. The scales motives have been found to be associated with intrinsic and extrinsic motivation with the interest/enjoyment, social, and competence scales relating to intrinsic motivation while the appearance and fitness scales relating to extrinsic motivation. Internal consistency estimates for the current sample across the five scales were consistent with those reported in the normative sample (Ryan et al., 1997) and indicative of good to very good reliability. Coefficient alphas for the current sample were as follows: fitness—alpha = 0.86, appearance—alpha = 0.91, competence—alpha = 0.87, social—alpha = 0.79, and interest/enjoyment—alpha = 0.83.

Data analysis

Statistical analyses were performed using Version 27 of the Statistical Package for Social Science (SPSS). A one-sample *t*-test was conducted to test the mean rating of five motive subscales. Multiple regression analyses were used to test if the number of years trained significantly predicted participants' ratings of the motivators. Finally, a one-way between subjects MANOVA was conducted to compare athletes' level of participation on their motivation ratings.

Results

The study was presented as a two-page survey *via* Survey Monkey (an online data collecting platform). The first page of the study consisted of demographic questions as well as level of participation of clients. Two hundred twenty-seven participants (99.6%) responded to all questions regarding country of origin, gender, age, and race, as well as all of the items on the MPAM-R.

To test *H1*, a one-sample *t*-test was conducted to test the mean rating of five motive subscales (appearance, competence, fitness, interest/enjoyment, and social) relative to sample mean of all items (overall $M = 5.54$, range 1–7) on the MPAM-R. Three subscales were found have significantly higher endorsements relative to overall sample mean: interest/enjoyment, $M = 6.40$; SD = 0.73, $t(227) = 17.78$, $p < 0.001$, Cohen's $d = 0.73$; competence, $M = 6.27$; SD = 0.89, $t(227) = 12.21$; $p < 0.001$, Cohen's $d = 0.90$, and fitness, $M = 5.95$; SD = 1.13, $t(227) = 5.47$, $p < 0.001$, Cohen's $d = 1.13$. Two subscales had significantly lower endorsement that overall sample mean: appearance, $M = 4.59$; SD = 1.46, $t(227) = -9.76$; $p < 0.001$, Cohen's $d = 1.46$; and social, $M = 4.47$; SD = 1.28, $t(227) = -12.62$; $p < 0.001$, Cohen's $d = 1.28$. Table 1

TABLE 1 One sample *t* test comparing relative strength of MPAM-R item responses (in descending order of mean score).

Item	*M*	SD	*t*(227)	*p*
Like to do this activity	6.64	0.78	21.34	<0.001
Enjoy this activity	6.61	0.89	18.04	<0.001
Find the activity stimulating	6.56	0.85	18.05	<0.001
Think it is interesting	6.54	0.85	17.91	<0.001
Makes me happy	6.54	0.98	15.45	<0.001
Want to get better at this activity	6.51	0.88	16.64	<0.001
It's fun	6.47	1.00	13.98	<0.001
Like the challenge	6.41	1.03	12.78	<0.001
Want to obtain new skills	6.29	1.13	10.00	<0.001
Like activities that physically challenge me	6.26	1.16	09.43	<0.001
Want to improve existing skills	6.26	1.25	08.69	<0.001
Maintain physical health and well-being	6.19	1.25	07.83	<0.001
Want to be physically fit	6.14	1.18	07.76	<0.001
Maintain physical strength for a healthy life	6.12	1.31	06.69	<0.001
Keep my current skill level	6.07	1.45	05.54	<0.001
Like activities that are physically challenging	6.04	1.38	05.56	<0.001
Want to improve cardiovascular fitness	5.72	1.49	01.83	0.07
Enjoy spending time with others doing the activity	5.64	1.60	00.95	0.34
Like to be with others who are interested in the activity	5.60	1.62	00.53	0.60
Want to have more energy	5.56	1.72	00.19	0.85
Like the excitement of participation	5.44	1.65	−00.93	0.36
Want to lose weight so I look better	5.03	1.92	−04.00	<0.001
Want to improve my body shape	4.88	1.78	−05.63	<0.001
Want to be with my friends	4.87	1.90	−05.30	<0.001
Want to improve my appearance	4.64	1.93	−07.06	<0.001
Define my muscles so I look better	4.49	1.90	−08.32	<0.001
Want to meet new people	4.35	1.93	−09.34	<0.001
Want to be attractive to others	4.07	2.00	−11.13	<0.001
Physically unattractive if I do not	2.99	2.15	−17.90	<0.001
Friends want me to do it	1.92	1.53	−35.76	<0.001

Item range 1–7 indicating reasons participants participate in BJJ with 1 being not at all true for them, to 7 being very true for them. Mean of all items for sample was 5.54 which served as the test value for the one-sample *t*-test.

presents the mean rating and relative difference from the overall sample mean for all items.

To address *H2*, five multiple linear regressions were calculated to predict if the number of years trained and level of training (operationalized as 1 = hobbyist, 2 = competitive hobbyist, and 3 = regular competitor) predicted participants' ratings of the motivators of interest/enjoyment, competence, appearance, social, and fitness. Follow-up simple regression were then used to examine the effect years of experience and training level separately.

Using the enter method it was found that years of experience and training level explained a significant amount of the variance in the value of competence, $F(2, 225) = 3.91$, $p = 0.022$, $R^2 = 0.34$, $R^2_{\text{Adjusted}} = 0.25$. The simple regression analysis showed that years of experience did not significantly predict value of competence motivators [Beta = 0.06, $t(227) = 0.90$, $p = 0.37$], however training level did significantly predict value of competence motivators [Beta = 0.16, $t(227) = 2.48$, $p = 0.014$].

Regarding interest/enjoyment motivators, the linear combination of years and experience and training level did not explain a significant amount of variance $F(2.225) = 2.64$, $p = 0.074$, $R^2 = 0.02$, $R^2_{\text{Adjusted}} = 0.01$. The simple regression analysis showed that years of experience did not significantly predict value of interest/enjoyment motivators [Beta = 0.059, $t(227) = 0.00$, $p = 0.996$], however training level did significantly predict value of interest/enjoyment motivators [Beta = 0.15, $t(227) = 2.27$, $p = 0.024$].

Regarding appearance motivators, the linear combination of years and experience and training level did not explain a significant amount of variance $F(2,225) = 0.27$, $p = 0.768$, $R^2 = 0.002$, $R^2_{\text{Adjusted}} = -0.007$. The simple regression analysis showed that neither years of experience [Beta = 0.01, $t(227) = 0.12$, $p = 0.903$] nor training level [Beta = 0.15, $t(227) = 0.69$, $p = 0.491$] significantly predicted value of appearance motivators.

Regarding social motivators, the linear combination of years and experience and training level did not explain a significant amount of variance $F(2,225) = 1.37$, $p = 0.256$, $R^2 = 0.012$, $R^2_{\text{Adjusted}} = 0.003$. The simple regression analysis showed that neither years of experience [Beta = −0.01, $t(227) = -0.16$, $p = 0.872$] nor training level [Beta = 0.11, $t(227) = 1.65$, $p = 0.109$] significantly predicted value of social motivators.

Finally, regarding fitness motivators, the linear combination of years and experience and training level did not explain a significant amount of variance $F(2,225) = 0.08$, $p = 0.916$, $R^2 = 0.001$, $R^2_{\text{Adjusted}} = -0.008$. The simple regression analysis showed that neither years of experience [Beta = −0.02, $t(227) = -0.35$, $p = 0.728$] nor training level [Beta = −0.01, $t(227) = -0.18$, $p = 0.859$] significantly predicted value of social motivators.

To address *H3*, a multivariate analysis of variance (MANOVA) was used to compare the effect of participant levels of participation (hobbyist, competitive hobbyist, or regular competitor) on their motivation ratings of interest/enjoyment, competence, appearance, fitness, and social. The multivariate test of the differences among the three groups was significant, Pillai's trace = 0.035, $F(10,444) = 3.11$, $p < 0.001$, partial $\eta^2 = 0.065$ (medium effect). Of the univariate tests, competence, $F(2,225) = 8.57$, $p < 0.001$, partial $\eta^2 = 0.071$ (medium effect), and fitness, $F(2,225) = 5.24$, $p = 0.006$, partial $\eta^2 = 0.045$ (small effect), were significant at $p \leq 0.016$ (for three levels). Using the Dunnett's C method (which does not assume equal variance due to sample size differences among the competitive training levels), each ANOVA for the three groups was tested at the 0.017 level. The only significant ($p < 0.017$) mean difference was between hobbyists ($M = 5.88$, SD = 1.01) and competitive hobbyists ($M = 6.47$, SD = 0.76) on the competence motivators. Regular competitors ($M = 6.32$, SD = 0.88) were different than hobbyists on the competence motivators at the $p < 0.05$ level (shy of the needed significant probability for comparisons among three groups). The univariate tests for interest/enjoyment, $F(2,225) = 3.09$, $p = 0.05$, partial $\eta^2 = 0.03$; appearance, $F(2,225) = 0.89$, $p = 0.51$, partial $\eta^2 = 0.01$; and social, $F(2,225) = 2.51$, $p = 0.08$, partial $\eta^2 = 0.02$ were not significant.

Discussion

The findings from this study suggest BJJ athletes find both intrinsic and extrinsic motivation to participate in their sport. However, these athletes tend to value the motivators of interest/enjoyment, competence, and fitness relatively stronger than appearance and social motives—especially if they compete in BJJ. Research supports the findings of interest/enjoyment with the recent boom of interest and popularity in BJJ by practitioners and spectators over the past few decades (Blue, 2013; Andreato et al., 2017). The findings also align with the fitness benefits that have been studied within BJJ practice such as reducing body fat and blood pressure as well as improvements in flexibility and cardiovascular functioning (Burke et al., 2007; Tsang et al., 2008; Boguszewski et al., 2014; Kim et al., 2014), while also highlighting the benefits regarding competition. Lean mass within the upper quartile of an athlete's weight class has been positively correlated with the ability to perform technical actions within a performance (Franchini et al., 2007; Kim et al., 2011; Marinho et al., 2012). These fitness benefits in novel practice and competition bring light to what lead fitness motivation to be in high regards with BJJ players. While interest/enjoyment and fitness were rated relatively high on the MPAM-R, competence was the motivator that participants referred to on multiple occasions.

Competence as motivation for BJJ athletes can be viewed in many aspects of the sport including the objective of the sport. For a competitor to be victorious in a match, the competitor must either submit their opponent or be ahead in points, based on positional dominance, at the end of the bout. Both avenues to victory create a need for BJJ players to be technically sound and possess a vast knowledge of submissions, passes, takedowns, and positions. BJJ players that fail to obtain and maintain competence in their technical ability will find it difficult to progress within the sport. This coincides with the findings of this study in that competition hobbyists and elite amateurs rated competence higher than hobbyists. Both elite amateurs and competition hobbyists compete in BJJ in some capacity within their participation. These athletes must be competent in their skills and techniques to compete with others within their competitive field, which is usually based on belt rank within BJJ, which is also a measure of competence.

Regarding *H2*, we found positive correlations between competitive training level and competence, and interest/enjoyment motivation ratings. Similarly, and related to *H3*, competitive BJJ athletes endorsed higher competence (medium effect) and fitness (small effect) motivators relative those athletes who identify as hobbyists in the sport. However, our hypothesis regarding relations between years of experience and sport motivation were not supported. As BJJ athletes gain competence in their sport, they are recognized by being awarded a higher belt rank within their training (either blue, purple, brown, or black) as a symbol of skill (Ovretveit et al., 2018). To advance to a new belt, BJJ players must exemplify mastery and competence over various techniques and skills to ensure that they are qualified for belt promotion. When BJJ players compete, they do so against other at the same skill or belt level. Thus, BJJ athletes' engagement in competition, regardless of number of years of sport participation, was found to be more predictive of their motivations for sport participation.

The results of this study also coincide with the basic psychological needs of competence and relatedness. Participants found competence to be a relatively high motivator which can also influence other perceived aspects of their sport. For example, high perceived competence within athletes increases expectations for success, intrinsic motivation, persistence to face and overcome adversity, exerted efforts, such as engagement, effort to master skills, persistence in the face of difficulty, and choice of challenging tasks (Roberts et al., 2007). Relatedness was expressed through the significantly high ratings that participants had for the social motivator. Participants seemed to value connectedness to others within their training environment. This relatedness has been shown to predict indices of self-determination and intrinsic motivation for both sport participation and exercise behavior (Stults-Kolehmainen et al., 2013).

Practical implications

The findings of this study could aid BJJ instructors in their training techniques for their students. BJJ instructors may take the notion of competence as a motivator and revise their training to emphasize the acquisition and mastery of skills and techniques, instead of emphasizing the progression of belt rank—especially for athletes with goals of competing in BJJ. This type of training can keep BJJ players engaged with their training for a more intrinsic motivator, which could maintain and/or increase participation, even if belt progression is not occurring at the frequency that the BJJ player would hope for.

Sport clinicians and sport psychologists can benefit from the findings of this within their own work with BJJ players. Sport psychologists may find that tailoring their interventions to focus more on the competence that the BJJ player has within their sport could foster more dialogue and a deeper therapeutic relationship between the sport psychologist and the BJJ player. For example, an intervention centered around the BJJ player's purpose for participation regarding competence could open avenues to further discuss concerns that the BJJ player may have in this area such as self-doubt, performance anxiety, and issues with focusing.

Limitations

There are a few limitations to this study, starting with the diversity in the participant pool. The majority of participants were White men from the United States. It is important to note that all recruitment message and study measures were only presented in the English language, thus, non-English speakers likely did not respond. It is unknown as to the level of English proficiency the participants had; however, analyses of internal consistency estimates are consistent with samples from previous investigations (e.g., Ryan et al., 1997) suggesting acceptable reliability of responses. This pool does not do justice to the many racial, sexual, geographical, and cultural differences within the BJJ community—especially among non-English speakers. Future researchers may wish to consider using multi-lingual translations of study instruments—most notably Portuguese (which is the native language in Brazil).

A second limitation to this study is the lack of qualitative data. While quantitative data provides a large dataset of numerical data, studies of this nature do a poor job of understanding the "why" behind participants' responses. With a topic such as motivation, it is important to hear from participants, in their own words, their purpose and motivation to participate in their sport. An inclusion of some qualitative measure should be added to dive deeper into the personal beliefs and reasonings behind athletes' motivations to participate in their sport.

While the concerns of blue belts within BJJ was previously addressed, participants were not to identify their belt rank within this study. Data were derived from a larger study of combat sport athletes—many of which were from sports without a belt ranking system. Future studies would greatly benefit from gathering this information to further study the influence of motivation within and across belt ranks within BJJ.

Conclusion

Motivation is a key foundation to the actions and behaviors that an athlete partakes in with their sport. This drive and direction of motivation can be influenced by a multitude of elements that an athlete faces in their daily lives. The athlete's motivation lies upon a spectrum between extrinsic and intrinsic motivation, depending upon the motivators driving them. BJJ players have been found to have a multitude of motivators that drive their motivation, however, there have been few studies that have provided a motivational profile for these athletes. The results of this study found that while BJJ players value both extrinsic and intrinsic motivators, there is a relative difference among motivators with competence being a driving motivator for those with goals of competing in their sport. From a practical perspective, these findings may aid practitioners, instructors, and clinicians in their approach to training and interventions with BJJ athletes.

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 University of Tennessee, Knoxville 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

TT and JL aided in the design of the study, data collection, and data analysis. TT was primarily responsible for writing the introduction and discussion. JL was primarily responsible for writing the method and results sections. All authors contributed to the article and approved the submitted version.

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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Exploring exercise adherence and quality of life among veteran, novice, and dropout trainees

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Introduction: The purpose of this study was to identify and reveal the different contexts, variables, and factors that may influence adherence to physical activity among veteran, novice, and dropout trainees, such as the frequency of the weekly training units, the trainees preferred type of exercise, the purpose of the physical activity, and the relationship between support and supervision by fitness instructors and professionals. This study also examined the relationships between trainees' seniority and the strength of the habit and adherence to physical activity, the effects of personal variables such as age and gender on adherence to physical activity, and how the seniority and adherence of trainees may affect their quality of life.

Methods: A total of 460 participants drawn from the broader Israeli exercise community, which encompasses a diverse range of individuals within the general adult population, were engaged in this study. These participants included seasoned exercisers, individuals who had recently initiated exercise routines, and those who had previously engaged in physical activity. Each participant completed a comprehensive set of questionnaires, including the Self-Report Habit Index, the Exercise Adherence Rating Scale, and the World Health Organization (WHO) Quality of Life Scale. In addition to the questionnaire responses, demographic data and inquiries concerning their physical activity were also collected.

Results: The results show that the average frequency of the weekly training units of veteran trainees was significantly higher than that of novice trainees: 3.95 and 2.93, respectively ($p < 0.0001$). We found no significant differences between novice and veteran trainees regarding their training goal preferences ($p = 0.07$). Veteran trainees who had been in training for more than a year appeared to have higher self-efficacy since 31.16% reported receiving no supervision compared to 16.67% among novice trainees. In addition, people over 45 appear to have more health-related goals compared to their younger counterparts ($p < 0.001$). The quality of life scores of the trainees was related to their seniority in physical training, but only by a small magnitude ($R^2 = 0.06$), $p < .001$). Those who trained in resistance training showed the greatest rate of adherence in relation to flexibility and aerobic training ($p < 0.001$), and women preferred more body toning and had more weight loss goals than men ($p < 0.001$).

Discussion: The results indicate that there are central and important factors that may affect adherence to physical activity, and that all these aspects must be taken into account when planning a training program or when there is a desire to maintain or increase adherence to physical activity. The research findings indicate that the main factors that can influence adherence to physical activity are identifying and increasing the trainee's self-efficacy, maintaining weekly training units with sufficient frequency to form a habit and incorporating resistance training into the training regime, as resistance training has shown high

levels of adherence. Moreover, it seems that people with different degrees of experience in physical training have distinct and varied training goals, and there is no one goal that fits all. In addition, specific factors such as age and gender must also be taken into account, because the age and gender of the trainees may significantly affect the goals of physical training.

KEYWORDS

exercise, adherence, training, dropout, physical activity, habit

Introduction

Numerous studies have underscored the pivotal role of regular physical activity in the management and prevention of noncommunicable diseases. Adherence to the physical activity guidelines set forth by the World Health Organization (WHO) has demonstrated the potential to substantially mitigate the risk of premature mortality by 20%–30%, while also contributing to a reduction in prevalent health issues such as cardiovascular diseases, diabetes, and dementia (1). Moreover, many studies that investigated the effects of physical activity on psychological discomfort, anxiety, and depression discovered that its effects may be comparable to those of medicine and psychotherapy (2). In addition, exercise adherence has a beneficial effect on physical function, pain, and chronic diseases (3). However, even though the benefits of having an active lifestyle are so well known, a major health concern is that a sedentary lifestyle and lack of physical activity are still so prevalent (4). Therefore, physical inactivity may even be considered a pandemic due to its prevalence and societal repercussions (3). Recent global estimations reveal a concerning prevalence as 1.4 billion adults, equivalent to 27.5% of the global adult populace, are failing to meet the recommended thresholds for physical activity, which are fundamental for the enhancement and safeguarding of their health (1). In the sphere of physical activity, the concept of adherence assumes a paramount significance, representing an individual's steadfast commitment to a structured training regimen (5). The online *Oxford Dictionary of Sport Science and Medicine provides* a definition of exercise adherence, describing it as "maintaining active involvement in physical activity." It further emphasizes that individuals with strong exercise adherence continue their participation in physical activity, even in the face of opportunities and pressures to withdraw (6). However, it's important to note that the definition of exercise adherence varies significantly across the literature, comprising four distinct measures: completion, attendance, duration adherence, and intensity adherence (7). In the realm of adherence assessment, various studies have adopted attendance as a pivotal criterion (8, 9), with indications that irregular attendance patterns can effectively identify individuals who may require adherence counseling (10). The complexity of participation and adherence to physical activity is further accentuated by the diverse array of factors influencing an individual's engagement, encompassing motivation, abilities, preferences, self-efficacy, social dynamics, environmental conditions, and policy considerations (11), along with social context, habit and past behavior, professional support, motives and barriers. In addition to personal characteristics such as gender, age, and level of seniority at the fitness facility affect participation (12).

Moreover, personal characteristics such as obesity, blue-collar status, and smoking have been associated with decreased adherence to an exercise program and an increased dropout rate. In addition, exercise programs have many variables that need to be taken into account that may also affect adherence such as the activity type, intensity, flexibility, and the cost of the program (13). Burnet et al. (14) identified specific physical training variables such as Frequency, Intensity, Time, and Type of activity (FITT) that may influence exercise adherence among different populations. Furthermore, beyond general physical activity, engagement in organized physical activity such as "exercise" has decreased, as evidenced by a drop in people's involvement in regular and scheduled physical activity in recent years (15). Moreover, a study of 5,240 members of a fitness club in Brazil found large abandonment rates, as 63% of the participants had abandoned their membership in the first quarter, and after a year, the abandonment rate reached an alarming 96% (16). Another study conducted in Spanish gyms showed abandonment rates of about 51% in a 1-year period (17). Still another study found that only 37% of participants reported regular adherence during the first year of their gym membership (18), while a recently published retrospective observational cohort study conducted in two gyms found adherence rates of only 11% and 19% (3).

According to these data, adherence to physical activity in general is problematic, particularly in high-income countries, where the rates of inactivity are twice as high as in low-income countries (1). In addition, there is evidence of low adherence rates in institutions such as fitness clubs and gyms (3, 16, 18). which play an important role in enabling recreational sports and daily physical activity to take place (19), promoting physical activity for individuals and groups, and providing a wide context for physical activity (20). On a global scale, the fitness and health sector is growing rapidly on a global scale. According to data, there are now over 150,000 fitness and health facilities worldwide, with over 140 million members, and the industry is worth $77.5 billion (21). Currently, the United States leads the world's gym market with over 30,000 establishments, followed by Brazil with approximately 24,000 units (22). According to data from Europe in 2018, the average number of members per fitness club increased at a rate of 7%, while the market as a whole was increasing at a rate of 3.2% based on the number of clubs (23).

By using fitness centers, people of all body types may exercise their bodies in a variety of ways, use a wide range of fitness equipment, and receive personalized advice from fitness professionals (24). Fitness centers stress and encourage many individuals to have healthy lives by exercising and receiving instruction (25). However, despite this data, it is clear that the fitness business suffers from high churn and low member loyalty, as well as the fact that between 19% and 24% of consumers discontinue partaking in sports activities after leaving the sports center (26). Aside from the fact that leaving gyms and sports centers is a major economic worry, this has the potential to become a global problem in terms of physical inactivity because sports centers are the primary drivers of such activity, creating a major public health concern (17).

Accordingly, the purpose of this study was to identify and reveal the various contexts, variables, and factors that may affect adherence to physical activity among veteran, novice, and dropout trainees and to understand whether this adherence may also affect their quality of life.

Overview and hypotheses

The purpose of this study was to understand the differences between experienced and novice trainees, and people who had exercised in the past, but who were not exercising currently. In addition, we sought to investigate and identify the variables, contrasts, and contexts that may affect exercise adherence, including the frequency of weekly training units, type of training preferred by the trainee, purpose of the training, and the relationship between support and supervision by the fitness instructors. Moreover, we examined the relationships of seniority with habit strength and adherence to physical exercise, the effects of individual characteristics such as age and gender on exercise adherence, and how trainees' seniority and adherence may affect their quality of life.

It is believed that the frequency of exercise affects adherence rates. Rodrigues et al. (15) showed that a weekly frequency of two workouts per week led trainees to maintain a future routine. Kaushal and Rhodes (27) found that in order to establish physical exercise habits, it was necessary to exercise at least four times a week and for a duration of about 6 weeks, while Clavel San Emeterio et al. (17) showed that a frequency of more than eight times a month is a parameter that significantly reduced the chance of retirement. Based on these findings, and leveraging the dataset at our disposal, our initial conjecture revolves around veteran trainees, delineated as individuals possessing extensive experience, spanning over 12 months, who consistently uphold a training frequency surpassing the threshold of three sessions per week. An additional supposition underlies our analysis, postulating that the training frequency of veteran trainees surpasses that of their novice counterparts. Consequently, we formed the following hypothesis:

> **Hypothesis 1**. *Trainees who adhere to physical exercise for more than 12 months, training with an average weekly frequency of above 3 sessions per week and will develop a stronger habit for physical exercise compared to novice trainees.*

The type of exercise training may also have an effect on adherence rates. Robison and Rogers (13) found that approximately 50% of individuals who start an aerobic exercise program will stop within the first six months. van der Vlist et al. (28) concluded that the tedious nature of endurance exercise makes it difficult for many people to establish a healthy exercise habit. Lee et al. (29) found that in overweight teenagers, a group who participated in aerobic training reported more boredom and less pleasure than a group involved in resistance training. Moreover, Picorelli et al. (30) showed that among older women, adherence rates to strength training were higher than to aerobic training. The reasoning behind the assumption that women will typically engage in more aerobic activity than males is based on research by Dworkin (31), who found that women preferred aerobic activities over weight training because they perceived that such activity allowed them to not only build strength but to maintain a feminine appearance. Thus, we believe:

> **Hypothesis 2**. *The rates of adherence to physical exercise will be higher for those who engage in resistance training than for those in aerobic training, flexibility training, or other activities. In addition, in general and regardless of the level of adherence, women will show more engagement in aerobic activity than in resistance training compared to men.*

Age and gender seem to affect the purpose of exercise. According to research by Kilpatrick et al. (32), among students with an average age of 22 years, concerns about beauty and weight control were important driving forces behind physical exercise. Caglar et al. (33) found that appearance-related motives were important for young adults, and Soekmawati et al. (25) showed that adults are motivated by aesthetic goals such as appearance and weight management.

In addition, women not only want to maintain their health (with an emphasis on maintenance and not improvement), but they also wish to increase their attractiveness and improve their appearance (25). Kilpatrick et al. (32) found that female college students had more concerns about their body weight than males, and Koivula (34) showed that women rated appearance as more important than men. Soekmawati et al. (25) reported that women were 2.4 times more likely to choose appearance-related goals as a motivation for physical exercise, and had greater concerns greater concerns about their body weight than men. Anić et al. (35) showed that women with a high BMI exercised to lose weight and that it was their body composition that affected their satisfaction and droves them to prefer weight management as their main motivation for exercise. In contrast, men were more motivated by social recognition, competition, challenge, strength, and endurance, and saw physical exercises as a means of achieving these ego-related results (25).

The assumption that the older the exercisers are, the more likely they are to pursue health-related goals stems from the findings of Lübcke et al. (36) who, in interviews with subjects

aged 65–81, demonstrated that, over time, physical exercise became for them an investment in health and social activity. Trujillo et al.'s (37) findings indicate that elderly people are more concerned about health outcomes than younger people. Therefore, we propose that:

> **Hypothesis 3**. *There will be a positive correlation between the age and gender of the exerciser and the purpose of the physical exercise, and as age increases, training goals will be more related to health related than to aesthetics. In general, women's goals will be more aesthetic, especially in relation to toning the body and losing weight, compared to men.*

The type of motivation trainees have affects their exercise goals. Ortís et al. (38) showed that external motivation was dominant during the early stages of behaviorial change in exercise, whereas at later stages and for long-term maintenance, internal motivation dominated. Furthermore, intrinsic motivation was positively associated with exercise adherence, and individuals with higher levels of intrinsic motivation reported higher levels of physical activity persistence and adherence over time (39). Thus, we hypothesize that:

> **Hypothesis 4**. *Experienced exercisers will prioritize goals related to improving physical fitness and health over goals of visibility and aesthetics because they likely have developed more internal motivation compared to beginners who depend more on external motivation.*

It would seem to make sense that trainees would benefit from guidance and instruction in the early days of their training, and that the longer they exercise, the less dependent they would become on this external support. Sperandei et al. (16) observed that adherence to physical activity in unsupervised programs was low, adding that the findings of their study revealed that more than half of gym members did not complete 3 months of active participation and that there was a less than 5% chance that a person would remain active for more than a year. Thus, receiving support from physical fitness instructors may create favorable conditions for the promotion of and adherence to long-term physical activity (15). According to Klain et al. (40), subjects who had personal trainers had more self-determined forms of regulation and were more adherent to physical exercise. Teixeira and Palmeira (41) stressed the importance of fitness professionals who understand how to build support for trainees in order to improve their adherence and psychological well-being. Based on these findings, we expect to find that:

> **Hypothesis 5**. *Most veteran trainees (over a year) received guidance and support in the past, but do not currently receive such guidance and, thus, are more independent.*

Lastly, because physical activity has a great effect on human health, both physiologically (42) and mentally (43), and this greatly impacts a person's well-being and quality of life (44), our last hypothesis is:

> **Hypothesis 6**. *People who persist and adhere to long-term physical activity have a better quality of life.*

Materials and methods

Participants and procedure

812 Israeli participants were recruited through social media and instant messaging apps. After giving informed consent, volunteers completed a Hebrew online research questionnaire about physical activity and quality of life. Some of the instruments included in the questionnaire already existed in Hebrew, whereas others were translated from English into Hebrew using the back translation method (45, 46). The Ethics Committee of West Timisoara University approved the questionnaire and research protocol (15227/7.03.2023). We excluded data from 352 participants, as 24 were screened out based on the first question in the study, and 328 failed to complete the responses in the questionnaires or filled them in carelessly or illogically and/or did not meet the inclusion criteria of the study. In total, the final sample comprised 460 participants with a mean age of 37.03 (SD = 11.71 years), and 53.7% were female. The BMI for the female participants ($N = 247$) was 23.66 (sd = 3.77), and for the males ($N = 153$), it was 25.93 (sd = 3.83). For the total sample ($N = 460$), the BMI was 24.71 (sd = 3.96), suggesting that the sample overall was of normal weight (47). The majority of the participants had a post-secondary education, with 69.80% having an academic education, and 71.74% of the participants reported that they worked fulltime. **Table 1** presents the remainder of the participants' characteristics, and their descriptive data are displayed in **Table 2**.

Instruments and measures

For inclusion in this study, participants were required to be: (1) at least 18 years of age, (2) Hebrew speaking and with no difficulty in reading and filling out the questionnaires, and (3) either actively

TABLE 1 Characteristics of participants.

	Male ($N = 213$)	Female ($N = 247$)	All ($N = 460$)
	Mean (±SD)	Mean (±SD)	Mean (±SD)
Age	36.85 (±10.87)	37.18 (±12.41)	37.03 (±11.71)
Body weight (kg)	81.58 (±13.99)	63.12 (±11.12)	71.66 (±15.54)
Body height (cm)	177.14 (±6.23)	162.45 (±10.83)	169.25 (±11.60)
BMI	25.93 (±3.83)	23.66 (±3.77)	24.71 (±3.96)
Seniority level adherence to exercise and/or physical activity (years)	8.73 (±9.28)	7.85 (±8.76)	8.25 (±9.01)
Seniority level adherence to exercise and/or physical activity (months)	1.58 (±2.69)	1.16 (±2.28)	1.36 (±2.49)
Training sessions per week	3.72 (±1.89)	3.14 (±1.81)	3.41 (±1.87)

TABLE 2 Descriptive data.

Characteristic		Percentage
Education	Less than secondary education	.4
	Secondary education	29.8
	Academic education	69.8
Employment	Unemployed	10.7
	Part time	17.6
	Full-time	71.7
Marital status	Single	36.5
	Married	55.0
	Divorced/separated	7.2
	Widowed	1.3
Supervision	No supervision at all—trains completely independently	36.7
	Supervised by a shift instructor in the gym who is responsible for all the trainees	15.9
	Online support (online trainer)	5.7
	Training in small groups (3–6 participants)	25.9
	Personal training (one-on-one)	15.9
Preferred type of training	Aerobic training	25.9
	Resistance training	54.6
	Flexibility training	9.1
	Other	10.4
Goals	Health	29.8
	Toning and weight loss	31.5
	Increase in muscle mass	17.2
	Improving physical fitness	21.5

TABLE 3 SRHI questionnaire *t*-test.

Item	Beginners ($n = 54$)		Veterans ($n = 337$)		*T*
	Mean	*SD*	Mean	*SD*	
1. I do frequently	3.78	1.14	4.61	.67	−7.51***
2. I do automatically	3.13	1.16	3.96	1.05	−5.33***
3. I do without having to consciously remember	2.74	1.15	3.31	1.32	−2.96*
4. That makes me feel weird if I do not do it.	3.24	1.31	4.33	.94	−7.42***
5. I do without thinking	2.89	1.19	3.35	1.26	−2.62*
6. That would require effort not to do it	2.76	1.24	3.36	1.22	−3.28**
7. That belongs to my (daily, weekly, monthly) routine	3.95	1.02	4.61	.59	−6.72***
8. I start doing before I realize I'm doing it	2.55	1.07	2.87	1.22	−1.99
9. I would find hard not to do.	3.04	1.23	4.21	1.06	−7.34***
10. I have no need to think about doing.	2.84	1.23	3.37	1.26	−2.97**
11. That's typically "me"	3.32	1.16	4.23	.92	−6.56***
12. I have been doing for a long time	3.28	1.34	4.61	.61	−12.06**

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

exercising at the moment or they had done so in the past. Accordingly, 812 exercisers answered the first question, which explained that the study was intended for people who had exercised and engaged in physical exercise in the past or who were currently engaged in an exercise regime. The purpose of this question was to initially identify the relevant subject population for the study. Of the respondents, 168 (20.96%) reported that they had exercised in the past, but were not currently exercising; 620 (76.35%) reported that they were currently exercising, whereas 24 (2.96%) reported that they were not currently exercising and had not exercised in the past. This last group was excluded from answering any further research questions.

Habit strength

The Self-Report Habit Index (SRHI) is an instrument for assessing habit strength. It consists of a basic question (stem) with variable responses that the researcher can choose and formulate according to his specific requirements, for example, "[Behavior X] is something…", with 12 items that assess aspects of the habit. In this study, the basic question was "Physical exercise is something that…" followed by e.g., "I do automatically", "I do frequently", "I do without having to consciously remember", and so forth (see **Table 3** for the specific statements). The participants were asked to rate their degree of agreement using a 5-point Likert scale. After this, internal reliability test of the scale was carried out ($\alpha = 0.92$). Finally, an average of the items was compiled to assess the strength of the habit (48).

Exercise adherence, helps and hindrances

In order to capture the exercise adherence of the participants and the factors that might help or hinder them, we used the Exercise Adherence Rating Scale (EARS) (49). Meade et al. (50) demonstrated that the EARS is a robust measure of adherence, with good face validity and comprehension.

It is a three-part self-report index that assesses and measures adherence to prescribed home exercise: The first section requires participants to document the exercise prescription provided to them by their healthcare provider, the second section measures the level of adherence using six items, and the third section measures ten items (factors that help or hinder) that affect exercise adherence. In this study, we did not require participants to complete the first section. Measurement was performed only according to data provided in the other sections ($\alpha = 0.88$). The EARS includes six adherence items and ten additional items of helps and hindrances. The score of each participant is the sum of the responses of all 16 items using a 5-point Likert scale.

Quality of life

In order to assess the quality of life of the study participants, we used the WHOQOL: Measuring Quality of Life questionnaire, a cross-culturally applicable quality-of-life assessment (51) that was obtained from the WHO website. This questionnaire probes how a subject feels about his quality of life, health, and other areas of life. It consists of 26 questions in total that are rated on a 5-

point Likert scale ($\alpha = 0.91$). A Hebrew translation of this questionnaire was done independently by the Department of Behavioral Sciences at the Ben-Gurion University of the Negev, Israel.

Statistical analyses

Data analysis was performed using IBM SPSS version 23.0. We utilized F-tests to determine the variance ratio between two samples, t-tests to find the mean difference between two independent samples with equal variance, and ANOVA and post-hoc tests for homogeneity. Chi-square tests were employed to see differences between gender, and veterans and novice trainees, and a Pearson chi-square determined the relationship between the age and gender of trainees and their training goals. Accordingly, a significance level of $p = 0.05$ was determined, and the effect size was evaluated for each test. Internal reliability of the questionnaires was performed using Cronbach's alpha.

Results

In order to examine Hypothesis 1, a confidence interval was first evaluated first, for the weekly training frequency among the 337 participants who had trained for more than 12 months with the following results: $\bar{x}_n = 3.947$, $\cdot \bar{s}_n = 1.563$, with a confidence level of 0.95. The formula $\bar{x}_n \mp t_{n-1,0.975} \frac{\bar{s}_n}{\sqrt{n}}$, produces a CI of [3.779,4.114] for which there is a 95% probability that the actual frequency value is inside. Next, a single tail *t*-test was carried out for the null hypothesis H_0: $\mu = 3$, vs. the alternative hypothesis H_1: $\mu > 3$. The null hypothesis was rejected with $p < 0.00001$, strongly supporting H_1. Additionally, a *t*-test comparing those who were currently training for more than 12 months ($N = 337$) to those who had trained for 12 months or less ($N = 54$) revealed a significant statistical difference between the two groups regarding the number of weekly training units they had performed: $t(389) = -4.46$, $p = .000$. Accordingly, the veteran trainees (more than 12 months) had an average score of 3.95 (sd = 1.56) weekly training units compared to the novice trainees whose average was 2.93 (sd = 1.55). Cohen's d value for the effect size was 0.66, indicating a medium effect.

Regarding the strength of the habit of physical exercise, the results of the SRHI questionnaire (52) that assessed habit strength were separated into two samples—one for those who had been training for over 12 months and the other for those training for at most 1 year. A chi-square test for the variance ratio between the two samples for each of the 12 items of the questionnaire showed variance equality for items 1–4, 7, 9, 11 and 12 (see **Table 3**) with $p < 0.05$. Therefore, a *t*-test determined the mean difference between two independent samples with equal variance applied to these items, as well as for two samples with unequal variances to the rest of items. See **Table 3** for a summary of these results.

TABLE 4 Adherence rating (EARS).

	N	Mean	Std. deviation	95% confidence interval for mean	
				Lower bound	Upper bound
Aerobic training	119	60.91	11.17	58.88	62.94
Resistance training	251	66.46	9.08	65.34	67.59
Flexibility training	42	53.36	12.53	49.45	57.26
Other	48	63.52	10.92	60.35	66.69
Total	460	63.53	10.92	62.53	64.53

The EARS was evaluated for each of the participants, giving an individual adherence score in the range of (16, 80), in which 16 represents the lowest adherence rating and 80 the highest.

A statistical summary of the CIs for the adherence score in each training category is shown in **Table 4**. An *F*-test was used to measure for variance homogeneity of $p < 0.001$ between the four training categories. ANOVA results show a significant difference between the four categories with $F(3,456) = 23.49$, $p < 0.001$, and an effect size of 0.14 using the eta measure. A *post-hoc* test for homogeneous subsets with a 0.05 level of significance resulted in the following subsets: (1) Flexibility training, (2) Aerobic training + other, and (3) Resistance training + other. The resistance trainees' adherence was significantly higher than that of the aerobic ($p < 0.001$) and flexibility trainees ($p < 0.001$), whereas the difference between the resistance trainees' adherence and the "other" category was not significant ($p = 0.34$).

The fourth hypothesis was investigated using a chi-square test. While a gender difference in resistance and aerobic exercise preferences was identified, it was not demonstrated to be statistically significant: $\chi^2 = (1, N = 370) = 1.76$, $p = 0.18$.

Two independent Pearson chi-square tests were used to determine the relationship between the age and gender of the trainees and their training goals (Hypothesis 3). The first test between the age groups (age ≤45 or age >45) and the training goal was significant with a medium effect size ($\chi^2 = (1, N = 460) = 19.97$, $p < 0.001$, phi = 0.22), showing that 48% of the participants in the older group (age >45, $N = 99$) preferred health goals over others, in contrast to only 24.6% of the younger group (age ≤ 5, $N = 361$). The second test, between gender and training goals, also had a significant result, with a medium effect size ($\chi^2 = (1, N = 460) = 18.97$, $p < 0.001$, phi = 0.21).

In testing the expectation that experienced exercisers will prioritize health goals and goals related to improving physical fitness over those of visibility and aesthetics (Hypothesis 4), a distinction between health and aesthetic goals (body toning and shaping, visibility, and muscle mass increase) was made. A chi-square test conducted between novice (less than a year of experience) and advanced (more than a year of experience) participants who reported that they were currently training, using a chi-square yielded results of: $\chi^2 = (1, N = 391) = 3.19$, $p < 0.07$.

In testing the fifth hypothesis, the results showed that 28.19% of the veterans reported that they were being given instruction

and guidance, 40.65% had received support in the past, but 31.16% had not received any support at all. In contrast, 44.44% of the novices reported that they were currently receiving extra support, 38.89% had received support in the past, while 16.67% had not. Along with these data, it is important to note that a chi-square yielded the following results with a small effect size: ($\chi^2 = (2, N = 391) = 7.43$, $p < 0.024$, phi = 0.14).

To examine the quality of life in relation to the level of seniority of the trainees (Hypothesis 6), we used the WHOQOL questionnaire. A regression analysis indicated that there was a significant effect between the seniority level and quality of life: $F(1, 457) = 30.87$, $p < .001$. The adjusted R^2 indicated that only 6% of the variance in the quality of life could be explained by the seniority level, which was shown to be a statistically significant predictor of quality of life ($t = 5.56$, $p < .001$). The regression model suggested that each increase in seniority level was related to a 0.37 mark improvement in the quality-of-life score. The regression equation for this model was: quality of life; *score* = 96.97 + (0.37 X seniority).

Discussion

The purpose of this study was to comprehensively investigate the array of contextual, variable, and situational factors that could potentially influence exercise adherence across distinct categories of individuals, including those with varying levels of experience in physical activity, ranging from seasoned participants to beginners and individuals who had discontinued their exercise routines. A secondary aim was to examine whether this adherence might be associated with discernible effects on their overall quality of life. In accordance with this research objective, our findings offer substantial support for our initial hypotheses. Specifically, the results highlight a considerable and statistically significant distinction between veteran trainees and novices. Furthermore, our data reveals that veteran trainees consistently engage in training sessions exceeding a frequency of three times a week, with an observed practical frequency approaching four times weekly. The frequency of a specific behavior assumes a crucial role, with repeated practice culminating in the establishment of a "routine behavior." This process integrates the behavior as an integral component of one's personal identity (53) and may illustrate the profound influence of consistent exercise habits on one's self-perception and daily routines. Additionally, it is prudent to consider that certain individuals engaging in exercise may modulate and oversee their exercise frequency based on their physiological capacities and adherence to exercise prescriptions in accordance with health organizations[such as the American College of Sports Medicine (ACSM) guidelines]. The adjustment in exercise frequency can be self-regulated or carried out under the supervision of a healthcare professional. This approach is warranted by prior research demonstrating that exercise frequencies of up to twice weekly can elicit improvements in aerobic capacity among individuals with lower fitness levels. However, it is essential to recognize that when aerobic capacity surpasses the threshold of 50 ml/kg/min, a minimum exercise frequency of at least three times weekly is deemed necessary (54). Expanding on this discourse, and as mentioned above, it is plausible that individuals across diverse fitness levels adhere to the guidelines and directives prescribed by health organizations. For instance, concerning resistance training, it can be noted that the American College of Sports Medicine (ACSM) suggests that novice practitioners engage in full-body workouts 2–3 times a week, intermediate participants partake in full-body workouts 3 times a week or adopt a split routine targeting upper and lower body 4 times a week, while advanced exercisers commit to 4–6 sessions weekly, each major muscle group trained once or twice a week (55).

Also it should be emphasized that in addition to the training seniority, there may be a relationship between training frequency and the strength of the habit, as indicated by the co-occurrence of performance frequency and stable connections as a key characteristic of the habit. Furthermore, previous data showed that since the habit measurement is constructed from the participants' answers to questions concerning frequency and stability, and has previously demonstrated good predictive validity and showing that frequency x stability measures of physical activity habits are highly related to the experience of physical activity as automatic (56). Therefore this reinforces the fact that there may be a relationship between the frequency of physical training and the formation of habits and the strength of the habit. Considering that the definition of habit formation in the APA Dictionary of Psychology is " the process by which, through repetition or conditioning, animals or humans acquire a behavior that becomes regular and increasingly easy to perform" (57). Moreover, in the context of the assumption that veteran trainees, characterized as those engaged in physical activity for over 12 months, possess a more ingrained exercise habit, our findings substantiate the validity of this presumption. Therefore, when these findings are collectively synthesized, they imply a potential interplay between the strength of an individual's exercise habit, their duration as an exerciser, and the frequency of their training sessions. This study offers valuable insights into the intricate dynamics of exercise habits, seniority, and exercise frequency among participants, thus shedding light on the potential relationships within this multifaceted framework. When we examined the degree of adherence to physical activity in relation to the different types of training (Hypothesis 2), we discovered that those who reported that they trained in resistance training had the highest degree of adherence compared to aerobic training and flexibility training, but there were no significant differences found compared to training defined as "other training". Furthermore, no statistically significant differences in training preference in regard to aerobic vs. resistance training were detected between men and women This contradicts previous research that found women prefer aerobic exercise over resistance training (31), that women have different cultural expectations about resistance training, and that women have higher levels of concern, all of which discourage them from participating in such training (58).

On the contrary, in the context of Hypothesis 3, wich predicted that the age and gender of the trainees would affect the goals of

their physical training, it can be seen that the age of the trainees did affect the goal of the exercise, as trainees (both women and men) over the age of 45 preferred health goals more than younger trainees. We chose to investigate the issue of age because it is a significant risk factor for common diseases in affluent countries that includes cancer, cardiovascular disease and neurodegeneration (59). We also chose the age cut-off of 45 because, according to ACSM Risk Factor Screening, age is a risk factor that must be taken into account when approaching physical activity (60). Although age as a risk factor for men and women differs (men >45 years, women >55 years), we decided to perform use the age of 45 for both sexes. These findings are consistent with previous studies that found older people to be more concerned about their health than younger people and that physical activity was seen as an investment in health (36, 37). In contrast, younger adults under the average age of 45 were significantly motivated to exercise in order to keep their weight under control and to remain physically attractive (32). Moreover, the gender of the trainees exerts an influence on their exercise objectives. Notably, women tend to prioritize goals related to body toning and weight loss, while men gravitate toward objectives centered on muscle mass augmentation, enhanced physical fitness, and overall health improvement. This pattern of gender-related differences aligns with established empirical findings from prior research, underscoring the heightened significance of body weight concerns among women in comparison to men. Additionally, women tend to derive greater motivation from goals related to external appearance within the context of physical training, and their levels of concern about body weight, as well as the interplay of body composition, significantly impact their contentment and serve as motivational factors for engaging in exercise (25, 32, 34, 35). However, the trainees' seniority had no effect on the physical training goals, and while we predicted that veteran trainees would prefer goals related to health and improving physical fitness components over visibility and aesthetics goals compared to beginners, no significant statistical differences were shown.

When we predicted that the most veteran trainees over a year had received instruction and guidance in the past but were not currently receiving any (Hypothesis 5), interesting results were obtained when compared to the prediction. The veteran trainees reported that 40.65% of them had received such instruction in the past, but were not currently receiving any compared to beginners who reported that 38.89% of them were. However, it is possible that some of the beginners will still receive supervision later in their physical training journey, so this percentage may change. What is more intriguing are the findings regarding those who had received no instruction and guidance, with the percentage for veterans standing at 31.16% compared to 16.67% for beginners, and the fact that this figure may still change and decrease for beginners, as just mentioned. As a result, these findings may indicate that physical training adherence is related to an individual's capacity for self-efficacy, and it is possible that people who are more independent or who have gained stronger self-efficacy will stick more to long-term physical exercise over time. These findings are consistent with those of Ahern et al. (61), who point out that self-efficacy also has a significant effect on the motivation for physical activity. They found that there is a linear relationship between self-efficacy and attitudes towards physical activity and that as a person gains more experience in physical activity, his self-efficacy also increases. Furthermore, Gabay and Oravitan (12), suggest that in order to promote consistency and commitment, fitness instructors should strive to create a joyful and positive environment, offer challenges, and improve the self-efficacy of trainees. An additional assessment was performed to appraise the quality of life of the subjects in relation to their seniority, where in accordance to the prediction (Hypothesis 6), a statistically significant result was obtained between seniority and quality of life. These results make logical sense given that the current study's data show that veteran trainees exercise at a higher training frequency than novice trainees and that previous research found that people who exercised more frequently reported significantly better health and quality of life than those who exercised less frequently (62).

Strengths

The participants in this study were primarily recruited through social media platforms. The phenomenal growth of such platforms has changed the ease of recruiting research participants, as they enable large groups of targeted participants to be quickly recruited at a low cost (63). In addition we chose to use an online survey because of the time required to complete it (data show that these surveys are two-thirds shorter than traditional ones), its ability to collect data automatically at a lower cost, to automatically and permanently save the database and access the data, and the fact that these surveys allow study participants to answer the survey questions at their choice of time and location (64). Further strengths of this investigation encompass the utilization of research instruments recognized for their robust reliability and internal consistency. For instance, the Self-Report Habit Index (SRHI) stands as a widely accepted and validated measure across diverse domains, particularly with regard to habit strength (65). Moreover, the Exercise Adherence Rating Scale (EARS) was purposefully crafted to assess adherence to physical activity, rendering it particularly germane to the study's focus (49). Notably, the World Health Organization Quality of Life (WHOQOL), developed by the esteemed World Health Organization (51), enjoys global acclaim and esteem as a comprehensive gauge of quality of life. It meticulously evaluates a multitude of domains, encompassing physical well-being, psychological health, social interactions, and environmental factors.

Limitations

This study's strengths include its comprehensive analysis of many variables that might affect participants' adherence to physical exercise, its multiple hypothesis testing, and use of a large participant pool. However, it does have a number of

obvious limitations. First, in relation to physical exercise, it should be noted that the definition of a habit as a particular behavior or action is oversimplified, as such exercise involves a complex variety of behaviors related to both the activity itself and the circumstances and actions that motivate an individual to engage in it such as planning, transportation, packing the necessary equipment, and financial ability (56). Moreover, in contrast to the preceding discussion, there are distinct drawbacks associated with the recruitment of research participants through social media. One salient issue pertains to the age demographics of active social media users, which predominantly lean toward younger individuals. Furthermore, ethnic and racial disparities in the utilization of social media platforms introduce a form of selection bias, as certain groups are more actively engaged than others. This selective engagement can further amplify the challenge of obtaining a representative study population (63). It is also essential to recognize that the characteristics of social media users may not accurately mirror the broader population. This discrepancy can potentially compromise the generalizability of research findings and introduce inherent biases within the study sample. Furthermore, in contrast to the aforementioned advantages, there are notable drawbacks associated with the utilization of online surveys as a research tool. While these surveys offer numerous benefits, they also have their limitations. One significant challenge pertains to the clarity of survey instructions, which, if ambiguous or poorly presented, can swiftly frustrate respondents, leading to premature survey abandonment. Additionally, online surveys rely heavily on self-reporting, which is susceptible to biases and inaccuracies (65).

Furthermore, it is imperative to address supplementary limitations warranting discussion. The observed outcomes pertaining to the influence of seniority on quality of life may, to some extent, be ascribed to considerations associated with the sample size. It is worth noting that these findings, while bearing statistical significance, manifest a relatively small in magnitude. Moreover, it is essential to duly acknowledge the presence of alternative variables that may exert a more pronounced impact on the quality of life experienced by individuals. Lastly, an imperative concern necessitates attention—the notable attrition rate among participants in the study, prominently manifested through instances of incomplete questionnaire responses.

Conclusions

This study provides valuable insights into the challenging issue of adherence to physical activity, with implications for individual health and public well-being. The findings offer a fresh perspective on the factors influencing adherence, including training frequency, habit strength, exercise goals, age, gender, and support. Key practical recommendations include personalizing training programs, promoting resistance training, tailoring support based on age and gender, emphasizing habit development through frequent training, and boosting self-efficacy. Future interventions and research should focus on tailored exercise prescription, resistance training promotion, age and gender specific approaches, habit formation strategies, self-efficacy enhancement, long-term adherence monitoring, cultural considerations, and behavior change interventions to advance our understanding and faciltate exercise adherence.

Practical Implications to Enhance Physical exercise Adherence:

- **Personalized Training Programs:** It is advisable for healthcare professionals and fitness experts to prioritize personalized training programs tailored to each individual's distinct goals and preferences, as opposed to generic, one-size-fits-all programs.
- **Resistance Training:** Integrating resistance training into exercise routines is highly recommended. Resistance Training demonstrated notable adherence rates and may serve as an effective strategy to enhance individuals' commitment to physical activity.
- **Targeted Support:** Recognizing the influence of age and gender on exercise goals is essential. It is desirable for training regimens to be in alignment with the exerciser's age and gender. For instance, training programs for individuals over the age of 45 may need to place greater emphasis on health-related components, recognizing the unique needs of this demographic.
- **Training frequency:** Encouraging individuals to engage in training sessions exceeding three times a week may be a good strategy to cultivate and solidify physical exercise habit, ultimately improving long-term adherence.
- **Self-Efficacy Assessment:** It is desirable to identify the trainee's level of self-efficacy and preserve or increase it if necessary

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 West Timisoara University research protocol (15227/7.03.2023). 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.

Author contributions

MG: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing – review & editing. OL: Data curation, Methodology, Software, Writing – review & editing. SP: Validation, Visualization, Writing – review & editing. CN: Validation, Visualization, Writing – review & editing. MM: Validation, Visualization, Writing – review & editing. MO: 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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A socio-ecological model of factors influencing physical activity in pregnant women: a systematic review

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Physical activity (PA) is safe for most pregnant women, improving both maternal fitness and birth outcomes. Despite evidence of benefits, most pregnant women eliminate or reduce PA during pregnancy. This systematic review aimed to analyze the factors affecting maternal PA during pregnancy with reference to a socio-ecological model. A systematic search of relevant published studies between 2001 and 2022 was conducted through PubMed, Scopus, Web of Science, Academic Search Ultimate, Medline, and SPORTDiscus with full text via the EBSCO platform. A total of 32 studies that met the inclusion criteria were reviewed. The findings revealed that various study designs can lead to different outcomes in terms of what is identified as a PA facilitator or barrier. The factors that positively influenced PA in pregnant women were: higher levels of education, knowledge, and skills, as well as access to mass media. Conversely, lower levels of education, lack of knowledge and skills, low income, pregnancy discomforts, limited time, safety concerns, and societal perceptions of PA in pregnancy acted as barriers. Additionally, family, colleagues/friends, and partners could either support or hinder PA. Factors affecting overall maternal PA were somewhat different from those affecting the moderate-to-vigorous intensity of PA. Pregnant women receive little organizational and policy support. There is an urgent need to provide accessible information and resource systems for pregnant women. Since most pregnant women are motivated to engage in PA and susceptible to family advice, interventions should not be limited only to pregnant women, but should involve a family member, especially partners. There is a need to take global, systemic actions to promote an active lifestyle in pregnancy. Addressing safety concerns related to PA during pregnancy should be a significant part of these promotional activities.

KEYWORDS

physical activity, influencing factors, pregnant women, social–ecological model, systematic review, pregnancy

1 Introduction

Physical activity (PA) refers to any bodily movement produced by skeletal muscles that require energy expenditure, including activities undertaken while working, playing, doing household chores, traveling, and engaging in recreational activities (1, 2). Current guidelines published by credible obstetrics, gynecology, and sports medicine institutions, including the World Health Organization (WHO), confirm PA in pregnancy is safe and desirable in the

absence of obstetric and medical complications or contraindications (3–6). During pregnancy, proper and sufficient PA plays a significant role in the health of the mother and the growth of the fetus (7, 8), including decreasing the incidence of preterm birth (9) and cesarean deliveries (10), avoiding excessive gestational weight gain (11), improving cardiovascular function (12), improving or maintaining physical fitness, reducing symptoms of depression (13), and enhancing psychological well-being (14). Nevertheless, many women tend to decrease rather than maintain or increase their PA during pregnancy (15, 16), and various studies indicate low levels of PA among pregnant women (17, 18).

Exercise is a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness. Exercise-related behavior is multifaceted and affected by many factors to varying degrees, which makes it complex to engage in PA (19). The PA of pregnant women is also affected by a variety of factors (20), so it is important to know which main factors are associated with PA behavior. A previous literature search found that most of the research on the PA of pregnant women focused on lifestyle interventions, and there were very few reviews on influencing factors of the PA of pregnant women based on a socio-ecological model. Consequently, the main aim of this review is to analyze the influencing factors of maternal PA in a socio-ecological model. We also aimed at exploring the disparities in influencing factors between overall PA (which refers to all kinds of bodily movements of varying intensities, including very low and low intensities) and moderate-to-vigorous physical activity (MVPA) among pregnant women. This will provide a reference for the research, intervention, and policy development to support the promotion of maternal PA.

2 The socio-ecological model

The PA of pregnant women is affected by a variety of factors (20). The multifactorial health promotion was advocated in the Ottawa Charter for Health Promotion as early as 1986 (21). For a more comprehensive understanding of the factors affecting the PA of pregnant women using the socio-ecological model (SEM) in line with McLeroy et al. (22), behavior is viewed as being determined by the following levels: (1) the personal level: the internal factors of individual characteristics (sociodemographic and biological, behavioral, psychological); (2) the interpersonal level: interpersonal processes and primary groups – formal and informal social networks and social support systems (e.g., family, public, etc.); (3) the organizational level: social institutions with organizational characteristics, such as health services and gyms, may also include influences from health care providers and PA consultants, etc.; (4) the community level: relationships among organizations, institutions, and informal networks within defined boundaries (e.g., appropriate facilities, living environment, etc.); and finally (5) the public policy level: local, state, and national laws and policies.

3 Materials and methods

The systematic review was conducted using "The PRISMA 2020 statement: An updated guideline for reporting systematic reviews" for the analysis material (23). The study protocol was registered on INPLASY (Registration number: INPLASY2022.11.0073). Bibliographic platforms and databases were searched, including PubMed, Scopus, Web of Science, Academic Search Ultimate, Medline, and SPORTDiscus with full text via the EBSCO search platform. The time range was set to 2001–2022, using the terms ("physical activity" or "exercise" or "fitness "or "physical exercise" or "sport"; "correlates" or "determinants" or "mediators" or "associated factors" or "psychosocial" or "environment"; "pregnant women" or pregnancy).

The date of the last search was 15 September 2022. Figure 1 shows the PRISMA diagram of the article screening process. The following inclusion and exclusion criteria were used to identify the eligible articles for review, and only empirical research articles were considered: Inclusion criteria were: (1) full text was available; (2) pregnant women were research participants; (3) a measurement or interview of PA (including MVPA) as the dependent outcome and examined the statistical associations with certain factors was reported; and (4) published in English-language, in scholarly (peer-reviewed) journals.

Exclusion criteria included research: (1) taking women with any disabilities or illnesses that could lower their ability in terms of bodily movement as the study population; (2) focusing on nutritional interventions or healthy eating; (3) involving a survey of parturient women; and (4) published only as an abstract, a comment, or a review due to a lack of data for extraction (but reference lists were checked for relevant studies).

Data extraction: Two independent researchers (SJ, MP) separately searched the databases and assessed the titles and abstracts of articles to determine the initial inclusions. The full texts were then assessed against the inclusion and exclusion criteria to finalize the articles eligible for inclusion in the review. Later, the two researchers independently analyzed all the articles using the extraction tables. If discrepancies were found and could not be resolved between the two researchers, a third researcher (AS) was invited to finalize the assessment.

4 Results

After removing duplicates and papers irrelevant to the selected topic (judging by the abstracts), 23 papers were finally included in the analysis (24–46). Based on the reference lists presented in these papers, additional 9 studies were included (47–55), and a total of 32 articles were at last included in the analysis (24–55) (Figure 1). Data including the author, date, number of people surveyed, research type, data collection method, country, and levels of SEM were extracted. To better understand the differences between factors influencing pregnant women's overall PA and MVPA, articles covering the issue of MVPA were indicated for additional analysis. Based on the model established by McLeroy et al. (22), PA behavior is determined or affected by above mentioned five levels or groups of factors. If the study involved relevant factors, it was marked as $\surd$. The information is summarized in Table 1.

4.1 Study characteristics

A summary of the characteristics of the 32 papers is given in Table 1. The publication period ranged from 2004 to 2022, with 20

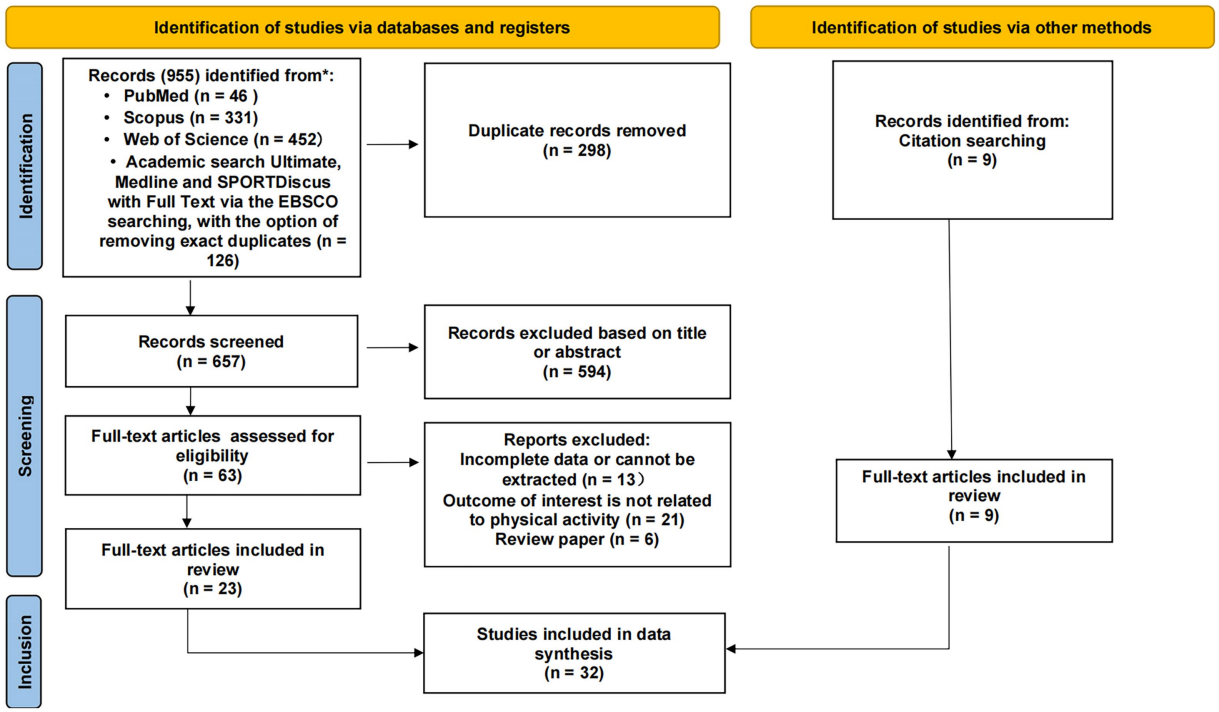

FIGURE 1
Flow diagram of study selection.

(62.5%) published after 2019. We found results related to MVPA in pregnant women (30, 31, 38, 40, 45, 50, 55) in 7 papers. The sample sizes ranged from 22 to 9,345 participants, for a total of 37,920. The types of studies included mixed (9), quantitative (16), and qualitative (7) methods. The data were collected through interviews as well as questionnaires, and prospectively followed. Interview (21) and questionnaire (13) were the most popular methods, with only one other collection method. A total of 14 countries, including developed and developing countries, were involved. Relative studies contained different contents on a personal level. In addition, 28 papers included socio-demographic factors (24, 25, 27, 28, 30–43, 45–51, 53–55); 24 included biological factors (24–30, 32, 33, 35, 36, 39, 41–44, 48–55); 21 included behavioral factors (25–30, 32, 33, 35, 36, 39, 41, 44–46, 48–51, 53, 55); and 19 included psychological factors (25, 27–29, 31–35, 42–46, 49, 51–53, 55), 32 in total, all of which involved the personal level. There were 24 articles analyzing the interpersonal level (N = 24) (24–30, 33–35, 39, 42–49, 51–55); 18 analyzing the organization level (N = 18) (25, 27, 29, 32–39, 42, 44–46, 51, 53, 55); 17 articles included factors related to the community level (N = 17) (25, 27, 29, 31–33, 35, 37–39, 44–46, 51–53, 55); and only 3 articles included factors related the policy level (N = 3) (25, 33, 51).

4.2 Factors of physical activity during pregnancy in SEM

Tables 2–5 summarize papers containing the factors of PA during pregnancy referring to the five levels of SEM. In these papers we could find whether the identified association is a facilitator or a barrier. The direction of the association is expressed by a facilitator "+" or a barrier "–". Relevant studies have different reference standards for the same factor (for example, the factor of knowledge and skills is a facilitator factor, while that of a lack of knowledge and skills is a barrier factor). To better analyze the factors of PA during pregnancy we also used following labeling: no association (coded with"0") and as an inconclusive finding (coded with "?").

4.2.1 Personal level (32 papers)

As shown in Table 2, personal factors include three aspects, involving 22 factors in total. In terms of socio-demographic and biological factors, a total of 10 factors associated with PA in pregnancy were presented. In 8 papers age of pregnant women tended to have no association with their PA level. There were also studies (N = 3 papers) in which older age had a promoting effect, while the effect of a younger age had diverse explanations. Being older appears to be associated with higher MVPA compliance (N = 3 papers). Some studies (N = 13 papers) considered high education a facilitator, and others (N = 6 papers) considered low education as a barrier. Higher education facilitated MVPA (N = 2 papers). Pregnancy discomforts were considered a barrier (N = 12 papers). In addition, authors considered high income as a facilitator (N = 3 papers) and regarded low income as a barrier (N = 6 papers). The first birth was considered a barrier (N = 3 papers), while parity was considered a facilitator (N = 5 papers) and a barrier (N = 2 papers). Regarding other factors such as ethnicity, work, marital status, and BMI, the results were not significantly different and remained controversial. There were differences in MVPA during pregnancy among different ethnic groups (N = 4 papers). Physical occupational work was related with higher amount of MVPA (N = 4 papers). The socioeconomic status (SES) was considered a barrier of PA during pregnancy (N = 2 paper).

There were five behavioral factors associated with PA during pregnancy, with the knowledge and skills on PA as a facilitator (N = 2

TABLE 1 Summary of studies on the factors influencing physical activity in pregnant women.

First author and year of publication	The number of women involved	Research type	Collection method	Country	Levels of SEM						
					Level 1			Level 2	Level 3	Level 4	Level 5
					Factors 1[1]	Factors 2	Factors 3				
Evenson K. R., 2004 (47)	1979	Quantitative	Tele-phone interview	United States	√/			√			
Schmidt M. D., 2006 (24)	233	Qualitative and quantitative	Questionnaire and interview	United States	√/√			√			
Chasan-Taber L., 2007 (48)	782	Quantitative	Interview	United States	√/√	√		√			
Evenson K. R., 2009 (25)	1,535	Qualitative and quantitative	Telephone interview	United States	√/√	√	√	√	√	√	√
Lynch K. E., 2012 (26)	903	Quantitative	Questionnaire	United States	/√	√		√			
Muzigaba M., 2014 (27)	34	Qualitative	Interview	South Africa	√/√	√	√	√	√	√	
Padmapriya N., 2015 (28)	1,171	Qualitative and quantitative	Interview	Singapore	√/√	√	√	√			
MRH Van Mulken, 2016 (29)	30	Qualitative	Telephone interview	Australia	/√	√	√	√	√	√	
Richardsen K. R., 2016 (30) (MVPA)	555	Qualitative and quantitative	Face-to-face interview	Norway	√/√	√		√			
Richardsen K. R., 2016 (31) (MVPA)	709	Qualitative and quantitative	Face-to-face interview and recorded PA data	Norway	√/		√			√	
Merkx A., 2017 (32)	455	Quantitative	Questionnaire	Netherlands	√/√	√	√		√	√	
Flannery C., 2018 (33)	22	Qualitative	Interview	Ireland	√/√	√	√	√	√	√	√
Rabiepoor S., 2019 (49)	325	Qualitative and quantitative	Questionnaire and interview	Iran	√/√	√	√	√			
Xiang M., 2019 (50) (MVPA)	1,077	Quantitative	Questionnaire	China	√/√	√					
Fathnezhad-Kazemi A., 2019 (51)	32	Qualitative	Interview	Iran	√/√	√	√	√	√	√	√
Hailemariam T. T., 2020 (34)	299	Quantitative	Questionnaire	Ethiopia	√/		√	√	√		
Walasik I., 2020 (35)	9,345	Quantitative	Questionnaire	Poland	√/√	√	√	√	√	√	
Okafor U. B., 2020 (36)	1,082	Qualitative and quantitative	Interview	South Africa	√/√	√			√		
Zhu G., 2020 (52)	746	Quantitative	Questionnaire	China	/√		√	√		√	

(Continued)

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TABLE 1 (Continued)

First author and year of publication	The number of women involved	Research type	Collection method	Country	Levels of SEM						
					Level 1			Level 2	Level 3	Level 4	Level 5
					Factors 1[1]	Factors 2	Factors 3				
Silva V. R., 2021 (37)	3,580	Qualitative and quantitative	Face-to-face interview	Brazil	√/				√	√	
Kershaw K. N., 2021 (38) (MVPA)	8,362	Quantitative	Interview and measurement	United States	√/				√	√	
Ahmadi K., 2021 (39)	300	Quantitative	Questionnaire	Iran	√/√	√		√	√	√	
Jones M. A., 2021 (40) (MVPA)	127	Quantitative	Questionnaire and interview	United States	√/						
Lü Y., 2021 (41)	2,485	Quantitative	Questionnaire	China	√/√	√					
Grenier L. N., 2021 (53)	66	Qualitative	Face-to-face interview	United States	√/√	√	√	√	√	√	
Baena-García L., 2021 (54)	134	Quantitative	Objective measure	Spain	√/√			√			
Addis A., 2022 (42)	333	Qualitative	Face-to-face interview	Ethiopia	√/√		√	√	√		
Syed Nor S. F., 2022 (43)	316	Quantitative	Questionnaire	Malaysia	√/√		√	√		√	
Shum K. W., 2022 (44)	22	Qualitative	Semi-structured interview	Singapore	/√	√	√	√	√	√	
Kianfard L., 2022 (45) (MVPA)	40	Qualitative	Interview	Iran	√/	√	√	√	√	√	
Beyene M. M., 2022 (46)	410	Quantitative	Questionnaire	Ethiopia	√/	√	√	√	√	√	
Sparks J. R., 2022 (55) (MVPA)	431	Qualitative and quantitative	REDCap and interview	United States	√/√	√	√	√	√	√	
Total	37,920	9	21	14	28/24	21	19	24	18	18	3
		16	13		32						
		7	2								

SEM, socio-ecological model; MVPA, moderate-to-vigorous intensity physical activity; REDCap, Research Electronic Data Capture; Level 1, Personal level; Factors 1, socio-demographic and biological factors; Factors 2, behavioral factors; Factors 3, Psychological factors; Level 2, Interpersonal level; Level 3, Organization level; Level 4, Community level; Level 5, Public policy level. [1]In the factors 1, on the left side refers to socio-demographic factors, and on the right, the "/" refers to biological factors.

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TABLE 2 Summary of studies ($n = 32$) on personal level of socio-ecological model (SEM) influencing physical activity during pregnancy.

Level 1	Study reference number				Total number			
	Facilitator (+)	Barrier (–)	No association (0)	?	+	–	0	?
					69	94	37	5
Socio-demographic and biological factors					39	47	30	2
Age	(24)[1,*], (34)[2,*], (38)[1,*], (47)[2], (48)[1,*]	(36)[2]	(28, 32, 37), (40)*, (41)[2], (43, 54, 55)		5	1	8	
Ethnicity	(24), (31)*, (40)*, (41)[3,*],	(30, 38)*	(28, 37, 47)	(27, 33)	4	2	3	2
Education	(24), (30)*, (34, 37, 39), (40)*, (41–43, 47–49, 51)	(32)[a], (35)[a], (36)[a], (43)[a], (46)[a], (54)[a]	(28, 50), (55)*		13	6	3	
Work	(34), (40, 45)*, (46, 49), (50)*	(25, 33), (36, 45)*[,b], (53), (50)*[,b], (51)	(28, 41, 43, 47, 54)		6	7	5	
Married status	(34), (40)*		(28, 54, 47), (55)*		2		4	
Income	(24, 39, 48)	(27)*, (33)*, (39), (45)*, (51), (53)*	(41)		3	6	1	
SES (family income)		(28)[a], (51)[a]				2		
Parity	(24, 26, 42, 49, 54)	(29)[c], (35), (36)[c], (39), (43)[c]	(41)[d]		5	5	1	
Pregnancy discomforts		(25, 27, 28, 32, 33, 35, 43, 44, 51–53), (55)*				12		
BMI	(48)*	(25)*, (26)*, (30)*, (35)[a], (43), (51)	(28, 41, 54), (50, 55)*		1	6	5	
Behavioral factors					12	20	5	0
Smoking		(41)	(48)			1	1	
Previous physical activity	(26, 29, 33, 35, 39, 41, 46, 48), (50)*, (53)	(28), (32), (36)[d,*], (39)[d], (50)[d,*]	(30)*, (44)		10	5	2	
Knowledge and skills	(29), (49)	(27)[d], (33)[d], (44)[d,*], (45)[d], (46)[d], (53)[d], (55)[d,*]			2	7		
Diet		(45)*	(50)*, (51)			1	2	
Lack of time		(25, 27, 33, 39, 44, 53)				6		
Psychological factors					18	27	2	3
Physical activity attitude	(33), (42), (45)*, (51), (52)	(46)[d]	(44)	(27), (32)	5	1	1	2
Physical activity intention	(42)	(46)[d]			1	1		
Perceived benefits of physical activity	(29, 33, 35, 43, 46, 49, 51), (55)*	(27)[d], (29)[d], (45)*[,d], (52)[d]	(44)		8	4	1	
Barriers to physical activity		(35), (51), (55)*				3		
Perceived behavioral control	(42, 52)	(28)[d]			2	1		
Motivation/goal	(27, 33)	(25)[d], (51)[d], (53)[d], (55)*[,d]		(32)	2	4		1
Safety concerns		(25, 27, 29), (31)*, (33, 34, 44), (45)*, (46, 49, 51, 53), (55)*				13		

Level 1, Personal level; BMI, body mass index; SES, socio-economic status; "+", facilitator; "–", barrier; "0", no association; "?", indeterminate association; [a]The factor is a barrier when is low (such as: the education is a barrier when is low), [b]The work is a barrier when is lose, [c]The parity is first, [d]The factor is a barrier when is lack (such as: motivation/goal is a barrier when is lack). [1]older age, [2]younger age, [3]regions, *relates to MVPA.

papers), a lack of knowledge and skills as a barrier ($N = 7$ papers), and a lack of time as a barrier ($N = 6$ papers). Some authors considered previous PA as a facilitator ($N = 10$ papers) and previous lack of PA as a barrier ($N = 3$ papers). Interestingly, other authors found that

previous PA was a barrier ($N=2$ papers), and in two papers there was an indeterminate association ($N=2$ papers) between previous PA and PA during pregnancy. There were fewer studies about smoking ($N=2$ papers) and diet ($N=3$ papers).

There were 7 psychological factors associated with PA during pregnancy. PA attitude ($N=5$ papers) and the perceived benefits of PA ($N=8$ papers) were considered facilitators. The lack of perceived benefits of PA was considered a barrier ($N=4$ papers). In three papers the authors mentioned specific barriers to PA (e.g., fear, anxiety, shame, exercise-induced fatigue, discomfort, and other perceptual disorders; $N=3$ papers). Lack of motivation/goal was considered a barrier ($N=4$ papers). Safety concerns were the main barrier to PA in pregnancy, mentioned in 13 studies.

4.2.2 Interpersonal level (24 papers)

Table 3 summarizes the factors at the interpersonal level. Some studies considered family a facilitator ($N=4$ papers) and its lack a barrier ($N=7$ papers). Colleague/friend was considered a facilitator ($N=3$ papers) and a barrier ($N=2$ papers). Some authors identified the public as a barrier ($N=6$ papers). Having children was considered a facilitator ($N=8$ papers) and a barrier ($N=10$ papers). Having a husband/partner was considered a facilitator ($N=9$ papers) and a barrier ($N=4$ papers).

4.2.3 Organizational level (18 papers)

Table 4 summarizes the factors at the organizational level. There were four external social support organizational factors for PA during pregnancy, with health care providers as the main influencing factors. Health care providers were considered a facilitator ($N=11$ papers) and, interestingly, also as a barrier ($N=3$ papers). In addition, a lack of healthcare provider support was considered a barrier ($N=9$ papers).

4.2.4 Community (17 papers) and public policy (3 papers) level

Table 5 summarizes factors at the community and public policy levels. There were five community and policy factors involved in PA during pregnancy. Information and resources were considered a facilitator ($N=4$ papers), while a lack of information was considered a barrier ($N=9$ papers). Appropriate facilities was considered a facilitator ($N=5$ papers), and a lack of appropriate facilities was a barrier ($N=4$ papers). In one study the authors mentioned a continuous positive correlation between good access to recreation sites and MVPA throughout pregnancy. The access to mass media was considered a facilitator ($N=8$ papers), and living environment was considered both a facilitator ($N=2$ papers) and a barrier ($N=2$ papers). There were only a few studies on neighborhood safety ($N=4$ papers) and the public policy level (N = 3 papers).

5 Discussion

This systematic review aims to examine existing studies on factors affecting PA in pregnancy, referring to the SEM developed by McLeroy et al. (22). We wanted to explore barriers and facilitators of PA in pregnant women, using the five levels of SEM. In the interpretation of our data it must be taken into account, that the research types are

TABLE 3 Summary of studies ($n=24$) on interpersonal level of socio-ecological model (SEM) influencing physical activity during pregnancy.

Level 2	Study reference number				Total number			
	Facilitator (+)	Barrier (–)	No association (0)	?	+	–	0	?
					25	29	2	1
Family	(42, 44, 51, 53)	(29, 33, 35, 39, 44), (45)*, (51)	(27)	(53)	4	7	1	1
Colleague/Friend	(33, 44), (45)*	(29), (30)*			3	2		
Public	(44)	(29, 35), (45)*, (51, 53), (55)*			1	6		
Having children	(24, 26, 28, 34, 39, 43, 48, 49)	(25, 27), (30)*, (33, 44, 51, 52–54), (55)*	(47)		8	10	1	
Having a husband /partner	(27, 29, 33, 34, 44), (45)*, (46, 51, 53)	(39), (45)*, (46, 51)			9	4		

Level 2, Interpersonal level; "+", facilitator; "–", barrier; "0", no association; "?", indeterminate association; *relates to MVPA.

TABLE 4 Summary of studies ($n=18$) on organizational level of socio-ecological model (SEM) influencing physical activity during pregnancy.

Level 3	Study reference number				Total number			
	Facilitator (+)	Barrier (–)	No association 0	?	+	–	0	?
					16	13		
Health care providers	(27, 29, 34–37, 39, 42, 44), (45)*, (53)	(25), (27)[a], (29)[a], (32)[a], (33)[a], (36)[a], (44)[a], (45)*, (46), (51)[a], (53)[a], (55)*[,a]			11	12		
Nutritionists	(53)				1			
Dietitians	(53)				1			
Physical activity Consultant	(29, 53), (55)*	(38)*[,b]			3	1		

Level 3, Organization level; "+", facilitator; "–", barrier; "0", no association; "?", indeterminate association; [a]The health care providers is a barrier when is lack; [b]the physical activity consultant is a barrier when is lack; *relates to MVPA.

TABLE 5 Summary of studies on community ($n = 17$) and public policy ($n = 3$) levels of socio-ecological model (SEM) influencing physical activity during pregnancy.

Level 4	Study reference number				Total number			
	Facilitator (+)	Barrier (–)	No association 0	?	+	–	0	?
					20	20	4	1
Information and resources	(32), (35), (44), (53)	(27)[a], (32)[a], (33)[a], (45)*[,a], (46)[a], (51)[a], (52)[a], (53)[a], (55)*[,a]			4	9		
Appropriate facilities	(27), (31)*, (37), (38)*, (51)	(27)[a], (33)[a], (45)*[,a], (51)[a]		(53)	5	4		1
Living environment	(31)*, (38)*	(39), (51)	(37)		2	2	1	
Neighborhood safe	(31)*	(27)[a], (45)*[,a]	(25)		1	2	1	
Media	(29), (32), (35), (45)*, (46), (51), (52), (53)	(27)[a]	(38)*		8	1	1	
Level 5		(33)[a], (51)[a]	(25)			2	1	

Level 4, Community level; Level 5, Public policy level; "+", facilitator; "–", barrier; "0", no association; "?", indeterminate association; [a]The factor is a barrier when is lack (such as: the public police is a barrier when is lack); *relates to MVPA.

mainly quantitative ($N = 16$ papers), and the sample for the qualitative evaluation is relatively small ($N = 7$ papers). It was found that different research types might lead to different results, while the combination of qualitative and quantitative types ($N = 9$ papers) might lead to a more accurate investigation of influencing factors. In the analyzed material, all studies involved the personal level, and very few concerned the policy level. Through literature analysis, it was also found that there were some differences in the factors affecting overall PA and MVPA during pregnancy, which need to be further verified. It must be underlined that one of the main barrier to PA during pregnancy were the safety concerns.

Personal factors included socio-demographic and biological, behavioral, and psychological factors. Age was not considered to be associated with PA in pregnant women (28, 32, 37, 40, 41, 43, 54, 55) by most researchers. Being older appears to be associated with higher MVPA compliance (24, 38, 48). Our observations show that the age of pregnant women should be taken into account when planning PA interventions. In terms of different ethnicities, the research views were controversial. There were differences in MVPA during pregnancy among different ethnic groups (30, 31, 38, 40). There might also be differences between different parts of the same country (41). Considering that all the studies analyzed the outcomes from one country, ethnic differences should still be considered when implementing the guidelines and policies supporting PA in pregnancy. Education was significantly associated with PA during pregnancy, and higher education promoted PA (24, 34, 37, 39, 41–43, 47–49, 51) and MVPA (30, 40). High income was also a PA facilitator (24, 39, 48). We can assume that higher education probably is associated with higher income and also with intellectual professional activity. There were some debates about the impact of work on PA during pregnancy. Some authors claim that heavy physical work can have negative impact on the progression of pregnancy. Nevertheless, it increases the amount of MVPA (36, 40, 45, 50). However, since exercise was a small part of maternal activity, and work affected PA duration (45), a balance should be struck in future interventions focused on the implementation of PA programs in women who perform physical occupational work.

Opinions vary widely on the impact of pre-pregnancy PA on PA during pregnancy, with one survey finding that previously active participants expressed that they did not continue their active lifestyle during pregnancy (44). It was even found that women with higher levels of PA before pregnancy were more likely to reduce PA (28, 32). The main interpretations for this result were that the pre-pregnancy PA was self-reported so there might be memory bias (30, 44), and that the pregnant women were recommended to stop their favorite exercise or other activity (32) by family and even care providers. In contradiction to these outcomes, previous PA was seen as a facilitator in other studies (26, 29, 33, 35, 39, 41, 46, 48, 50, 53), while inactivity before pregnancy was seen as a barrier (36, 39, 50). In one paper, there was a suggestion that PA intensity could be increased by encouraging more PA before pregnancy (40). Low education (32, 35, 36, 43, 46, 54), first parity (29, 36, 43), lack of knowledge and skills (27, 33, 44–46, 53, 55), pregnancy symptoms (25, 27, 28, 32, 33, 35, 43, 44, 51–53, 55), lack of time (25, 27, 33, 39, 44, 53), low income (27, 33, 39, 45, 51, 53), lack of motivation/goal (25, 51, 53, 55), and safety concerns (25, 27, 29, 31, 33, 34, 44–46, 49, 51, 53, 55) were all identified by the researchers as barriers. The lack of time mainly came from family commitments (44), while low education, first parity, and lack of knowledge and skills were all related to safety concerns. Fewer of the included articles addressed diet and smoking. It is very worrying that, although some pregnant women showed positive attitudes toward PA and agreed with its benefits, most did not engage in PA (44). There was a discord between positive attitudes toward PA and actual behaviors (44). In future PA interventions, more attention should be paid to populations with low education, first parity, lack of knowledge, and low income, and further research should be conducted on the way to effectively utilize the positive attitudes and perceptions of pregnant women. What is more, evidence-based educational programs on various forms and intensities of PA, including higher intensity exercise (6) should be implemented.

Analysis of the interpersonal level, which included family, colleagues/ friends, and husband revealed that these factors could both promote and be a barrier to PA in pregnant women. A commonly reported facilitators were "social influences," which included encouragement of PA by family and friends. Women's partners or husbands were the most influential factor, and women enjoyed meeting other pregnant women and expressed interest in PA classes tailored to pregnancy (33). Having an active spouse before pregnancy was identified as the strongest predictor of performing moderate-intensity to vigorous-intensity PA during pregnancy (39). Additionally,

emotional support from family and friends was commonly mentioned as one of the motivators for undertaking PA during pregnancy (44). Studies also found that during pregnancy, women were discouraged from PA by people at work and the gym, as well as family and acquaintances (29). A study observed that participants lacking encouragement from mothers and mothers-in-law tended to not engage in PA (56). Similarly, pregnant women received most of their advice on PA from their families, friends, or media (57). It was also reported that conflicting advice regarding PA from healthcare professionals and family members was confusing (44). The public was unanimously cited as a barrier factor (29, 35, 45, 51, 53, 55), and physically active women were more often criticized than praised for being active during pregnancy. Women commonly felt stared at, avoided, and treated differently during pregnancy, and often felt treated as if they were infirm or disabled, and that their pregnancy was viewed as a disease (29). Having a child was somewhat controversial; it was seen as a barrier mainly due to the need to care for other children and the limited exercise time available, which made it challenging to perform physical activities outside a daily routine (25, 27, 30, 33, 44, 51–55). In studies about having children as a facilitator, results were mainly derived from data; however, mainly qualitative analysis provided results indicating it was a barrier. Further analysis of the impact of different research types on the results is still needed. In future PA in pregnant women interventions, the family and husband/partner should be very important facilitators, and it is necessary to get the family and husband involved.

Third, at the organizational level, our analysis focused on the role of health care providers, and the results were consistent. The health care providers were the facilitating factor for engagement in PA during pregnancy (27, 29, 34–37, 39, 42, 44, 45, 53). The lack of support from health care providers was a barrier to pregnant women to be physically active (27, 29, 32, 33, 36, 44, 51, 53, 55). Surprisingly, in three papers we found that the health care providers themselves were identified as a barrier. We may assume that their conservative approach to prenatal PA may discourage their patients from performing PA. Related studies found that educating pregnant women about PA was not a priority for healthcare professionals who provided prenatal care during routine antenatal visits. As a result, many pregnant women did not receive information and advice about PA from healthcare providers (58, 59). Informational support from healthcare providers could have a significant influence on the views and decisions of pregnant women (59). In addition, nutritionists (53), dieticians (53), and PA consultants (29, 53, 55) might promote PA in pregnant women. It could also be observed that pregnant women's dependence on the advice of health care providers was related to the lack of participation of other organization members (which might be the specialists indicated above). In the future, more scientific research institutions, schools, fitness operators, and health promotion agencies should participate in PA intervention guidance for pregnant women. Importantly, a tailored educational programs for health and exercise professionals should be developed and implemented to prepare them to properly support pregnant women in the engagement in PA.

At the community level, both information and resources were considered a facilitator (32, 35, 44, 53), while the lack of information and resources was a barrier of PA in pregnant women (27, 32, 33, 45, 46, 51–53, 55). The analyzed studies revealed that participants were more likely to be active if they received sufficient information about PA during pregnancy (37, 44). Unfortunately, many participants also reported the lack of access to information (27, 33, 45, 53). The access to sport facilities was also a facilitator (27, 31, 37, 38, 51), while a lack of it was considered a barrier (27, 33, 45, 51). There was a continuous positive correlation between good objective access to recreation sites and MVPA throughout pregnancy (31). Research supported this view that high-quality PA was associated with the quality of PA amenities (60). Living environment was sometimes considered a facilitator (31, 38) and sometimes a barrier (39, 51). In a word, the physical attributes of neighborhoods are positively associated with PA (31). The access to mass media promoted PA in pregnant women (29, 32, 35, 45, 46, 51–53), and access to mass media and education were very important factors in raising public awareness (29). In future health education, it is very necessary to establish corresponding obstetrics lectures, new mass media platforms, and valid internet sites for education to provide information sources and enhance citizen consciousness.

Finally, in relation to the public policy level, there were only a few studies on PA policies for pregnant women, and policies were not a major concern for pregnant women (25). However, as the external driving force that influenced an individual's participation in physical activities, socio-ecological theory emphasized that regulations, educational policies, public health policies, etc. at the outermost levels of policy had a pronounced impact on individual behavior (22). At the same time, most prenatal PA interventions were based on recommendations from national and international organizations (55). Yet, as reported by the WHO on October 19, 2022, data from 194 countries showed that overall, less than 50% of countries had a national PA policy, of which less than 40% were being implemented (61). It was also evident from this review that policies did not seem to be working as they should, and this supported the view of the WHO that there were gaps in the formulation of policies and serious gaps in their implementation concerning PA. Policies played a guiding role for organizations and individuals and guaranteed cooperation between different regions, sectors, and groups. In the future, countries should refer to WHO policy recommendations in the global status report on PA 2022, increase their levels of participation across four strategic policy areas, including active societies, active environments, active people, and active systems (62) and enhance the policy drive for individual behavior.

Pregnant women face more obstacles to their PA compared to non-pregnant populations. As a result, they cannot comply with PA recommendations, unless these obstacles are overcome (55). The lack of organizational and policy support is an important factor that makes it difficult for pregnant women to engage in PA despite their willingness. A study has shown that implementing a PA plan that meets the recommended level of PA may be more effective if prescribed individually by an appropriate specialist or trained clinician (55). PA is the key to improving health and addressing non-communicable diseases (62). Therefore, overcoming barriers to PA requires a deep integration of PA and medicine. With advancements in technology, mobile applications and digital technologies provide opportunities for real-time interaction, information sharing, and multisectoral collaboration (63). In this case, governments should join forces with relevant organizations to increase advocacy and knowledge and consolidate resources to create a more supportive environment through a government-led, multisectoral collaborative approach to health interventions. At the national level, efforts should be made to establish a digital technology-based, government-led, multi-sector cooperative health integration

intervention system, thereby creating a more supportive and friendly environment for the PA of pregnant women.

Our literature review is of high practical value. In particular, due to the fact that there is a very low level of PA during pregnancy in different populations worldwide (64). For example, a study done in Ethiopia (2019), a low-income country, reported a physical inactivity prevalence of 21.9% (65). One study conducted in the United States (2013) identified that 31% of pregnant women reported engaging in mild-intensity activities, 38% in moderate-intensity, and 32% in vigorous-intensity PA (66). This figure was even lower in a study from Brazil (2010), where only 4.7% of pregnant women were physically active (67). Only one-fifth of pregnant women in Ireland (2011) met the recommended guidelines, and over 10% reported no PA (68). A cross-sectional study (2014) among urban Chinese women reported that 74.4% of total participants reduced PA during pregnancy (69). A Shanghai study (2022) found that only 2.8% of pregnant women achieved the level of prenatal PA recommended by the international guidelines (70). An adequate level of PA in Iran (2010) was found to be 39% (71), in Norway (2020) it was 14.6% (72), in India (2015) 18% (73), and in Nigeria (2014) 10.2% (74). These numbers prove the need to take systemic measures to promote PA during pregnancy in various countries, including underdeveloped countries.

This review study has its limitations. First, one criterion for inclusion in the analysis is the publication of papers in English. There may be other studies on maternal PA influencing factors available in other languages. Second, since much of the literature is qualitative, relevant factors are not directly reflected in the results and conclusions, which made potential bias in our review analysis. Third, there are other types of socio-ecological models or theories (75). Although this review followed a rigorous, systematic protocol, given the ontological and epistemological assumptions inherent to configurative reviews (76), other studies and reviews that followed different SEM or theories might have addressed the factors differently. In consequence, they may not result in the same conclusions.

6 Conclusion

Through this systematic review, it was found that SEM can provide a wide-ranging overview of factors that influence PA in pregnant women. Nevertheless, a more comprehensive system of factors revision is needed, where a more accurate approach combining qualitative and quantitative methods will be used. The factors that positively influenced PA in pregnant women were: higher levels of education, knowledge and skills, as well as access to mass media. Conversely, lower levels of education, lack of knowledge and skills, low income, pregnancy discomforts, limited time, safety concerns, and societal perceptions acted as barriers. Additionally, family, colleagues/friends, and partners could either support or hinder PA. Factors affecting maternal overall PA are somewhat different from those affecting MVPA.

Safety concerns are the main barriers to PA in pregnant women. Therefore, the solutions addressing safety concerns should be a significant issue in promoting maternal PA. What is more, pregnant women receive little organizational and policy support and are exposed to a lack of external drivers to be physically active. There is an urgent need to provide accessible information and resource systems for pregnant women. Since most pregnant women are motivated to engage in PA and susceptible to family advice, interventions should not be limited only to pregnant women, but should involve a family member, especially partners. For pregnant women themselves, physical activity or exercise prescriptions tailored individually by appropriate specialists or trained clinicians may be the most effective means to help them meet PA guidelines, all of which need to be supported by government policies.

Author contributions

JS and AS contributed to the conception and design of the study. JS, AS, MP, and AW performed data collection and analysis. JS wrote the first draft of the manuscript. AS and MP screened, reviewed, and revised the manuscript. All authors contributed to the article and approved the submitted version.

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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.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1232625/full#supplementary-material

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Analysis of anthropometric and physical performance variables in U-17 soccer players

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Introduction: Soccer is considered a multifaceted collective sport, and to reach an elevated level, players must have moderate to high power, good agility, joint flexibility and muscle development. Also, players must be able to generate high torques during fast movements, which implies the development of different capacities, understood as multifactorial preparation. The objective was to analyse the effects of training (aerobic and continuous) on the leg power, fatigue levels, speed, agility, body fat, muscle mass and bone mass of these players.
Methods: Seventy-two soccer players, male and under 17, from 4 teams participated. The teams performed 3 times a week training sessions of about 60–90 min each. Informed consent requests were given to their parents for authorisation to participate in this investigation. Data was collected in two different time points, about ten months apart. Specific tests were performed for each variable: the vertical jump with Bosco System for leg power, the *T*-Test for agility, the linear sprint test for speed and the RAST test for fatigue levels. A precision Tanita scale was used for the anthropometric tests such as body fat, muscle mass and bone mass. Statistical procedures were applied through the Wilcoxon test to compare the two time points of evaluation.
Results: Improvements were found between evaluations regarding the level of anthropometric and physical fitness variables.
Conclusions: The implemented training improved all the analysed variables with significant statistical values for leg power, speed, bone mass, muscle mass and fat mass.

KEYWORDS

soccer, young players, anthropometric variables, physical performance, leg power, velocity, fatigue levels

1. Introduction

Soccer is considered the most popular sport in the world, particularly among younger people (1–4), consisting of intermittent exercises with high intensity (e.g., running with quick changes of direction, starts, sudden stops, jumps, shots) interspersed with periods of low-intensity exercise (2, 5–7).

The physiological profile of this sport requires well-developed physical fitness (7–9), so anthropometric and physical levels are genuinely relevant to make a correct assessment of the potential of the players (2).

It is considered a multifaceted collective sport (9), and to reach a high level, players must have moderate to high aerobic and anaerobic power, have good agility, joint flexibility and

muscle development, as well as being able to generate high torques during fast movements (10). Silva and Marins (11) emphasise that the complexity of the physiological requirements in soccer implies the development of different capacities (aerobic, anaerobic, muscular strength, speed and agility), so that preparation must be multifactorial.

Sousa et al. (12) consider that a longer time of sports practice can lead to a better capacity to use the elastic energy and the contractile capacity of the muscle, being, therefore, an aptitude that can be developed through training. Thus, an adequate training process can accelerate the development of several motor skills and reduce the aptitude differences between young people and adults. With the same opinion, Santos (13), with four different age groups (15, 16, 17–18 years and adults), notes an improvement in physical capacity according to age development, with the age group of 17–18 years old reaches values close to those reached by adult players.

The investigation (2) is crucial to clarify the role of the training process in the development of anthropometric levels and the physical performance of young soccer players. In this context, field tests are considered an adequate alternative to laboratory tests (8, 9), namely because of their suitability for the sport, low cost and ease of implementation. According to these aspects, it will allow its frequent use during the competitive season (7).

It is important that there is objective information about the players' physical performance to guide the planning and objectives of the training process and thus optimise their performance. These data can be obtained through tests that assess the levels of physical fitness, whether in the laboratory or the field, in this case, more directed towards specific aspects of the sport (7). In this way, numerous tests have been developed to assess the physical abilities of players, both in detecting talent at training levels and in controlling the training process (11).

Longitudinal studies have shown that regular training allows, in the case of young players, to improve anthropometric parameters and physical performance (2, 14). In particular, Vänttinen et al. (14) state that the most important variables to measure performance in soccer are physical fitness and technical and tactical performance, and physical fitness is usually measured in terms of endurance, speed, power and strength. They consider that, although it is relatively easy to assess the physical fitness of young soccer players, it becomes more complicated to differentiate the effects of the training process from the effects of the influence of growth. In this sense, Malina et al. (3) understand that coaches of training levels should be familiar with the basic principles of growth and maturation.

The assessment of the explosive strength of the lower limbs of soccer players has been performed using mainly two techniques: the vertical jump with countermovement and the vertical jump without countermovement (6, 15). In the Bosco tests (16), consisting of a set of reference tests, CMJ (countermovement jump), SJ (squat jump), DP (drop jump), RJ (reactive jump), the flight time and possibly the contact time (17).

The equipment initially designed for its evaluation is called Ergojump-Boscosystem, consisting of a contact platform composed of several pairs of parallel and equidistant metal bars connected to a microcontroller. Each pair of bars works as a contact, closing the circuit with the individual's weight and returning to its original position (open circuit) when no pressure is applied (17).

On the other hand, speed is also considered an especially vital component in soccer, as the ability to accelerate can be decisive during a game. Its evaluation is usually done through sprints of 10, 20 and 30 m (7), and the tests are based on two different methodologies: static position start or launched start (11). Little and Williams (18) consider that to evaluate the speed components (acceleration, maximum speed and agility), specific tests directed to this sport should be used, noting that in the case of soccer, a 10 m acceleration test will be adequate, a 20 m top speed thrown test and a zig-zag agility test.

In the same line of thought, Sheppard and Young (19) state that in addition to the training of acceleration, maximum speed and speed resistance, there must also be an incidence in the training of speed of change of direction, that is, the emphasis must be placed in the specificity of training through exercises with specific movement patterns. They consider that the ability to run and change direction while running is a fundamental aspect of sports performance in sports such as soccer.

There are some works in the literature with soccer players in the 15–16 age group and of different competitive levels which evaluate the speed through 20 m sprints, namely Vandendriessche et al. (20), Sonesson et al. (21) and Keiner et al. (22).

In the study by Keiner et al. (22), elite players were familiar with the test because physical assessment timepoints were part of the semi-annual routine, while non-elite players did not take regular performance tests. In the study by Vandendriessche et al. (20), the players were differentiated by age level (Under-17 and Under-16) and maturational level. Photoelectric cells were used in the three studies to carry out the tests.

Agility implies an adequate combination of strength, speed, balance and coordination, being considered as the ability to change the direction of the body quickly (7). Modern soccer requires players to have good agility, and tests that incorporate quick and frequent changes of direction are used for evaluation (7). However, it is important that these are used in conjunction with sprint tests, unique in order to obtain a complete indication of the speed capacity of the players (18).

Repeated sprint tests present different protocols with differences in the distance to be covered, in the time and the type of recovery (23). The RAST (Running anaerobic sprint test) is a repeated sprint test widely used to measure anaerobic parameters in soccer due to its specificity and ease of implementation (11, 24, 25). Reilly et al. (10) mention that the performance in the test of repeated sprints in youth soccer is significantly better for elite players in relation to non-elite players. Svensson and Drust (7) consider that a disadvantage of repeated sprint tests is the possibility of subjects developing "pace" strategies throughout the test, thus not being able to exert maximum effort in some sprints, while Wragg et al. (23) refer to the existence of a learning effect in repeated sprint tests, so it is essential to get used to them to ensure more accurate results.

Several studies in the literature with soccer players aged 15–16 years and of different competitive levels assess anaerobic power through the RAST test (24–26).

In their proposed battery of physical tests for young players, Silva and Marins (11) refer to the RAST test (anaerobic capacity), as well as the 10 m and 20 m sprint tests, the CMJ test (lower limb power), the Illinois test (agility) and the Yo-Yo Intermittent Recovery Test (aerobic capacity). Morphological characteristics and physical abilities are important success factors in young soccer players and may be influenced by training (2, 14, 27). Reilly et al. (10), also refer to marked individual differences in anthropometric and physiological characteristics among elite players. They mention that the physical performance of young and adult soccer players has been evaluated in different ways, concluding that the positional role of a player is related to his physiological capacity. Thus, anthropometric and physical tests are important to obtain a reasoned assessment of the players' potential. However, even considering the existence of numerous tests, especially those related to physical fitness, there is still little information about the effect of training on the anthropometric and physical characteristics of amateur soccer players (28).

The previously mentioned authors state that anthropometric characteristics and physical abilities successfully discriminate soccer players by competitive level and even by position on the field. However, most studies focus mainly on players aged 10–16 years old, with little information on teenage players aged between 17 and 18, being one of the last competitive age groups that precede competitions at the highest level, presenting results that refer mainly to elite players. In this sense, we believe that is necessary analyzing anthropometric characteristics and physical abilities at these specific ages.

The main objective of the study was to analyse changes in anthropometric variables and physical fitness according to the training implemented between two evaluation timepoints.

2. Materials and methods

A total of 72 male soccer players, belonging to four Under-17 teams, participated in the study. The team performed 3 times a week training sessions between 60 and 90 min each and one official game every weekend lasting between 90 and 100 min. Participants were chosen from the teams that agreed to participate in the study according to the ages intended for the study. They were informed about the methodology and objectives of the study. The eligibility criteria sports for these participants, beyond the required age, were that they practiced only soccer as a sports activity and did not present any physical or psychological limitations or any type of injury when carrying out the physical tests. These players were federated athletes, registered in the Portuguese Football Federation, in competition playing at national level. Informed consent requests were given to their parents for authorisation to participate in the study. The investigation was approved under the number 209/2023 by the institution's Ethics Committee.

There were two evaluation time points, about ten months apart, the first around mid-September and the second in mid-July at the end of the competitive season. In the two time points of evaluation, the first tests to be conducted were on the anthropometric measurements. After a slight functional and physiological warm-up of 20 min, before the training began, the vertical jump and agility tests were carried out on the first day, as speed tests and the RAST test on the second day. No player included in the study was injured, and the evaluations took place on a synthetic turf field in the late afternoon.

All players were properly equipped according to the type of sport and conditions for playing football, using official football balls. The researchers did not interfere in the training or the type of exercises performed; they only instructed the coaches on how the tests should be carried out and participated directly in carrying them out. As already mentioned, the tests were carried out individually, and the entire team trained together in accordance with the training and work model selected by the coaches. The coaches involved hold the official and necessary qualifications with UEFA certification to carry out their duties. All exercises and tests performed were under supervision. Before performing each test, players were instructed regarding the protocol and verbally encouraged to give maximum effort during the tests.

According to what is presented in **Table 1**, the skewness and kurtosis numbers do not show values for a normal distribution, which, associated with the sample size itself, led us to opt for non-parametric tests.

2.1. Assessment of anthropometric variables

Height was measured using a stadiometer, using the standard protocol: the distance from the vertex (top point of the head) to the ground, with the individual barefoot in the anthropometric position on a smooth surface. The weight is distributed over both feet, and the head is oriented horizontally (Frankfort plane). The left hand was placed under the subject's chin, while the right hand placed the movable rod of the anthropometer over the vertex, applying enough pressure to compress the hair.

Fat, muscle and bone mass were measured using a Tanita R-604 bio-impedance scale. It was placed on a flat and firm surface. The player, barefoot and wearing only shorts and a shirt and without any accessories, climbed onto the scales slowly and then remained still, with their head erect. Their eyes fixed straight ahead, their arms extended alongside their bodies with the palms of their hands facing inwards and feet in a parallel position with

TABLE 1 Descriptive analysis of the sample characteristics (participants players under study (n = 72).

Variables	$M \pm SD$	Min.	Máx.	Skewness	Kurtosis
Age (years)	16.82 ± 0.84	15.8	17.6	0.83	1.47
Years of practice (years)	9.6 ± 4.4	8.8	10.2	0.25	1.21
Height (m)	1.78 ± 0.51	1.65	1.89	0.12	1.36
Weight (Kg)	71.2 ± 8.7	52.30	91.20	0.56	0.37

the weight evenly distributed. The measurement was then conducted according to the desired variable and recorded in a specific document.

2.2. Assessment of physical fitness variables

This section presents a description of the technical implementation protocols for collecting values for the variables under study, which allow the reproducibility of the study.

2.3. Vertical jump

They are considered the most used tests by soccer players to assess the explosive strength of the lower limbs. There are different forms and techniques for executing the jump, with the option of the single jump, to the detriment of continuous or intermittent jumps, as well as the technique of the jump with countermovement, as it is closer to the specificity of the jumps performed during a soccer game (11).

Each athlete performed four jumps in each condition, two facing in one direction and the other 2 in the opposite direction. The differences found correspond to differences in measurements by the microcontrollers and platforms, as well as imbalances in the jumps by the athletes. The results were considered excellent (with ICC values of 0.949; 0.950; 0.821 with an average difference of 1.38% and the deviation was 1.11) both in the comparison between the Chronojump platforms and between the Chronojump platform and the Ergojump-Boscosystem reference, concluding the validation and reliability of the platform used in this work (Chronojump, rigid format, 60×42 cm) (17), thus allowing to evaluate, among other parameters, the height, the flight and contact time and the power of the jump.

In the technique of jumps with countermovement, the player is initially in an erect position and hands on the waist, performing a brief flexion of the knees (up to approximately 90°) and trunk, followed by a vertical jump, with the hands always kept on the waist (26, 29). The player was instructed to start and end the jump with the feet resting inside the contact mat area and keeping the knees extended during the jump. The players were weighed and equipped before the tests, in the first moment and the second moment of evaluation. Each player performed two previous jumps as a warm-up and training and then the respective jumps with an interval of 2–3 min, registering the best result. In case the execution technique was not correct, the player repeated the jump (see **Table 2**). The Chronojump-Boscosystem technological system consisted of a contact mat, a microcontroller and free software (http://chronojump.org/software.html) installed on a portable computer.

TABLE 2 Application protocol of chronojump platform related to the activation/deactivation times test condition (adapted from (17).

	Jumps	Foot 1	Foot 2
Condition 1	2 jumps	Chronojump A	Chronojump B
	2 jumps	Chronojump B	Chronojump A
Condition 2	2 jumps	Chronojump B	Ergojump-Boscosystem
	2 jumps	Ergojump-Boscosystem	Chronojump B

2.4. Agility *T* test

The test was conducted with soccer boots and artificial turf in the team's training ground.

This test has several variants, the following being chosen (27). The route started at cone 1 (start/finish line), where the athlete started from a static position. At the signal, he would run to cone 2, touching it with his right hand, then move to the left, towards cone 3, which he would touch with his left hand. Then, he would run 10 m to the right, towards cone 4, touching it with his right hand and returning to cone 2, which he would touch with his left hand. It was finally heading to cone 1, the start/finish line, where the time count ended. The test was always carried out with a frontal race, and touching all the cones with one hand was necessary. Each athlete performed two attempts with a 5-min interval between them, counting the best result. Pauole et al. (30) have stated that the intraclass reliability of the *T*-test was 0.98 across 3 trials. In the tests with men, Pearson product moment correlations between the *T*-test and the 40-yd dash, vertical jump, and hexagon test were $r = 0.53$, $r = -0.49$, and $r = 0.42$, respectively ($p < 0.05$). Regression analyses has shown that for men 48% of the variability of the *T*-test scores can be predicted from measures of leg power, leg speed, and agility ($p < 0.05$).

2.5. 20-m linear sprint test

This test evaluates the maximum displacement speed, and players must be instructed to perform it at maximum effort and was performed as shown in **Figure 1**. Each player performed two

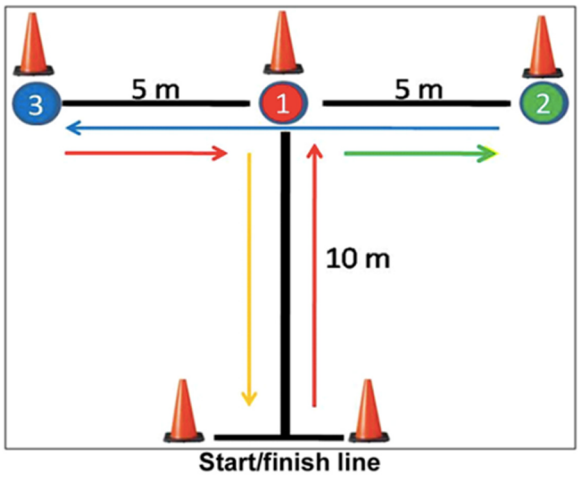

FIGURE 1
Agility *T* test scheme.

linear sprints of 20 m, registering the best time. The player was initially standing and stopped at the starting line and the signal, started the sprint. A recovery period of approximately 2–3 min was respected between each sprint, during which the athlete walked on the grass. Time was recorded in hundredths of a second. According to Altmann et al. (31), regarding intraday and interday reliability, scores of ICC > 0.75 and CVs < 3.0% were considered effective and reliable on the majority of the speed tests applied.

2.6. RAST test

This test was conducted with soccer boots and on artificial turf in the team's training ground. The players were weighed and equipped before the tests (in the 1st moment and in the second moment of evaluation), subsequently performing a 10-min warm-up with 5 min of recovery. They then performed six sprints of 35 m at maximum speed (with 10 s of recovery between sprints). Time was recorded in hundredths of a second for every 35 m of running. Each sprint was timed by two elements (one in each line 35 m apart), and the start for each sprint (10 s intervals) occurred with an acoustic sound. For the testing process to be as accurate and accurate as possible, each element had a stopwatch and a whistle. The first element was positioned in the initial line and the second in the other line so that the time of the 2nd, 4th and 6th sprint and the beginning of the 1st, 3rd and 5th would be in charge of the first element and the time of the 1st, 3rd and 5th sprint and the start of the 2nd, 4th and 6th in charge of the second.

With the weight of the players (Kg), the distance covered (35 m) and the times obtained, the maximum, average and minimum power was calculated, both in absolute terms (W) and in relation to body mass (W/Kg). Peak power is the highest power output, providing information about muscle strength and top speed. The average power is related to the ability to maintain the anaerobic performance throughout the test, reflecting the resistance of the muscle group in exercise. Minimum power is the lowest power output used to calculate the fatigue index. A fatigue index of less than 10 indicates the ability to maintain anaerobic performance. With a high fatigue index, the player may need to train lactate tolerance.

The formulas used in this test were as follows:

Calculation of absolute power

$$\text{Power (W)} = \text{Weight (Kg)} \times \text{Distance (m)}^2 \div \text{Time (s)}^3$$

Calculation of relative power

$$\text{Power (W/Kg)} = \text{Power (W)} \div \text{Weight (Kg)}$$

Fatigue index calculation

Fatigue index (W/s) = (Pmax (W) – Pmin (W)) ÷ Total time of the 6 sprints (s). RAST test in terms of validity and reliability showed by Burgess et al. (32), that it had a strong value for peak power of ($r = 0.70$, $p < 0.001$) and an average power of ($r = 0.60$, $p = 0.002$). Also the RAST test demonstrate a very good relative reliability for average power with an ICC = 0.88 and good relative reliability for peak power with an ICC = 0.72.

2.7. Statistical procedures

The statistical analysis program (Statistical Package for Social Sciences (SPSS 22.0) was applied as an auxiliary means for the introduction and statistical analysis of data. Descriptive statistics techniques were also applied to calculate measures of the central tendency of the variables under study (minimum and maximums, means and standard deviations).

To evaluate the sample distribution values, skewness and kurtosis tests were carried out, where, according to Pestana and Gageiro (33) are proposed the limits, in absolute value, and considered values up to 2 for skewness and 7 for kurtosis for a behavior similar to normal; between 2 and 3 for skewness and between 7 and 21 for kurtosis for moderately normal behavior; and values greater than 7 in skewness and 21 in kurtosis for extremely normal behavior.

Non-parametric tests were applied as the assumption of normality was not achieved. However, in order to obtain statistical inferences, Rho Spearman correlations and comparisons of variables between variables at the two evaluation timepoints were also presented using the Wilcoxon test. A significance level 0.05 was used for a confidence interval of at least 95%. The magnitude of the effect size was also calculated using *Cohen's d* (34), where values lower than 0 are classified as adverse effects, values between 0.0 and 0.1 have developmental effects, between 0.2 and 0.3 are considered teacher effects and higher values to 0.4 are considered as a zone of desired effects.

3. Results

This section presents the results obtained through the evaluation instruments used. It characterised the entire sample regarding the level of anthropometric and physical fitness variables, namely speed, agility, lower limb power and the fatigue index. All variables were analysed according to the results obtained in the two time points of evaluation, the comparison between them, the correlation and significance values. The following tables show the results obtained in the anthropometric variables and in the physical fitness tests with reference to maximum, minimum, mean, standard deviation and statistical significance values.

Regarding the results obtained in **Table 3**, the anthropometric variables, according to a plausible interpretation, more favourable values are verified at the end of the season, that is, in the second moment of evaluation, there is an increase in bone mass, muscle mass and a decrease in fat mass with significant changes in the three analysed variables. According to the effect size values, it can be found that they demonstrate a teacher effect resulting from the intervention carried out.

The following table presents the minimum, maximum, and average values and respective standard deviation, as well as the

TABLE 3 Descriptive statistics for the anthropometrics measurements, Wilcoxon statistical test for significance between the two evaluation timepoints and effect size of the analysed variables.

Variables	*N*	Minimum	Maximum	Median	Q1 – Q3	*M* ± SD	*Z*	*p*	*Cohen's d*
Bone mass (%)/1st moment	72	2.50	3.40	2.8	2.62–2.97	2.82 ± 0.21	−3.73	0.001	0.23
Bone mass (%)/2nd moment	72	2.52	3.41	2.83	2.71–3.03	2.87 ± 0.22			
Fat mass (%)/1st moment	72	13.50	28.70	19.3	15.45–23.6	20 ± 5.1	−3.63	0.000	0.17
Fat mass (%)/2nd moment	72	12.0	27.2	18.9	14.94–21.07	18.8 ± 8.8			
Muscle mass (%)/1st moment	72	38.70	48.20	43.4	41.7–44.7	43.1 ± 2.50	−3.35	0.001	0.34
Muscle mass (%)/2nd moment	72	40.00	49.20	44.01	42.08–45.1	43.97 ± 2.68			

$p \leq 0.05$.

TABLE 4 Descriptive statistics for the physical tests, Wilcoxon statistical test for significance between the two evaluation timepoints and effect size of the analysed variables.

Variables	*N*	Minimum	Maximum	Median	Q1 – Q3	*M* ± SD	*Z*	*p*	*Cohen's d*
Leg Power (watts) (1st)	72	595	1,053	788	734–841	786 ± 104	−3.15	0.002	0.40
Leg Power (watts) (2nd)	72	647	1,062	817	778–913	825 ± 103			
Speed test 20M (s) (1st)	72	3.24	4.19	3.48	3.31–4	3.64 ± 0.27	−2.72	0.006	1.19
Speed test 20M (s) (2nd)	72	3.09	3.67	3.43	3.01–4.2	3.39 ± 0.12			
Agility *T* Test (s) (1st)	72	8.24	10.95	10.05	9.62–10.6	10.1 ± 0.67	−1.42	0.157	1.3
Agility *T* test (s) (2nd)	72	8.14	10.23	10.83	9.67–10.4	9.31 ± 0.57			
Fatigue index (w/s) (1st)	72	3.14	8.61	5.7	3.94–6.35	6.01 ± 1.22	−0.92	0.360	0.67
Fatigue index (w/s) (2nd)	72	2.47	7.88	2.8	3.36–6.21	5.04 ± 1.63			

$p \leq 0.05$.

TABLE 5 Correlation values of the Rho spearman analysis between the variables under study.

Time points	Test	Variables	Leg power (watts)	Speed test 20M (s)	Agility *T* Test (s)	FI W/s
1st time point	Rho Spearman ($N = 72$)	Muscle mass (%)	0.85**	−0.30	−0.20	0.20
		Fat mass (%)	0.75**	−0.02	−0.13	0.13
		Bone mass (%)	0.74**	0.51*	0.34	0.10
2nd time point		Muscle mass (%)	0.88**	−0.41	−0.44	0.02
		Fat mass (%)	0.81**	0.35	0.35	−0.16
		Bone mass (%)	0.68**	0.42	0.32	0.20
Effect size	*Cohen's d* ($N = 72$)	Muscle mass (%)	0.12	0.13	0.27	0.18
		Fat mass (%)	0.15	0.40	0.50	0.07
		Bone mass (%)	0.12	0.11	0.02	0.08

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

statistical significance, in relation to the two evaluation time points of the analysed variables (power of the lower limbs, sprint test, *T*-test and fatigue index).

Table 4 demonstrates that there were improvements in results in all analysed variables, with significant changes in leg power and the 20-m speed test. The *t*-test of agility and the fatigue index obtained much more favourable values despite not showing statistical differences. In terms of effect size, variables with significant changes present values considered as desired effects. The following table presents the correlation values between anthropometric and physical fitness variables.

Table 5 analyses correlational values between anthropometric and physical fitness variables. The lower limb power variable appears to have a direct relationship with the anthropometric variables with all significant changes. Consequently, the correlation between bone mass and the speed test also presents significant values. However, there are values close to statistical significance between muscle mass and the *T*-test, as well as between bone mass and the 20-m speed test. Some values appear negative, which is why we consider them to be inverse values, meaning that, these values appear lower in the second timepoint because as it is a test measured in seconds, the mean times taken to perform the test are shorter, which means improvements in the performance of the players. Regarding the effect size between the first and second timepoints, teacher effects were evident between the analyzed variables, as well as desired effects between fat mass, agility test and speed test variables.

4. Discussion

Anthropometric and physical tests can help frame individual player profiles and identify their strengths and weaknesses, as well as assess the impact of the training process on the level of

physical fitness, contributing to the development of more appropriate preparation strategies. With regard to anthropometric measurements, more favourable values were verified between the two evaluation time points, with significant changes, that is, muscle and bone mass improved and fat mass decreased, verifying a direct influence on some of the variables of physical fitness, as it was verified.

In the physical aptitude variables, regarding the jump with countermovement, there was an improvement in the average values from the first to the second moment of evaluation, increasing the average power of almost 5%. The results of the present study are similar, in the case of the second evaluation moment, to the studies that present results for the non-elite competitive level (13, 21, 35), although lower than the registered in studies for the elite level.

There was a slight improvement in the agility *T*-test, with mean values increasing equally and respectively between the first and second evaluation moment. The values correspond well with the study by Matta et al. (35) who obtained a similar mean value of 10.10 s ± 0.5 ($n = 84$) for an identical competitive level, and studies that assess agility through the *T*-test in the 15–16 age group are scarce. The study by Sonesson, Lindblom, and Hägglund (21), however, without specifying the competitive level, recorded an average value of 11.5 s ± 0.7 ($n = 13$). However, the protocol was not precisely the same as the previous one. In the study by Rebelo et al. (27), with the same protocol as Matta et al. (35) but focusing on a higher age group, Under-19, the following average values were recorded based on the players' field position and competitive level: goalkeeper, 9.02 s ± 0.33 and 9.39 s ± 0.46 ($n = 18$; elite/non-elite: 9/9); central defenders, 8.86 s ± 0.27 and 9.9 s ± 0.46 ($n = 26$; elite/non-elite: 13/13); lateral defenders, 8.87 s ± 0.23 and 9.07 s ± 0.28 ($n = 27$; elite/non-elite: 14/13); mean 8.88 s ± 0.24 and 9.21 s ± 0.38 ($n = 68$; elite/non-elite: 38/30); advanced, 8.84 s ± 0.26 and 9.18 s ± 0.51 ($n = 41$; elite/non-elite: 21/20). There was a difference between the competitive levels and between the different positions. With regard to the 20 m sprint test, there was also an improvement, with mean values of 3.52 s ± 0.23 and 3.45 s ± 0.19, respectively for the first and second moments of evaluation. Compared with studies that performed the same test with U-17 soccer players (20–22), the times obtained in the present work are higher, although this difference decreases if considering the non-elite competitive levels. Regarding the RAST test, the average values of maximum, average and minimum power revealed some stability, with a slight decrease in maximum power and a slight increase in minimum power, from the first to the second moment of evaluation. There was also a decrease in the fatigue index. For the relative maximum power in the RAST test, the study by Pellegrinotti et al. (36) obtained 9.54 W/Kg ±0.81 ($n = 25$), while Matta et al. (35) obtained 8.68 W/Kg ±1.5 (84).

On the other hand, the study by Silva et al. (26), which was also carried out on artificial grass, together with Kalva-Filho et al. (24) that compared performance in the RAST test on different surfaces concluded that performing the test on natural grass may underestimate the power generated by the lower limbs compared to tests performed on the track. According to these authors, it has been demonstrated that running energy needs can be influenced by the type of surface, with higher values on sand and grass compared to firmer surfaces, according to the work by Souza et al. (25). This may be due to the superior competitive level of the players tested in these studies, as performance in repeated sprint tests in youth soccer is significantly better for elite players (10).

Considering the six sprints, the lowest average time was registered in the second sprint in the two evaluation time points, decreasing successively until the last sprint, as verified in the study by Souza et al. (25). Although players were always instructed to perform maximum effort in all sprints, this may be related to a lesser familiarity with the RAST test (23) or the eventual development of pacing strategies (7, 21). Differences between the values obtained in the present study compared to others, both national and international, may be related to competitive levels, as many of the referred studies included elite players; that is, they belonged to the highest competitive level in the respective countries. On the other hand, when comparing studies that focused on similar age groups and competitive levels, it is pertinent to consider that the maturational status of players may be different.

That is, the assessment of players in these age groups is complex, considering the heterogeneity presented in the performance of the tests that result from differences in maturity, physical fitness and muscle control compared to adult or elite athletes (21, 26). On the other hand, the results may also have been affected by the moment in which they were obtained, especially in the RAST test in the 2nd moment of evaluation, at the end of the competitive season, when greater physical exhaustion was already being felt in the squad.

Finally, statistically significant differences were found regarding the power of the lower limbs and the sprint test ($p \leq 0.05$), between the 1st and 2nd assessments, which may indicate that the training carried out during the season had a significant effect on these variables. It was also performed a correlation between the muscle mass and power of the lower limbs and the *T*-test, where it was verified that the athletes' muscle mass has a significant influence on the results of these variables.

The implemented training (aerobic and continuous) promoted improvements in the players' variables between the two evaluation time points, particularly in leg power and speed, and stimulus tasks should be developed during training sessions so that athletes maintain their abilities throughout the entire sports season.

5. Practical applications

As the Chronojump platform is an easy test to perform, sensitive to the effects of training and valid, the authors recommend its use to evaluate the explosive leg power of football players in the absence of laboratory tests, a variable very close to the running movement and other training methods for developing explosive strength.

The authors state that anthropometric characteristics, physical fitness and consequent technical capacity can influence the type of training in players at training levels. This selection made by coaches

and/or clubs or the combination of both is not always possible since it is not always possible that the team available to the coach is the one, he chooses, but the one he has available. At youth levels, total training time can be critical in player development.

The results in terms of bone density support that sports have beneficial effects on growth, reporting that young football players were skeletally more mature compared to others of the same chronological age that dońt practice sports.

6. Study limitations

It's possible to identify as study limitations the fact that coaches do not have access to laboratory equipment, which makes it impossible to analyze fatigue indices using a spirometer; the possibility of having a higher number of participants and clubs analyzing whether the results found maintain these trends or not; the possibility to evaluate rest periods between competitions were, identifying whether at any point there were variables that remained stagnant or with a loss of performance; it was not possible to evaluate other variables in a laboratory context.

Data availability statement

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

Ethics statement

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

SH: Conceptualization, Project administration, Validation, Writing – review & editing. MB: Methodology, Writing – review & editing. JS: Conceptualization, Writing – review & editing. JP: Writing – review & editing. MR: Formal analysis, Writing – review & editing. FV: Writing – review & editing. AL: Data curation, Investigation, Writing – review & editing. JS: 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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Adoption, acceptability and sustained use of digital interventions to promote physical activity among inactive adults: a mixed-method study

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Introduction: Despite the positive effects of physical activity (PA) to prevent lifestyle diseases and improve health and well-being, only one-third of Norwegian adults meet the minimum recommendations on PA. Digital interventions to promote PA in inactive adults may improve health and well-being by being available, personalized and adequate. Knowledge on users' adoption, acceptability and sustainability of digital interventions to promote PA is still limited.

Objective: To investigate the adoption, acceptability and sustained use of three digital interventions for promoting PA among inactive adults.

Design: A randomized control trial (ONWARDS) with 183 participants assigned to 3 groups and followed up for 18 months. All participants received a wearable activity tracker with the personalized metric Personal Activity Intelligence (PAI) on a mobile app, two groups received additional access to online training and one group had also access to online social support.

Methods: A mixed-methods approach was used to address the study objective. Acceptability was evaluated through the System Usability Scale (SUS) ($n = 134$) at 6 months. Adoption and sustained use were evaluated through a set of questions administered at 12 months ($n = 109$). Individual interviews were performed at 6 months with a sample of participants ($n = 18$). Quantitative data were analyzed with descriptive statistics, whereas qualitative data were analyzed using the Framework approach.

Results: PAI was the most successful intervention, with satisfactory usability and positive effects on motivation and behavior change, contributing to high adoption and sustained use. Online social support had a high acceptability and sustained use, but the intervention was not perceived as motivational to increase PA. Online training had low adoption, usability and sustained use. The qualitative interviews identified five main themes: (1) overall approach to physical activity, (2) motivation, (3) barriers to perform PA, (4) effects of PA, and (5) usability and acceptability of the digital interventions.

Conclusion: Personalized digital interventions integrating behavior change techniques such as individual feedback and goal setting are more likely

to increase acceptability, adoption and sustained use. Future studies should investigate which digital interventions or combinations of different interventions are more successful in promoting PA among inactive adults according to the characteristics and preferences of the users.

Trial registration: Clinical trial registered at ClinicalTrials.gov: NCT04526444.

KEYWORDS

digital intervention, RCT, physical activity, adoption, acceptability, sustained use, motivation, behavioral change

Introduction

Insufficient physical activity (PA) has major implications for health and the prevalence of lifestyle diseases like cardiovascular conditions, cancer and diabetes (1, 2). Active individuals have lower rates of all-cause mortality, lower risk to develop lifestyle diseases, higher level of cardiorespiratory and muscular fitness and healthier body mass and composition (3–5). In Norway, only one third of adults meets the minimum recommendation on PA, and in Northern Norway the PA levels are lower than for southern part of Norway (6).

Digital technology is increasingly used in interventions targeting PA, and some interventions show a potential to make PA more accessible to all age groups and support long-term adherence to PA recommendations (7, 8). Wearable activity trackers linked to mobile apps are now widely adopted and can assist individuals to be physically active (9, 10). Online home-based exercise programs have been reported to be feasible and effective in promoting PA in low-active older adults (10, 11). Peer support groups through social media has been shown to support adherence to PA and maintenance of behavioral change (12–15).

It is important to understand how digital interventions can address key barriers to perform PA in inactive adults, such as lack of motivation, lack of knowledge on how they can increase their level of PA, lack of facilities, weather conditions, time constraints and lack of social support (8, 16). Interventions based on behavior change techniques, including goal setting, monitoring, feedback, and social support, have shown to be effective at increasing PA levels among young adults in the shorter term (17). Digital interventions for PA based on wearable technology, SMS and mobile apps have the potential to promote health and well-being by improving availability, personalization and adequacy (18). However, while some studies have shown positive effects of digital interventions to increase PA levels in inactive adults, others have shown no effect at all (18–22).

The social cognitive theory is a well-known framework for behavior change, including the following five constructs: measurable outcomes (i.e., number of steps), proximal goal setting, procedural knowledge, perceived self-efficacy and the influence of social support (23, 24). Perceived self-efficacy, or beliefs about a person's ability to carry out desired behaviors, affects both motivation and actions and is important for the sustainability in being physically active (25). Behavior change techniques such as goal setting, feedback, rewards and social factors are often included in digital interventions to promote physical activity, but it is unclear which of these components are most used and effective, and their effects on long-term adherence to PA (8, 17).

Implementation outcomes serve as necessary preconditions to understand if a digital intervention has obtained the desired effect (26). Acceptability is the perception of how a given treatment, service, practice or innovation is satisfactory, and low acceptability represents a well-known challenge in implementation research (26). Adoption is defined as the intention or action for the uptake or use of the intervention, whereas sustainability is described as maintenance, routinization and/or continuation of an intervention (26). A randomized controlled trial (RCT) on the acceptability and satisfaction of a web-based video-tailored PA intervention showed that the participants experienced the intervention insufficient to ensure good usage, perceived usefulness and satisfaction (27).

Despite the increasing number of studies on how digital interventions can promote PA, most interventions have a short-term duration (a few weeks or months), and the long-term effects are therefore unclear. In addition, most studies focus on specific age groups (e.g., young healthy individuals or older adults) or people from a specific disease group (e.g., cancer), measuring quantitative outcomes (15, 28–30). There is little knowledge on how digital interventions aimed to increase PA levels are accepted and used by inactive adults at risk to develop lifestyle diseases, and how they affect their motivation and perceived benefits (22). In addition, it is necessary to understand what influences people's choice to take an intervention into use (i.e., adoption) and maintaining it in a long-term (sustained use).

We conducted a RCT aimed at evaluating the effects of three different digital health interventions on PA among adults recruited from the general population who were at risk of developing lifestyle diseases due to insufficient levels of PA (31). The purpose of this mixed-method study was to investigate inactive adults' adoption, acceptability and sustained use of the digital interventions.

Materials and methods

Study setting

We conducted a hybrid type 1 effectiveness-implementation RCT aimed at an inactive and presumably high-risk population living in Northern Norway – the ONWARDS study (31). To be eligible for enrolment, participants had to fulfill the following inclusion criteria: (1) young (18–40 years) or middle aged (40–55 years) healthy adults, both men and women; (2) inactive (undertaking <150 min of moderate-intensity PA per week) in the last 3 months; (3) living in the

Troms and Finnmark county; (4) current owner of a smartphone; and (5) able to understand training instructions in English language.

One hundred and eighty-three participants were randomized to 3 groups and participated for 18 months. The three groups were provided the following interventions: group (A) activity tracker (Mi Smart Band 5, Xiaomi, China) with the personalized metric Personal Activity Intelligence (PAI) on the mobile app PAI Health (PAI Health, Canada), group (B) activity tracker with PAI and access to online training videos (Les Mills+) to perform home-based training, group (C) activity tracker PAI, home-based online training and additional online social support via social media (Facebook). No control group receiving "standard care" was applied in this RCT, as inactive adults do not often access a training facility or use equipment for home-based training. Group A was considered the reference group of this RCT, as group B and C received additional digital interventions. The rationale for this RCT was to test which combination of strategies is more effective in increasing PA levels and maintaining PA levels in a long-term perspective of 18 months.

PAI is a personalized metric which takes into account age, sex, resting and maximum heart rate, and provides a score indicating whether the current PA level is sufficient to obtain or sustain good health (PAI score) (32). The goal setting is to reach and maintain a score of ≥100 weekly PAI. Individual feedback on the current PAI score was provided through the smartphone. Participants were also required to install and access regularly another app linked to the activity tracker (Zepp Life) so that the data stored in the PAI Health app were always up to date. Les Mills+ is a home-based online training solution offering videos of training classes (cardio, strength, flexibility, core etc.) available 24/7 trough a website, and is accessible from any device, smart TV, internet, PC, tablet or smartphone. The social support group was offered through a closed Facebook group aimed at providing a platform to share experiences, advice, support and motivation from peers. The Facebook group was administered by the project team, which regularly (one a week to twice a month) provided general information and educational advice about PA, motivational support, rewarding messages, technical and practical help.

Well-known external barriers to perform PA in inactive populations include environmental obstacles (e.g., weather), access to training facilities (due to distance or poor economic situation), time constrains, and lack of social support (8, 16). To decrease those barriers, we provided all participants with digital technologies and wearable devices at no cost for the participants. This was especially important to include inactive adults regardless of their socio-economic status (7). Home-based online training did not require more space than a few squared meters, making it feasible for most users. Online social support was based on a closed group on Facebook, a social media which is highly adopted and accessible by the target population of this study.

Study design and data collection

Participants' adoption, acceptability, and sustained use with the digital interventions were investigated through a mixed-methods approach, where different methods were selected, and their results supplemented each other to address the study objectives. We used triangulation as a technique to combine the qualitative and quantitative results, to gain a more complete picture of the study objective (33). Acceptability with the digital interventions was explored through the System Usability Scale (34), a standardized 10-item questionnaire with five response options per question (ranging from Strongly agree to Strongly disagree). Each of the interventions was evaluated through one questionnaire by the study participants who received it. The SUS was administered at 6-month follow-up. Adoption and sustained use were evaluated through a set of questions administered at 12-month follow-up (Supplementary Table 1). Study participants were asked whether they used the received intervention and for how long they used it. Depending on their answer, they were asked their opinion on the use or the main reasons not using it.

Semi-structured individual interviews were conducted via the video-based solution Teams (Microsoft, state, United States) at 6-month follow-up in a subsample of participants from all the three groups ($n = 18$) to collect in-depth information on adoption, acceptability, and sustained use. We sent an invitation by e-mail to a random sample of 50 participants asking whether they were willing to take part in an interview. We aimed to include the same number of participants in each group and achieve data saturation. The interview guide was structured around the following main themes: (1) motivation to participate in the project, (2) changes in physical activity habits and maintenance, (3) experience with the use of the three digital interventions, (4) perception of social support, and (5) experienced motivation and effects (Supplementary File 1). The interviews were performed by one researcher (USM) in the period January–June 2022 and lasted between 25 and 45 min. The interviews were audio recorded and then transcribed as a whole (verbatim transcription). Citations reported in this study were translated from Norwegian to English.

Data analysis

The System Usability Scale (SUS) measures different aspects of a system; (1) Effectiveness (how users can achieve their objectives), (2) Efficiency (how much effort is expended in achieving the objectives), and (3) Satisfaction (was the experience satisfactory) (34). The following procedure was applied to calculate the score of SUS: The answer to each question ranging from strongly disagree (1) to strongly agree (5), is converted into a new score, ranging from 1 to 5. For odd-numbered questions (1, 3, 5, 7, and 9) the new score is the answer minus 1, for even numbered questions (2, 4, 6, 8, and 10), the new score is 5 minus the answer. This scales all values from 0 to 4 (with four being most positive response). The converted values are then summed, and the total multiplied by 2.5 (ref.). The final SUS score ranges from 0 to 100. Based on research, a SUS score above 68 is considered above average, and anything below 68 is below average (34).

Adoption of the three interventions was computed as the ratio between the number of respondents who used the intervention and the total number of respondents who answered the question. Sustained use was computed as the ratio between the number of respondents who still used an intervention after 1 year and all those who adopted the intervention. The qualitative data from the interviews were analyzed by a multidisciplinary team consisting of four members (USM, PZ, EHS and KA) using the Framework method (35, 36). Further, this approach identify commonalities and differences in qualitative data, before focusing on relations between

different part of the data seeking to draw descriptive or explanatory conclusions around themes, and is especially used in multidisciplinary research teams. The research team had a background in health science, nursing, health technology and sports science. First, two of the transcribed interviews were randomly selected and read by the entire team to become familiar with the transcripts, develop initial impressions and ideas for codes. Second, the two transcripts were thoroughly read and independently analyzed by each member of the team. Interesting segments were underlined, and notes were made to describe the content of each passage with coding labels. Then the team met to share the coding labels previously assigned to the two transcripts. We analyzed every passage to discuss how it would be useful to address the research questions. The coding labels used to describe each passage were compared to find similarities in the interpretations of the content and to resolve differences. Further, a working analytical framework was developed around a set of codes that were explained by a short definition of their content. All the remaining transcripts were then assigned to the four members of the team and analyzed using the working analytical framework. New codes that arouse and that were not included in the initial framework were added to the already defined codes as additional impressions emerged. During this process, the team had regular meetings to discuss new codes, merge codes that were conceptually related and refine the initial analytical framework, until no new codes were generated. The quantitative results from the questionnaires and the qualitative findings from the interviews were finally analyzed and interpreted by triangulation, which is recommended in mixed methods research. This approach allows comparing multiple sources and consider where findings from each method agree (convergence), offer complementary information on the same issue (complementarity), or appear to contradict each other (discrepancy or dissonance) (33).

Ethical considerations

The study is approved by the Regional Committee for Medical and Health Research Ethics (66573/REK nord) as well by the Data Protection Officer of the University Hospital of North Norway. The participants provided their written informed consent to participate in this study.

Results

Usability of the interventions

A total of 134 patients out of 183 answered the SUS at 6 months. The total score for the SUS was highest for the social support group (Table 1). The PAI smartphone application had a score of about 68 which is considered average, while the score for Les Mills + was under average. The results from the single questions provide a better understanding of the different dimensions of usability of the interventions (Supplementary Table 1). Overall, the Facebook group had higher scores regarding user friendliness and competence needed to use the intervention. However, PAI was the intervention that the participants intended to use most frequently.

TABLE 1 Scores for the System Usability Scale (SUS) questionnaires at 6 months, and SUS Item Scores (1–5) for the three digital interventions ($n = 134$).

Questionnaire	PAI	Online training	Online social support
SUS score, total, mean ± SD	**68.4 ± 22.4**	**61.4 ± 23.0**	**80.6 ± 15.7**
SUS score, each item			
1. I think that I would like to use this intervention frequently	3.4	2.8	2.9
2. I found this intervention unnecessarily complex	2.3	2.3	1.3
3. I thought this intervention was easy to use	3.6	3.2	4.4
4. I think that I would need assistance to be able to use this intervention	1.9	1.9	1.1
5. I found the various functions in this intervention were well integrated	3.1	3.0	3.5
6. I thought there was too much inconsistency in this intervention	2.1	2.3	1.7
7. I would imagine that most people would learn to use this intervention very quickly	3.7	3.5	4.5
8. I found this intervention very complicated to use	2.1	2.3	1.6
9. I felt very confident using this intervention	3.6	2.9	3.9
10. I needed to learn a lot of things before I could get going with this intervention	1.8	2.0	1.3

Adoption and sustained use of the interventions

A total of 109 participants out of 183 answered the question administered at 12-month follow-up on whether they used the interventions they received. Adoption was highest for the PAI (89.9%) (Table 2). Adoption of online social support among respondents in group C was also above average (76.5%), while only one third of the respondents in group B and C reported to use home-based online training (31.4%). Most of those participants who adopted online social support were still using it after 12 months (96.2%). Sustained use for PAI after 12 months was lower (78.6%), but many of the participants used the interventions for more than 10 months. For online training

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TABLE 2 Adoption and sustained use of the interventions at 12 months.

Measure	PAI	Online training	Online social support
Adoption	89.9%	31.4%	76.5%
Sustained use			
Still in use after 12 months	78.6%	18.2%	96.2%
Used it for 1–3 months	0.0%	68.2%	3.8%
Used it for 4–6 months	4.1%	4.5%	0.0%
Used it for 7–9 months	2.0%	4.5%	0.0%
Used it for 10–12 months	15.3%	4.5%	0.0%

most of the participants discontinued the use within 3 months (68.2%).

Qualitative interviews

Data saturation was achieved at a total of 18 interviews, with six participants included from each intervention group thirteen women and five men in the age range between 32 and 54 participated. The final analytical framework consisted of 26 codes grouped into five main themes: (1) Overall approach to physical activity, (2) Motivation, (3) Barriers to perform PA, (4) Effects of PA, (5) Usability and acceptability of the digital interventions (Table 3).

Overall approach to physical activity (before the study)

The participants had different experiences and approaches to PA prior to the study. Some participants were used to exercise before (e.g., in their youth), but their PA level had decreased or completely stopped in their adult life, and they stated that they wanted to start doing PA again. Others considered themselves as physically active to some degree, such as going to work, walking with their dog, or hiking from time to time, but wanted to get in better shape by doing more regular exercise. Fewer participants had never or rarely been physically active before and wanted to start with participating in the ONWARDS study.

> I used to be active earlier, but after having kids it has been difficult. I have always been exercising and enjoy it (ID 10).

Reasons for not being active were lack of motivation, lack of time, bad weather conditions, or restrictions during the pandemic. Others did not like to exercise. The lack of ability to plan and incorporate PA into the everyday life was also highlighted as a reason for not performing PA.

The participants had different views on how to increase their level of PA. While some just wanted to increase their number of daily steps, others wanted to perform regular training sessions (e.g., running, skiing, strength) several times a week. Many saw the ONWARDS study as an opportunity and motivation to be more active, exercise regularly, increase their fitness level and gain overview and control of their PA level.

> I do not like to be physically active; it is not integrated in my everyday life although I know it is important (…). So, I thought "why not"? Maybe participating in this project can help me to get a kick-start (ID 11).

Social support from family, friends, or colleagues to be physically active varied between the participants. While it was perceived as important for some, others did not experience any need for social support. Some had previous experience with wearable devices for PA (e.g., sport watches measuring heart rate, number of steps, sleep quality) or applications (e.g., for weight control), but none had used PAI or monitored their level of PA over a long period of time.

Motivation and demotivation

A major motivational factor for many of the participants was the feedback on their individual PAI score and the earning system in the wearable activity tracker with the connected PAI app. The reward from an increasing PAI score was perceived as a boost to be physically active, giving a good feeling of mastery when achieving the expected goal (100 PAI/week). The feedback when the PAI score was low motivated several participants to increase their PA level. Over time, many participants learned how much extra effort they needed to do to obtain 100 PAI/week.

> When I have reached a high PAI score, I get motivated to maintain the score. I get kind of attached to the thing (PAI), checking the PAI score in the morning to find out how much effort I need to do to maintain the PAI level that day (ID 16).

Several participants got motivated from the feeling of physical and psychological well-being they gained by being more physically active. In addition, a strong motivational factor was being able to maintain this feeling of well-being, confidence, and ability to make PA as a routine in their everyday life. For some participants, motivation to continue with PA lasted over time and some experienced that it was easier to increase the level of PA even if the PAI score had been low for a period. At the same time, the feedback of their PAI score felt demotivating for others, especially if they for different reasons did not have the opportunity to be physically active for a period, and the PAI score reminders were perceived as annoying or stressful.

> I am receiving fewer points than I deserve. I am probably very concerned about the number of PAI-points. But at the same time, I think it gives me a motivation to work out on days where I normally would not work out (ID 3).

The lack of PAI score from low-intensity activities like strength training was also perceived as a demotivation for some, as they had been active but were not able to reach the expected PAI goal. Some did not see any difference at all in their motivation to be more PA and expressed the main reason to be the lack of intrinsic motivation rather

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TABLE 3 Analytical framework.

Themes and codes	Description
Overall approach to physical activity	
Experience with physical activity*	Barriers for and/or experience with physical activity
Motivation/incentive to participate*	Incentive for participating in ONWARDS, barriers to physical activity
Experience with other digital interventions/devices*	If they have used other devices before and/or during study
Social support	Support from family, friends, colleagues etc.
Motivation	
Motivation from PAI	Feedback / rewarding from PAI
Demotivation from PAI	Technical issues hindering registration of PAI-points, types of exercise not rewarded etc.
Motivation from experienced effects	Response to training
Intrinsic motivation	Internal competition as motivation
Competition with others	Motivation training/competing with others (social)
Internal barriers to physical activity	
The "door step mile"	It feels prohibitive to "go out the door" for physical activity, hesitation
Oneself as a barrier	Want to be more active but do not have enough motivation/drive
Lack of "vitality"	Low vitality/energy to start exercise
Prioritization	Family, work, not prioritizing oneself
Health factors	Injury, illness, hindering physical activity
External barriers to physical activity	
Lockdown (pandemic)	Training centers closed, isolation, quarantine
Weather / season	Affects if you are physical active or not due to the seasons and/or weather
Where to exercise	Access to training center, nature, residence
Costs	As a barrier to perform physical activity (training center or training gear)
Life factors	Job, family, lack of time
Effects	
Impact on physical activity habits	Easier after joining ONWARDS, intensity, length, level, increased focus
Planning of physical activity	Goal setting, planning or not planning, (combination)
Health gains	Weight loss, better sleep, lower stress level, investing in own health
Well-being	Vitality, energy, bad conscience, self-esteem
Experience with digital interventions	
Experience with MiFit/PAI/wearable activity tracker	Included non-use/problems, experiences, user friendliness
Experience with Les Mills+	Included non-use/problems, experiences, user friendliness
Experience with Facebook group	Including non-use/problems, experience

*Before the study.

than the digital devices they used. Being active together with family members, friends or colleagues was an important motivation to increase PA for some, while others were motivated from having some time for themselves.

Barriers to physical activity

Internal barriers are factors within the persons themselves hindering them from being physically active. The *doorstep mile* was often named and explained as *it feels prohibitive to go out the door for physical activity, making the person hesitating and stay indoors doing nothing instead.* Low vitality, as well as illness or injuries, were also common barriers to be more physically active. Many participants described that it was hard to prioritize time to be PA, as family and work often came first.

> The total amount of things to do and the energy one uses is not always enough for both work, family, and me. The things that most often are deprioritized are those related to me. It is very wrong, then you have less to give to everyone else also. But that is what happens, and partly still do. When you have done everything else that day, and there is no time for me, there is nothing (energy) left (ID 5).

Several external barriers for PA were pointed out, one of them being the pandemic situation with isolation, quarantine and training centers closed for several weeks or months. Lack of space or gear to

exercise at home was named as a barrier, although most participants preferred to be outside for PA. Others did not have access to training centers due to long distances, living in rural areas or the cost of a membership was perceived as too high. Poor weather conditions, especiallyin winter, affected some participants, hindering people to be outside and be active for parts of the season. The period with no sun (the dark period) in Northern Norway lasting from November to January was a common barrier for some.

> Now we have recently had the dark period. It is often a heavy period up here. It makes me more passive. It has been colder as usual, so I have not done so much winter activities as usual. But now the sun is back, it is getting a bit warmer and easier (ID 5).

Some experienced their work situation, characterized by responsibility, traveling or long working hours, as a barrier to perform as much PA as they wanted and needed.

Experienced effects and behavior change

Most of the participants experienced that participating in the study had a positive impact on their PA habits, describing that they became more focused on performing PA and that it felt easier to be more physically active in their everyday life than earlier. Some explained they found a lot of joy and fun in performing PA now, and they got in better shape.

> It really affects me, It's really fun and a lot more motivating when I see that I can run four times a week, and I am in a much better shape now (ID 20).

Some participants set goals for their activities/training, doing regularly exercise two or more times a week on fixed days, or had a plan for the different types of exercise during a week. Others were happy just to go out for a walk sometimes during the week, and were more focused on doing everyday activities (i.e., walking instead of taking the bus). Many participants made a plan to have time to prioritize PA, whilst others were active when it was possible (e.g., while their children were on activities, on their way to and from work). Some experienced that they lost some weight as a result of being more active, with a consequent positive effect on their self-esteem and ability to perform PA.

> It is good to be physically active and feel the endorphins I gain after being active. It is a satisfactory feeling to be happy with myself and not have the bad conscience for it (ID 3).

Some participants experienced better sleep quality or lowered stress levels when doing PA regularly. Others pointed out the effects of their increased activity level as a good and important overall investment in their own health, especially for those being from the higher age group (≥40). There were also participants who had not experienced any objective or subjective health gains during the first 6 months of the study.

> I had a desire of increasing my level of PA by joining this study, but nothing has changed, and I have a persistent low level of PA. It is not exactly motivating, and I do not feel any benefit of the interventions (ID 12).

Usability and acceptability of the digital interventions

Experiences from using the activity tracker Mi Smart Band varied among participants. Some thought that the activity tracker was too simple and small, especially for those who previously had used other sport watches (Garmin, Polar, Apple). In a few cases the device needed to be replaced with a new one after being used 24/7 for several months.

> It has gone perfectly well. It takes some time to get used to it (the Mi Smart Band), that's the only thing, Otherwise, it is very nice and easy to use. Although it lacks some activities you can choose on the watch. So far, it's pretty good (ID 17).

Technical issues were experienced by some, especially with synchronizing the activity tracker with the two apps (PAI Health and Zepp Life), which could make participants demotivated to continue in the study because their fitness scores were not up to date.

> I am using the apps in between just to update and synchronize, and to follow my PAI score (…). But I do not use it actively, I think the system seems kind of cumbersome (ID14).

Most participants liked to follow their PAI score and found it very motivating to reach the goal, or notice they need some more PA that day or week to reach 100 PAI-points.

Few participants used Les Mills+. Most participants perceived the website and classes as too advanced, with too many options and difficult to navigate to find a suitable training program fitting their personal level of fitness. Lack of space or equipment at home was also an issue for some. Some perceived that online training did not suit them or did not increase their motivation, others preferred to exercise outside or at their local gym instead of using online home-based exercise. Only few participants had no problem using Les Mills+ and found the site easy to use, but only one used it regularly.

> I think I only tried it twice, but I did not feel that it gave me anything. That Les Mills-thing was not for me (…). I tried an activity for the whole body, but it was too much jumping up and down. It is not that I do not like group training, but on a digital platform is not for me. I like a real-life instructor present (ID 12).

Most participants did not find the Facebook group motivating or to have any influence on their PA level. Some participants did not join the group at all because they were not on Facebook, whilst others followed the group but did not actively interact. Another reason for not being active in the Facebook group was the fear of losing their own feeling of mastery when comparing themselves to other group members. Some also recognized another participant in the group, making them even more reluctant to post from their own activities or sharing experiences. Caution in posting things and pictures about themselves was highlighted as a factor for not being active in the group, although some participants liked status and pictures posted on

PA from other participants. Some wanted more information and follow-up from the project group, like posts on how many PAI scores during a week or month they had, or other information regarding motivation to perform PA.

> That Facebook group …there has not been so much activity there, but it is fun to see when someone post pictures. I do not think it has motivated me to do something about my own activity level (ID 20).

Discussion

This mixed method study explored inactive adults' adoption, acceptability and sustained use of three different digital interventions aimed at increasing PA. The activity tracker with PAI was perceived as the most successful of the three digital interventions due to its sufficient usability, it was widely adopted and used over time due to its perceived effect on motivation and increase in PA levels. Although acceptability and sustained use of online social support were high, the intervention was not perceived as motivational for PA. Online training was the intervention with the lowest adoption, usability and sustained use. Personalized feedback and goal setting through PAI seemed to be major factors for a positive behavioral change among the study participants. These behavioral change components were not included in the two other interventions.

Personalized feedback from digital devices, like smartphone apps, is considered as an important facilitator for lifestyle behavior change (24) and an effective component to increase motivation for PA (10, 24, 37). At the same time, other studies showed inconsistent results on the how personalized feedback affects motivation for PA (20, 22). Goal setting is another component which is frequently included in PA interventions, as well as in technical devices like fitness/activity trackers to increase motivation for users to be more active (38). A scoping review suggested that assigning a goal to users is more effective than letting the users set their own goal (18). A recent study also reported that users preferred goals matching their abilities, which made it more possible to boost motivation to continue regular PA (22). An advantage of using PAI compared to other activity trackers (e.g., pedometer trackers) is that PAI is personalized to a person's age, gender and fitness level, and provides a single individual score indicating whether the current PA level is sufficient to obtain or sustain good health (39, 40). Most of the study participants experienced the PAI score and goal of 100 PAI/week as major factors to gain motivation and positive effects on physical and mental well-being. These, in turn, contributed to a higher adoption (89.9%) and sustained use (78.6%) of this intervention at 12 months compared to home-based online training and online social support. At the same time, a disadvantage of using PAI for goal setting on PA is the reliance on the users' heart rate patterns during PA (32), which may favor aerobic activities over resistance-based activities (e.g., strength exercise). As a consequence, some participants found the feedback on PAI score to be demotivating or stressful, especially in periods of low activity or when receiving much fewer PAI points for strength activities compared to cardiovascular activities.

We expected home-based online training and online social support to give an additional effect to the users. However, as these two interventions were delivered as an addition to PAI, which was perceived as the most effective and useful intervention, their added impact and effect was limited. If home-based online training and online social support were delivered as stand-alone interventions, the impact on motivation and experienced effect may have been higher.

This study was partly conducted during the COVID-19 lockdown or when socializing with others was limited, and it was expected that home-based online training would provide a good alternative to do PA in this time of limited PA resources. A study on the acceptability of online workout classes by a population in isolation during the pandemic reported good feedback on the impact on PA (10), whereas other found unclear results of online workout classes in young adults and the impact of social network to promote PA (12, 28). Although the participants in this study live in an area of Norway often affected by harsh weather conditions, most of them preferred exercising outdoors. This may have affected the perceived usefulness of home-based online training. While the usability score was acceptable (moderate), only few participants used the intervention for more than a short period of time, showing low adoption and sustained use. Other studies on web-based video-tailored PA interventions report short adherence to the intervention and a low perceived usefulness from the users (27). Another reason which might have affected acceptability, adoption and sustained use was that the website for online training was too overwhelming and there were too many classes to choose from.

The purpose of the online social support was to offer a closed online forum where participants could exchange experiences, discuss and motivate each other to perform PA, reach PAI point goals and create a social support environment. Although the intervention had the highest usability score and a good score on adoption and sustained use, was perceived to have a limited additional value relative to PAI on the motivation to do PA. Studies on the impact of peer-support interventions to promote PA through social media showed inconsistent results. One study reported that more activity and feedback from the users in a social support group on Facebook increased the participants PA level slightly (30). Another study reported the effect of social support through Facebook groups on PA, but only in the short-term (12). A recent study reported that adding goal setting, self-monitoring, tailored feedback and educational information was perceived as the most effective strategy for increasing PA in digital social network groups (15). Interestingly, the usability of the online social support in the current study was perceived as very high. Facebook is a well-known social network platform, and many of the users were familiar with it prior to the study. Furthermore, its wide use beyond the purpose of this study might have contributed to the increased sustained use observed. This indicates that established social networking platforms with widespread use can be ideal delivery media for digital interventions.

Digital interventions for increasing PA have shown positive effects mostly in younger populations (13, 15, 28). The current study targeted a population of mostly middle-aged (30–55 years old) inactive adults, who were presumably at risk of developing lifestyle diseases caused by the lack of PA. Moreover, most studies have a short-time duration, making it difficult to measure long-term adoption and sustained use of digital interventions (17, 41). The current study was characterized by a unique duration of 18 months, and most of the participants were still using PAI after 1 year. The high sustained use of this intervention shows the potential for long-term adoption for inactive adults.

Strengths and limitations

The study was designed without an ordinary control group. All participants were provided with an activity tracker and PAI, and

home-based online training and online social support were additional interventions in two groups. The design of this study might have limited the potential effect of these interventions compared to PAI. A mixed-method approach is an advantage as the study was based on both quantitative data from a larger population as well as qualitative data from a selected group of users. Although the information gained from the scores on acceptability, adoption and sustained use, the in-depth experiences reported from the qualitative interviews allowed to further examine why and how participants perceived the different digital interventions. The framework approach to qualitative analysis was chosen as it is a flexible tool that can be adapted for use in multidisciplinary research teams and within research projects using a mixed-method design (35). The quantitative data were based on self-reported data after 6 and 12 months. Self-reported data are known to be a risk for bias compared to objective measurements.

Conclusion

This study evaluated the adoption, acceptability and sustained use of three different digital interventions aimed at promoting physical activity in inactive adults. The activity tracker with the personalized metric PAI on a mobile app was the most successful intervention, with a satisfactory usability and perceived positive effects on motivation and behavior change which, in turn, contributed to a high adoption and sustained use. The online social support had a high acceptability and sustained use among the study participants, but the intervention was not perceived as particularly motivational to increase PA. Online training had low adoption, usability and sustained use. Personalized digital interventions integrating behavior change techniques such as individual feedback and goal setting are more likely to support motivation for behavioral change in inactive adults and increase acceptability, adoption and sustained use. Future studies should investigate which digital interventions or combinations of different interventions are more successful in promoting PA among inactive adults according to the characteristics and preferences of the users.

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.

Author contributions

UM: Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. ES: Formal analysis, Investigation, Writing – review & editing. KA: Formal analysis, Investigation, Writing – review & editing. PZ: Formal analysis, Investigation, Methodology, 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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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1297844/full#supplementary-material

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Validity, reliability, and invariance across sex of a German version of the Behavioral Regulation in Exercise Questionnaire

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Objective: Since there is no scientifically validated German version of the Behavioral Regulation in Exercise Questionnaire (BREQ-3), the aim of this study was to assess its psychometric parameters and invariance across sex in a sample of German-speaking young adults. The BREQ-3 is an instrument measuring the social and internal influences of motivation toward exercising. This tool is widespread within the scientific community and has been validated in several languages.

Methods: A total of 271 participants (45% women; mean age = 20.67 ± 2.17 years; effect size ≥ 0.5) filled in the BREQ-3 at one time point, with a small sub-sample ($n = 37$) responding it a second time after 15 days. Confirmatory Factorial Analysis, Structural Modeling, and Intraclass Correlation Coefficient were used to examine the German version of the questionnaire.

Results: Results highlighted a good fit of the six-dimensional model after the removal of two items (CFI = 0.912; SRMR = 0.0594; RMSEA = 0.064), as well as full invariance across sex ($p_{\chi 2} = 0.218$; $\Delta CFI < 0.01$). Internal consistency and reliability were moderate to good.

Conclusions: The 22-item German BREQ-3 is a scientifically valid instrument that can be used in cross-national studies dealing with social aspects of exercise behaviors.

KEYWORDS

motivation, self-determination theory, active behavior, validation, young adults

1 Introduction

Motivation is one of the most prominent studied variables in human behavior and behavioral change (Deci and Ryan, 1985). According to the Self-Determination Theory (SDT; Deci and Ryan, 1985), motivation can be categorized in six different types along an internalization continuum representing the level of autonomy with which an individual will tend to carry out a behavior. One end of this continuum is represented by the most autonomous motivation to act (intrinsic motivation), and the opposite end by a total lack of drive (amotivation) (Center for Self-Determination Theory, 2022). Deci and Ryan (1985) provide a thorough description of each type of motivation in the continuum: the intrinsic one is the most internal one since it is activated by people's inner interests and enjoyment, and it is usually associated with the development of long-term habits;

integrated motivation is the second most autonomy-guided type, since behaviors are driven by an individual's internal desire to be self-aware; a further step away from autonomy is represented by identified motivation, which describes behaviors as driven by personal values that an individual attributes to them, rather than enjoyment of carrying them out; introjected motivation is a more controlled type that is guided by an individual's need of self-control, which may depend on external sources, such as, for instance, fear of being judged by others; external motivation is the most externally controlled type in the continuum, since behaviors are regulated by fear of punishment for not carrying them out or by potential external rewards (for instance, receiving a gift for participating in an experiment); amotivation represents the final ending of the continuum, and it describes a person's complete lack of willingness to carry out a behavior (Center for Self-Determination Theory, 2022). Sport science is one among different scientific areas that have widely studied the interaction between motivation types and sources and behaviors, in particular in understanding what drives individuals to choose an active or sedentary lifestyle (Brandenbarg et al., 2023; Fang et al., 2023). This may have important consequences not only on the short term, but also on long-term health (Teixeira et al., 2012). Indeed, better exercise experience is associated with the intrinsic types of motivation (Liu et al., 2023). Other studies highlight that the most autonomous end of the continuum (intrinsic and integrated motivations) tend to have highly positive association with exercise-related parameters, whereas this association becomes negative as we move to the opposite end of the continuum (Durán-Vinagre et al., 2023; Fresno-Alba et al., 2023). For this reason, several scientific tools have been developed and tested over time to ensure a rigorous assessment of people's motivation in relation to sport and exercise (Plonczynski, 2000). In this sense, the Behavioral Regulation in Exercise Questionnaire (BREQ), based on the theoretical framework of SDT and developed by an exercise motivation research team from Bangor University, has become one of the most widely used instruments when the focus of research is active behavior related to health in the general population, as demonstrated by an extensive body of literature (e.g., Lev Arey et al., 2022; Mikkelsen et al., 2022; Vancampfort et al., 2023). The initial version of BREQ showed high levels of skewness for the "amotivation" items, which led to the exclusion of said subdomain, along with the "identified" one. However, Markland and Tobin (2004) were able to add "amotivation" in the second version of the instrument (BREQ-2), reporting good validity parameters. The BREQ-2 has now been translated and validated in several languages and has already been used successfully in scientific research worldwide. Nonetheless, despite constituting a sounder tool compared with the initial version, the BREQ-2 did not fully represent the motivation continuum as described in the SDT since it could not solve the issues with the "identified" subdomain. This was later addressed by Wilson et al. (2006), who were able to test a newer version of the questionnaire (BREQ-3) that included an extra item for the "introjected" subdomain along with a 4-item "identified" subdomain. The BREQ-3 reflects more accurately the six-motivation structure proposed in SDT's internalization continuum. The third version of the BREQ is composed by 24 items equally distributed in 6 sub-domains: amotivation (*I think exercising is a waste of time*); external regulation (*I exercise because other people say I should*); introjected regulation (*I feel ashamed when I miss an exercise session*); identified regulation (*I think it is important to make the effort to exercise regularly*); integrated regulation (*I exercise because it is consistent with my life goals*); and intrinsic regulation (*I find exercise a pleasurable activity*). Responses are given on a Likert scale ranging from 0 (not true for me) to 4 (very true for me). Average scores are used to establish the levels of each motivational regulation. The questionnaire has been validated in different languages, including Spanish (González-Cutre et al., 2010), Chinese (Luo et al., 2022), Italian (Cavicchiolo et al., 2022), Portuguese (Cid et al., 2018), or Malay (Chai et al., 2022), and extensively implemented in latest research focused on exercise and health (Chen et al., 2022; O'Loughlin et al., 2022; Sánchez-Herrera et al., 2022; Durán-Vinagre et al., 2023; Fresno-Alba et al., 2023; Lock et al., 2023; Reyes-Molina et al., 2023; etc.). A German version of the BREQ-3 translated by Rausch Osthoff (2017) is currently available online. However, although the BREQ-2 has already been validated by Witzki and Leyk (2014), the German version of BREQ-3 did not undergo any psychometric evaluation, hence, it cannot be considered scientifically valid in its current state and until a formal assessment of its psychometric parameters is provided. Despite its strength, its diffusion among the scientific community, and the fact that BREQ-3 allows to observe the entire internalization continuum and associated motivational sources, the lack of a scientifically validated version of the BREQ-3 in the German language represents a gap that needs to be filled. Indeed, providing a scientifically proven version of the German BREQ-3 would be an essential step not only for the research community in German-speaking countries, but it would also allow using a single, reliable tool in cross-national studies, with the possibility of comparing results of different communities and countries, finding common strategies for the promotion of active habits, as well as tailoring interventions based on regional differences. Therefore, the aim of this study was to test the validity of the German version of BREQ-3 provided by Rausch Osthoff (2017) in a population of young adults from Austria.

2 Materials and methods

2.1 Design

This is a validation study using quantitative, non-experimental and cross-sectional approach.

2.2 Sample

For confirmatory factor analysis by means of structural equation modeling, the minimum sample size necessary in order to achieve a large effect size (0.5) and statistical power (0.8) with a significance threshold set at 0.05 for a questionnaire composed by six latent variables and 24 items is 100 respondents (Westland, 2010). Our initial sample consisted of 298 young adults recruited from the population of first- and second-year bachelor students at the researchers' institution. Nonetheless, due to missing data ($n = 21$) or typos in the data transcription ($n = 6$), the final sample was composed by 271 respondents (122 women; mean

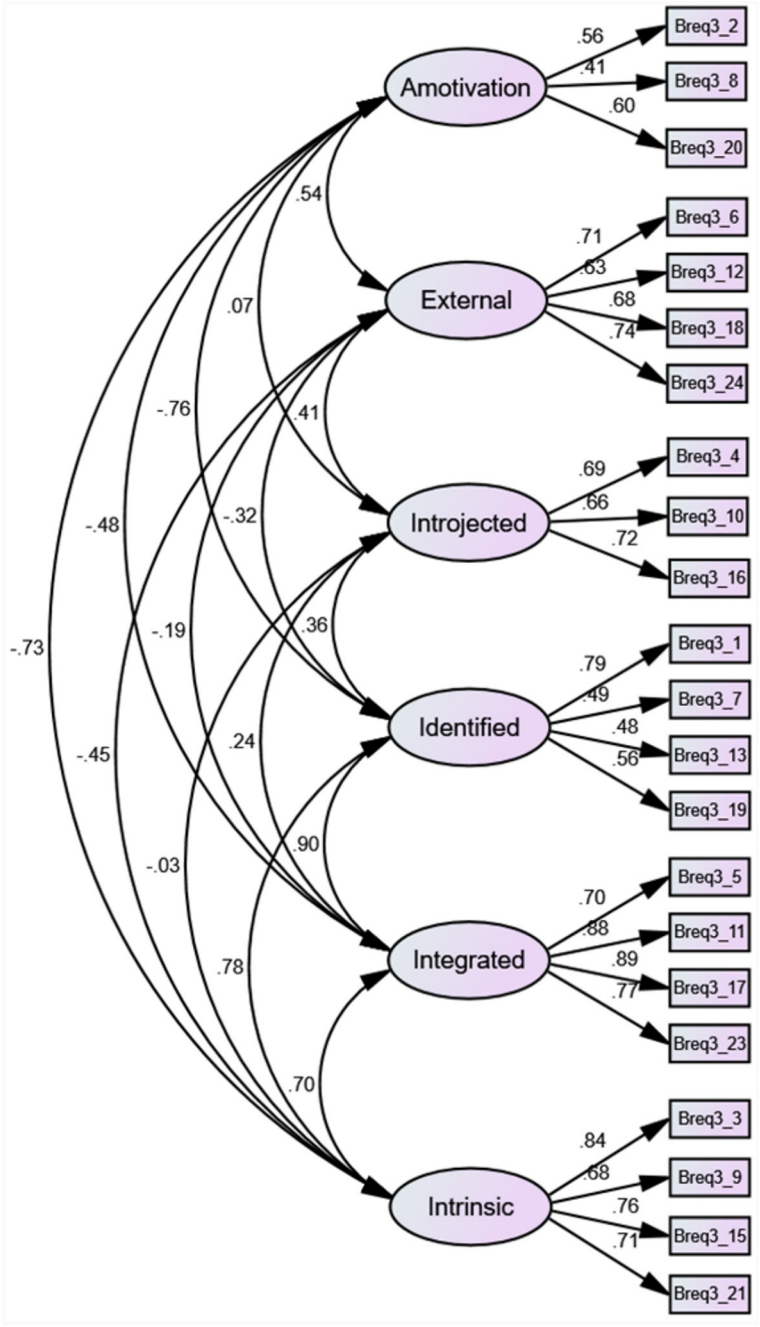

FIGURE 1
Structural model of the German Behavioral Regulation in Exercise (BREQ-3).

age = 20.67 ± 2.17 years). For the reliability analysis, a smaller sample of 36 participants (mean age = 23.64 ± 1.93 years) responded to the questionnaire twice within 15 days (Streiner et al., 2015).

Formal approval from the Ethical Committee of the Institution had been previously provided. Signed informed consents were collected from all participants before the start of the data collection period.

2.3 Instruments

The BREQ-3 (Markland and Tobin, 2004; Wilson et al., 2006) is composed by 24 items distributed in six sub-domains (four items per sub-domain), as described above. Compared to the BREQ-2, this version includes an additional item in the "introjected regulation" sub-domain (item 22: *I would feel bad about myself if I was not making time to exercise*) and the "integrated regulation"

sub-domain. Its translation to the German language was carried out and published online by Rausch Osthoff (2017). Since this author's version was adapted for sports training, their translation was maintained with the exception of the word "training," which was substituted with "exercise," thus reintroducing the actual meaning and focus by which the original BREQ-3 was created.

2.4 Data analysis

The questionnaire's psychometric parameters were tested using both IBM SPSS version 26 and IBM Amos version 22 software. Cronbach's Alpha and McDonald's Omega were calculated for the whole pool of items together and for each sub-domain separately in order to assess internal consistency. According to Hajjar (2018), internal consistency may be considered acceptable for values between 0.60 and 0.80, and good for values above 0.80. Regarding the structural assessment of BREQ-3, Confirmatory Factorial Analysis (CFA) with the Maximum Likelihood estimation method was run setting standardized estimates, residual moments, and modification indices as output for model fit evaluation (Schermelleh-Engel et al., 2003). Cut-off values for items' factor loadings were set at 0.50, whilst loading at or above 0.40 are considered sufficient (Fabrigar et al., 1999), whilst loading lower than 0.30 should be discarded (Field, 2013). In order to allow contrasting our parameters with those provided for the BREQ-3 in other languages, model fit assessment was carried out by examining the Comparative Fit Index (CFI; cut-off values at 0.90 or above); the Standardized Root Mean Square Residual (SRMR; cut-off values at 0.08 or below); and the Root Mean Square Error of Approximation (RMSEA; cut-off values at 0.08 or below) (Hu and Bentler, 1999; Cid et al., 2018). For poor model fit, the following criteria were used for model modifications: items with factor loading lower than 0.50 (sufficient) or below 0.40 (poor); and standardized residual covariances (SRC) between items, if higher than 2 (Fabrigar et al., 1999; Collier, 2020). Additionally, correlations among items within the same sub-scale and between each item and its sub-domain were carried out by means of Pearson's correlation analysis, with a significance level set at 0.05 or lower. This was done to monitor potential multicollinearity issues, with values above 0.70 considered at risk (Dormann et al., 2013), and for ensuring that the items and sub-scales correlated sufficiently and significantly, with item-item and item-sub-scale correlations recommended to be higher than 0.30 and higher than 0.50, respectively (Hajjar, 2018). Average Variance Extracted (AVE) and Composite Reliability (CR) were calculated for each dimension, as well. Recommended cut-off points are set at 0.50 for AVE (Fornell and Larcker, 1981), and at 0.70 for CR (Hair et al., 2014). These values have been used for testing each sub-scale convergent validity; discriminant validity is also established if the AVE of a sub-scale exceeds the squared correlation between that sub-scale and the others (Cid et al., 2018; Chai et al., 2022). Moreover, the Intraclass Correlation Coefficient, with a two-way mixed model and absolute agreement, was used to examine test-retest reliability of the instrument. According to Bobak et al. (2018), ICC values between 0.5 and 0.75 imply moderate reliability, whilst reliability is considered good for values between 0.75 and 0.9. Finally, configural and metric invariance based on sex was examined by testing an unconstrained model's fit and successively comparing it with a model with factor loadings constrained between males and females. As suggested by Putnick and Bornstein (2016), invariance is confirmed if the difference of Chi-square (χ^2) between the two models is not significant ($p > 0.05$), and the absolute value of the CFI differential (ΔCFI) is lower than 0.01.

TABLE 1 Internal consistency of the six sub-scales of the German Behavioral Regulation in Exercise Questionnaire (BREQ-3) and for the whole questionnaire.

Sub-scale	Cronbach's Alpha	McDonald's Omega
Amotivation (3 items)	0.602	0.607
External (4 items)	0.779	0.781
Introjected (3 items)	0.730	0.734
Identified (4 items)	0.652	0.662
Integrated (4 items)	0.880	0.884
Intrinsic (4 items)	0.839	0.842
BREQ-3 (22 items)	0.749	0.701

3 Results

The 24-item version of the German BREQ-3 showed several issues during the first structural examination ($\chi^2 = 593.035$; df = 237; CFI = 0.877; SRMR = 0.0844; RMSEA = 0.073). High SRCs were found for the newly included item 22 (*I would feel bad about myself if I was not making time to exercise*), as well as for items 16 (*I feel like a failure when I haven't exercised in a while*), 8 (*I can't see why I should bother exercising*) and 7 (*I value the benefits of exercise*). Items 7 and 8, along with item 13 (*I think it is important to make the effort to exercise regularly*) had loading between 0.50 and 0.40, as well. The model was tested after the removal of each of these items individually, and an improved fit was found with the exclusion of item 22 ($\chi^2 = 491.749$; df = 215; CFI = 0.899; SRMR = 0.0632; RMSEA = 0.068). Nonetheless, the CFI was still below the acceptable threshold. Additionally, items 7, 14 (*I don't see the point in exercising*), and 20 (*I think exercising is a waste of time*) had too high SRCs. Loadings for items 7, 8, and 13 remained between 0.50 and 0.40. Again, the analysis of the structure was run after removing each of these items individually. The model further improved with the exclusion of item 14 ($\chi^2 = 418.741$; df = 194; CFI = 0.912; SRMR = 0.0594; RMSEA = 0.064), with all indexes indicating a good fit. The obtained model is shown in Figure 1.

Items' loadings in the final model ranged from 0.41 to 0.89. The correlational analysis among items within the same sub-scale delivered highly significant values ($p < 0.001$). No correlation coefficient surpassed the threshold set for multicollinearity (0.70). Item-sub-scale correlation coefficients ranged from 0.625 to 0.834 ($p < 0.001$). Internal consistency of the sub-scales is presented in Table 1.

All sub-scales, as well as the BREQ-3 as a whole, obtained acceptable (>0.60) to good (>0.80) levels of internal consistency in the 22-item version presented above. Scores for AVE ranged

from 0.51 to 0.74; for CR, values were between 0.76 and 0.91. The summary of AVE and CR for each sub-scale are provided in Table 2 below, along with sub-scale square correlations.

Reliability was moderate for amotivation, external regulation, introjected regulation, and identified regulation (ICC values between 0.522 and 679), and good for integrated and intrinsic regulation (ICC = 0.789 and 0.752, respectively). The questionnaire as a whole showed good reliability (ICC = 0.773). A summary of the psychometric properties of the final German BREQ-3 contrasted with scores obtained in other translations is presented in Table 3.

Sex invariance was tested by comparing the unconstrained 22-item model (configural invariance) with the model with constrained factor loadings (metric invariance). Both the model for males (n = 149) and the one for females (n = 122) showed parameters in the acceptable range (Table 4).

Chi-square comparison between unconstrained and constrained models was found to be not significant (p = 0.218). Additionally, the absolute value of ΔCFI was lower than the threshold of 0.01 (ΔCFI = 0.001).

4 Discussion

The aims of this study were to assess the psychometric parameters of a German version of the BREQ-3 and to examine its invariance by sex, in a sample of Austrian young adults.

The original model of the BREQ-3 (Markland and Tobin, 2004; Wilson et al., 2006) did not properly fit the data and participants of our study. However, the structure showed an acceptable fit after the removal of items 22 and 14. In particular, the inclusion of item 22 was one of the major changes that Wilson et al. (2006) implemented in BREQ-3 compared to its previous version, the BREQ-2. In our case, this new item seems to bring issues that affect the entire structure of the tool. Therefore, its removal led to reinstating the previously validated structure of the sub-scale of "introjected regulation" as presented in the BREQ-2, i.e., with three items. This constitutes no particular problem, considering that not only the structure of BREQ-2 (including the mentioned sub-scale) had been already validated both in its original language (Markland and Tobin, 2004) and in German (Witzki and Leyk, 2014), but it was also widely used in previous literature in the field of exercise and health (Jekauc et al., 2021; Kovács and Kovács, 2021; Ostendorf et al., 2021). Regarding item 14, which belonged to the "amotivation" sub-scale, our findings are not in line with the outcomes from validation processes in other languages (González-Cutre et al., 2010; Cid et al., 2018; Cavicchiolo et al., 2022; Chai et al., 2022; Luo et al., 2022). Nonetheless, none of these processes was able to confirm the original 24-item model, which, with some differences, always delivered a poor fit in its initial form. For instance, González-Cutre et al. (2010) obtained a proper fit for the Spanish BREQ-3 only after removing one item from the "identified regulation" sub-scale. On the other hand, Chai et al. (2022) validated the BREQ-3 with a 5-sub-scale structure, and i.e., they were forced to remove an entire sub-scale to obtain a sound model in a sample of Malay young adults. The Portuguese version of BREQ-3 required the elimination of one item per each sub-scale in order to obtain a fitting model, and consequently, that version of the BREQ-3 was confirmed with a total of 18 items equally distributed into the six original sub-scales (Cid et al., 2018). These results led some authors to directly translate Cid's 18-item version of the questionnaire, rather than the original one (Cavicchiolo et al., 2022). Issues were also found in validating the Chinese version of the 24-item BREQ-3 (Luo et al., 2022), with the authors suggesting that the original structure proposed by Markland and Tobin (2004) might need to be revised. In this sense, the elimination of items from our version seems in line with the procedure carried out for the existing models in other languages. The fact that each of these models differs in which particular items from the original model were controversial may be attributed to regional differences requiring cultural adaptation (Huang and Wong, 2014).

Regardless of the above-mentioned cultural differences, the parameters found in our final version of the instrument are in line with those reported in other adaptations. In fact, compared to the CFI for the German version (CFI = 0.91), values for the other versions ranged from 0.91 to 0.94, except the Italian (CFI = 0.96) and the Chinese one (CFI = 0.98) reporting values above 0.95 (Cavicchiolo et al., 2022; Luo et al., 2022). Similarly, SRMR for other adaptations also remained usually in the range of 0.05 to 0.07 and was 0.059 in our study. The RMSEA was perhaps the index with the greatest fluctuation, with the poorest value (RMSEA = 0.09) reported in the original English version (Wilson et al., 2006), whilst the best (RMSEA = 0.04) in the Chinese ones (Luo et al., 2022). In our case, an RMSEA of 0.064 represents an average value compared to those previously reported. Test-retest reliability was only reported for the Spanish adaptation (González-Cutre et al., 2010), and only for the questionnaire as a whole. Although their reported ICC was higher (0.90) than in our study, both remain within the range considered as good.

Finally, our outcomes indicate full invariance for the 22-item German BREQ-3 by sex, the questionnaire needing no further modifications depending on the sex of the participants. This is in line with previous studies, also reporting full invariance by sex for their BREQ-3 versions (González-Cutre et al., 2010; Cid et al., 2018; Cavicchiolo et al., 2022; Luo et al., 2022).

4.1 Limitations

The main limitation of this study is represented by the lack of other valuable validation procedures, i.e., construct and criterion-related validity. These procedures tend to play a more essential role in untested or newly created questionnaires, which is not the case with the BREQ-3. Although we calculated convergent and discriminant validity by means of AVE and CR scores, following the same procedure as other country-specific BREQ-3 validation studies (Cid et al., 2018; Chai et al., 2022), studying these parameters using comparable gold-standard tools provided in the literature would bring further strength to this work. Additionally, not all valid measurements for the mentioned procedures are available in German, meaning that additional steps would be required. Nonetheless, they always provide additional information and may help to further confirm the soundness of the model proposed in this work. Another limitation may be that the model presented in this work was tested with a population of young adults only. Considering that the original instrument has been

TABLE 2 Average Variance Extracted (AVE), Composite Reliability (CR), and square correlations between sub-scales of the final version of the German Behavioral Regulation in Exercise (BREQ-3).

Sub-scale	CR	AVE	Square correlations					
			AM	EX	IJ	ID	IG	IM
Amotivation	0.76	0.52	1	0.29	0.005	0.57	0.23	0.53
External	0.86	0.61	0.29	1	0.17	0.10	0.04	0.20
Introjected	0.85	0.65	0.005	0.17	1	0.13	0.06	0.001
Identified	0.81	0.51	0.57	0.10	0.13	1	0.81	0.61
Integrated	0.91	0.74	0.23	0.04	0.06	0.81	1	0.49
Intrinsic	0.89	0.68	0.53	0.20	0.001	0.61	0.49	1

AM, amotivation; EX, external; IJ, introjected; ID, identified; IG, integrated; IM, intrinsic.

TABLE 3 Psychometric parameters of the final version of the Behavioral Regulation in Exercise Questionnaire (BREQ-3) in different language translations.

	CFI	SRMR	RMSEA	Factor loading range	Internal consistency range
German version*	0.912	0.0594	0.064	0.41–0.89	$\alpha = 0.60–0.88$ $\omega = 0.61–0.88$
Chinese version (Luo et al., 2022)	0.98	NA	0.040	0.197–0.801	$\omega_c = 0.80–0.90$
Italian version (Cavicchiolo et al., 2022)	0.96	0.040	0.050	0.51–0.95	$\omega = 0.65–0.94$
Malay version (Chai et al., 2022)†	0.949	0.052	0.049	0.580–0.868	CR = 0.746–0.841
Portuguese version (Cid et al., 2018)	0.93	0.060	0.060	0.50–0.82	CR = 0.73–0.77
Spanish version (González-Cutre et al., 2010)	0.91	0.060	0.060	0.52–0.86	$\alpha = 0.66–0.87$

*As presented in this paper; † the final model presents 5 factors; CR, composite reliability.

TABLE 4 Indexes of goodness of fit of the Behavioral Regulation in Exercise Questionnaire (BREQ-3) for the unconstrained and constrained model, and by sex.

Model	χ^2	df	CFI	SRMR	RMSEA
Final 22-item model	418.741	194	0.912	0.0594	0.064
Unconstrained	636.724†	388	0.901*	0.0701	0.049
Constrained factor loadings	656.773†	404	0.900*	0.0729	0.049
Males	301.109	194	0.914	0.0706	0.061
Females	294.856	194	0.917	0.0719	0.064

† $p = 0.218$; * $\Delta CFI = 0.001$.

used in different environments and with different age ranges, including youth and elderly, an important step forward would be to assess measurement invariance by age, as well as to test the instrument in special populations (sedentary, different types of diseases, etc.). An additional recommendation would be to use the Basic Psychological Need Satisfaction Scale (BPNSS; Deci and Ryan, 2000) for construct convergent validity - currently, there is no German version of this tool -, since this questionnaire is built within the same SDT framework and it has been already used with such purpose (Luo et al., 2022); and to gather information on weekly physical activity (self-reported or via accelerometry) for criterion-related predictive validity, as it is known that different types of motivation are associated with exercise habits (Kalajas-Tilga et al., 2022).

5 Conclusions

As could have been expected based on the results of other language adaptations, the German version of the BREQ-3 could not be confirmed in its original 24-item structure. Nonetheless, the final 22-item version presented in this study shows good indexes of goodness of fit and full invariance across sex, at the same time as it maintains the main feature that made the original BREQ-3 widespread within the scientific community, i.e., the inclusion of all six types of motivation as described in the framework of the SDT. Although further examination is required to verify its structural stability across ages and populations, the German version of the BREQ-3 proposed in this study is scientifically robust and may be recommended to be used in future research in the field of sport sciences and, in particular, exercise and health.

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 Board for Ethical Questions in Science of the University of Innsbruck. 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

AC: Data curation, Formal analysis, Methodology, Writing — original draft. MK: Methodology, Resources, Visualization, Writing — review & editing. KG: Conceptualization, Investigation, Resources, Writing — review & editing. KL: Validation, Writing — review & editing. MC: Formal analysis, Methodology, Writing — review & editing. GR: Conceptualization, Investigation, Supervision, Writing — review & editing.

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Physical activity promotion among pregnancy – the role of physician from the women's perspective

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Objective: The clear benefits of planned and supervised physical activity (PA) during pregnancy make it imperative that women are encouraged and educated about this activity. This study aimed to investigate how effectively physician promote physical activity and exercise among pregnant women. It also examines pro-health changes in selected health behaviours during pregnancy.

Methods: This cross-sectional study recruited a total of 353 pregnant women in Wielkopolskie Voivodship in Poland. An anonymous survey (on-line or in-paper) was used to assess physical activity before and during pregnancy (with Pregnancy Physical Activity Questionnaire), physical activity self-efficacy, well-being (WHO-5 Well-Being Index), and guidance received from physicians on physical activity during pregnancy.

Results: Only 41% of women surveyed followed WHO recommendations for PA before pregnancy, and they were much more likely to discuss safety and the need to change the intensity or type of PA with their doctor or gynaecologist. Only 23% of women were asked about their PA before pregnancy and less than 40% were encouraged to be active during pregnancy. We observed a higher probability of poor well-being among pregnant women who were inactive before pregnancy (OR = 1.873, 95%CI 1.026 to 3.421, $p = 0.041$).

Conclusion: Health professionals infrequently educate and motivate women to be physically active during pregnancy. Physician advice, as it is currently perceived by women, seems to be insufficient to help pregnant women meet the recommendations for PA during pregnancy.

KEYWORDS

physical activity, exercise, pregnancy, advice, counselling, practitioner, physician

1 Introduction

Pregnancy is a unique and thought-provoking time in a woman's life. It is also a "teachable moment" for positive changes in health behaviour (1) that will benefit the health of the developing child in her womb. There is no longer any doubt about the need for women to engage in physical activity (PA) both before and during a pregnancy, as long as it is a normal pregnancy.

For the past two decades, various national and international opinion leaders have been issuing increasingly detailed recommendations on PA during pregnancy, emphasizing its beneficial effects on the health of both the woman and the new-born. One of the first more detailed guidelines was the recommendation of the American College of Obstetricians and Gynaecologists published in 1985 (2), revised in 1994 (3) and updated in 2002 (4). Their update clarified that a pregnant woman's health training should be repeated at least 3 times a week or more often (5). These recommendations were detailed by the Centers for Disease Control and Prevention (CDC), which recommends that pregnant women should spend at least 150 min per week on moderate aerobic exercises, for example, fast marching, gardening, swimming, and other exercises that involve large muscles groups and increase the heart rate (6). Many other organizations around the world, such as the U.S. Department of Health and Human Services (7), Sports Medicine Australia (8), The Royal Australian and New Zealand College of Obstetricians and Gynaecologists (9), and the UK Department of Health and Social Care (10), have similar views on PA during pregnancy. Also, after reviewing the latest scientific evidence regarding the relationship between PA and health, experts from the Guideline Development Group published new World Health Organization (WHO) recommendations on PA in 2020, including for pregnant women. The WHO recommends that all pregnant and postpartum women without medical contraindications engage with regular PA and perform at least 150 min of PA of moderate intensity per week, as well as aerobic, muscle-strengthening, and gentle stretching exercises (11). In this context, the current position of the Polish Society of Gynaecologists and Obstetricians (PTGiP) until 2023 was surprising to say the least. The PTGiP recommended lowering PA levels in women with uncomplicated pregnancies and described undertaking or increasing it as contraindicated (12). It is immensely gratifying to see the new recommendations published by PTGiP (13). PTGiP and PTMS (Polish Society of Sports Medicine) have created detailed guidelines for doctors, midwives, coaches, and physiotherapists regarding recommended PA for women, including those with various dysfunctions and pregnancy-related contraindications, based on the latest recommendations of international institutions and Evidence-Based Guidelines (14). Recommended activities include endurance, resistance, stretching exercises, neuromotor exercise training, and pelvic floor training for previously inactive and active women, broken down by age.

Physical activity in pregnant women stimulates the whole body and has multiple both short- and long-term benefits for maternal and fetal health (15–19). Moderate-intensity physical activity during pregnancy can decrease the likelihood of excessive weight gain, gestational diabetes, and postpartum depression symptoms (20). Physical activity is also one of the most important protective behaviours against poor well-being, which affects at least 25% of pregnant women, especially those with less education and social support (21, 22). In addition to alleviating pregnancy-related symptoms, physical activity during pregnancy can also reduce low back pain, prevent urinary incontinence and fetal macrosomia, increase joint mobility, improve circulatory function by strengthening the heart and blood vessels, and reduce the risk of hypertension and pre-eclampsia (23, 24). Two meta-analyses found no or a small effect of leisure-time physical activity on mean birth weight, and no differences in low birth weight or mean birth weight between the exercise and control groups (20, 23). Regular physical activity during pregnancy promotes healthy weight gain, aids in postpartum weight loss, and facilitates a rapid return to a state of general fitness (20, 24). PA is proposed as a preventative or therapeutic measure to reduce pregnancy complications and optimize maternal–fetal health (25).

Despite the proven benefits of physical activity for the health of pregnant women, many are not properly advised and concerns about potential risks contribute to the abandonment or refusal to exercise during this period. According to a national study by Banys et al. (26), up to 46% of women surveyed reduced their PA after becoming pregnant. It should also be added that these women were moderately physically active before becoming pregnant. Meanwhile, Wojtyła et al. (27) report that in a study of 3,451 Polish women, more than 60% of them reported limiting PA during pregnancy, most often due to concerns about the proper development of the foetus.

According to Atkinson et al. (28), there are many challenges to practicing physical activity during pregnancy. This include: women's lack of knowledge about existing recommendations, lack of knowledge about how to engage in physical activity, lack of social support, and unavailability of physical activity opportunities. After the assessment of potential contraindications for exercising, healthcare providers should offer counselling on an active lifestyle and refer pregnant women to a qualified exercise professional (i.e., exercise physiologist or prenatal exercise specialist) with a background and experience in pregnancy and/or postpartum physical activity and/or exercise (29). The evident benefits of planned and supervised PA during pregnancy make it imperative that women are encouraged and educated about such activity. This is especially true in view of the apparent hypokinesia of modern man in the 21st century (sedentary lifestyle, passive leisure, and passive recreation). An expectant mother should be aware that her health-promoting behaviour affects both her health and that of her baby. A positive relationship was observed between mothers' knowledge of PA during pregnancy and their daily PA (30). Hence, the role of health professionals (doctors, midwives, physiotherapists) is so important, and why they should form habits in women that affect the proper course of pregnancy. This shows the high expectations placed on this group of professionals in terms of their educational role, detailed knowledge, and willingness to cooperate in PA with both perinatal women and other maternity care providers.

The study assesses how well physicians and gynaecologists promote physical activity among pregnant women. It also examines pro-health changes in physical activity, smoking, and alcohol consumption during pregnancy. Our hypothesis suggests health professionals fail to meet expectations for promoting physical activity during pregnancy and that pregnancy is a time for pro-health changes.

2 Methods

2.1 Study design and study population

We conducted cross-sectional study among 353 pregnant women in Wielkopolskie Voivodship in Poland from 2018 to 2022. The women were over 18 years old and willing to complete an anonymous survey (on-line or in-paper). Women were recruited using the snowball method among pregnant women in maternity clinics, at birthing schools, on classes for pregnant women, at hospitals. In

addition, a web-based online survey for pregnant women was used, which was promoted in forums for expectant mothers.

2.2 Measurements

2.2.1 Physical activity and self-efficacy in physical exercise

Anonymous questionnaires were used in the research. Physical activity (PA) level before pregnancy was assessed using two questions based on WHO recommendations regarding accumulation of at least 150 min of moderate physical activity or 75 min of vigorous physical activity, or a mix of the two, per week. We asked about the number of days with at least 30 min per day of moderate or 20 min per day of vigorous physical activity in the average week before pregnancy. Self-perceived changing in PA during pregnancy were also assessed by asking the question: "Did your physical activity change after you became pregnant?," where the respondent had five possible answers on a Likert scale from "at a much lower" to "a much higher." PA during pregnancy was assessed using the Polish version of the Pregnancy Physical Activity Questionnaire (PPAQ-PL) (31). It consists of 33 items grouped into the following activity categories: household/caregiving (15 items), occupational (5 items), sports/exercises (7–9 items), transportation (3 items), and inactivity (3 items). The levels of PA were measured as energy expenditure (MET minutes/week). According to the authors' guidelines the following activity intensity ranges were used: sedentary <1.5 METs; light 1.5 – < 3.0 METs; moderate ≥3.0 – ≤ 6.0 METs; and vigorous >6.0 METs (32).

A questionnaire developed by Schwarzer and Renner (33) was used to assess health–specific self-efficacy The Physical Exercise Self-Efficacy Scale includes five statements referring to the potential obstacles to carrying out exercises by respondents. The four responses were proposed for all statements from "very uncertain" to "very certain".

2.2.2 Well-being and health behaviours

The World Health Organization- Five Well-Being Index (WHO-5) was used to assess current mental health and well-being (34). According to the authors' recommendation, a score of less than 13 indicates poor well-being and is an indication for testing for depression according to ICD-10. Self-perceived changes in smoking and alcohol consumption during pregnancy were also assessed by asking the question: "Your contact with cigarettes/alcohol before and after pregnancy," where the respondent had three possible answers for smoking before pregnancy and the same during pregnancy: "I did not smoke," "I smoked occasionally," I smoked regularly" and four possible answers for drinking alcohol before pregnancy and the same during pregnancy: "I did not drink," "I drank occasionally," "I drank little regularly," "I drank a lot regularly".

2.2.3 Physician advice on physical activity

To assess doctors' activity in promoting physical activity among pregnant women, participants were asked whether their doctors, during consultations: (1) asked you about physical activity before pregnancy? (2) encouraged you to do the physical activity you needed during pregnancy? (3) stated that you had no health contraindications to undertake PA? (4) You were the first who ask for advice on PA during pregnancy? (5) Has your doctor recommended a modification of your current PA? If so, what is it: duration, frequency, intensity, or type of physical activity? The questionnaire was developed by an interdisciplinary team of experts including a gynaecologist, a physiotherapist, a medical trainer, and an exercise specialist. Then, it was tested for comprehension and clarity of wording by 6 pregnant women. The consistency of responses from 30 pregnant women was also assessed by analysing the test and retest results. For the 5 analysed questions the Cohen's kappa scores ranged from 0.80 to 1.00, indicating almost perfect agreement and good reliability of the tool (35).

2.2.4 Pregnant' characteristics

Sociodemographic characteristics included maternal age, gestational age, height, pre-pregnancy and current weight, body height, educational level, place of residence, number of pregnancies.

2.3 Statistical analysis

The calculations were performed using STATISTICA 13.3 (StatSoft, Inc.). The characteristics were shown as mean ± standard deviation (SD), medians, and mean rank or as proportions if variables were categorical. To evaluate differences in self-efficacy, well-being, BMI and physical activity during pregnancy between active and inactive before pregnancy women the nonparametric Mann–Whitney U test was used. Effect sizes r were calculated from the test statistic z (z/sqrt (n)). Effect sizes were interpreted as small when $r \geq 0.1$, medium when $r \geq 0.3$, and large when $r \geq 0.5$ (36). Odds ratios with 95% CI were calculated for poor well-being by physical activity before pregnancy status. To evaluate differences in the frequency of receiving information from physicians between active and inactive before pregnancy women the chi square test was used and Fi effect size was calculated, with following interpretation: as small when $r \geq 0.1$, medium when $r \geq 0.3$, and large when $r \geq 0.5$ (36). Odds ratios with 95% CI were calculated for being ask about PA and encouraging for PA by physical activity before pregnancy status. In all tests, a *p*-value of less than 0.05 was statistically significant.

3 Results

We analysed the results of 353 women with a mean age of 29.3 years (SD = 4.3). There were 6% in the first, 29% in the second and 65% in the third trimester of the pregnancy. In terms of social status most of the women surveyed had a high school education (69%), followed by secondary education (24%) and vocational education (7%), and lived in a big city (52%), followed by a small city (27%) and countryside (21%). For 55% of respondents this was their first pregnancy, for 28% it was their second pregnancy and for 17% it was more than second pregnancy (see Table 1).

According to the level of PA before pregnancy, followed by the WHO recommendation, we divided the studied women into two groups: active (reported at least 5 days with 30 min of moderate-intensity aerobic physical activity or at least 3–4 days with 20 min of vigorous-intensity aerobic physical activity or an equivalent combination of moderate- and vigorous-intensity activity throughout the week). In terms of the studied group declaration, 41% of the women had sufficient physical activity. The differences in the analyzed parameters between active and inactive women before pregnancy are shown in Table 2.

TABLE 1 General studied sample characteristics ($N = 353$).

Variables	Mean	SD	Median
Age (years)	29.3	4.3	29
BMI before pregnancy (kg/m^2)	22.5	3.7	21.6
Self-efficacy in PA[a] (pts)	13.2	4.2	13
Well-being WHO-5[b] (pts)	15.2	5.0	15
Total PA during pregnancy[c] (METs)	167.81	87.25	147.61
Physical activity during pregnancy by intensity[c] (METs)			
Sedentary	25.92	21.08	18.90
Light	92.72	52.50	80.68
Moderate	48.03	47.44	32.80
Vigorous	1.14	2.93	0.00
Physical activity during pregnancy by type[c] (METs)			
Household	78.27	64.98	344.27
Occupational	23.12	47.62	0.00
Sport	13.20	13.71	9.52
Transportation	17,0.19	18.44	12.60
Inactivity	36.032	25.26	31.50

[a]The Physical Exercise Self-Efficacy Scale, score ranging from 5 to 20.
[b]Five Well-Being Index (WHO-5), score ranging from 0 to 25.
[c]Pregnancy Physical Activity Questionnaire (PPAQ-PL) in MET minutes/week.

TABLE 2 Biopsychosocial characteristics and PA during pregnancy for physical active and inactive women before pregnancy.

Variable	Active before pregnancy ($n = 146$)			Inactive before pregnancy ($n = 207$)			p	r
	x (SD)	Median	Mean rank	x (SD)	Median	Mean rank		
BMI before pregnancy	22.4 (3.9)	21.3	181.79	22,5 (3,6)	21,9	169.04	0.247	−0.062
Self-efficacy in PA[a]	14.8 (3.6)	15	174.86	12.0 (4.1)	12	119.16	**<0.0001**	0.300
Well-being WHO-5[b]	16.1 (4.44)	16.5	121.21	14.44 (5.27)	15	101.25	**0.021**	0.123
Total PA during pregnancy[c] (METs)	180.46 (92.82)	158.63	189.52	158.98 (82.36)	140.75	165.58	**0.029**	0.116
Physical activity during pregnancy by intensity[c] (METs)								
Sedentary	25.95 (19.70)	18.90	179.42	25.94 (22.08)	18.90	172.72	0.542	0.033
Light	96.90 (56.19)	80.46	181.75	89.76 (49.79)	80.68	171.08	0.331	0.052
Moderate	55.70 (50.93)	39.29	193.20	42.69 (44,26)	27.56	162.98	**0.006**	0.146
Vigorous	1.91 (4.19)	0.00	186.12	0,60 (1.28)	0.00	167.99	0.099	0.088
Physical activity during pregnancy by type[c] (METs)								
Household	78.12 (65.96)	55.65	172.98	78.39 (64.60)	61.25	177.29	0.695	−0.020
Occupational	25.81 (53.33)	0.00	175.5	21.33 (43.27)	0.00	175.5	0.999	0.000
Sport	18.24 (15.36)	13.45	216.79	9,63 (11.17)	6.19	146.34	**<0.0001**	0.342
Transportation	21.09 (24.47)	14.00	191.68	14.40 (11.92)	10.71	164.05	**0.012**	0.134
Inactivity	37.21 (23.82)	35.70	183.77	35.23 (26.32)	30.45	169.65	0.199	0.068

[a]The Physical Exercise Self-Efficacy Scale, score ranging from 5 to 20.
[b]Five Well-Being Index (WHO-5), score ranging from 0 to 25.
[c]Pregnancy Physical Activity Questionnaire (PPAQ-PL) in MET minutes/week
Bold values are p-value < 0.05.

TABLE 3 Frequency of consultations and interviews on PA with doctors and gynaecologists – differentiation between active and inactive women before pregnancy (results of chi-square test).

Doctors' questions/ advice on[a]:	All (n = 353) yes (%)	Active before pregnancy (n = 146) yes (%)	Inactive before pregnancy (n = 207) yes (%)	p	Fi
PA before pregnancy	23.6	29.5	19.4	**0.029**	0.116
Encouraging to PA	37.5	43.8	33.0	**0.039**	0.110
Contraindications to PA	54.3	60.3	50.0	0.057	0.102
Women first ask for a consultation on PA	41.2	56.2	32.2	**<0.0001**	0.239
The doctor recommends modification of the PA	30.7	43.2	21.8	**<0.0001**	0.228
Modification of time*	44.4	46.6	41.5	0.616	0.050
Modification of frequency	38.1	37.5	39.0	0.879	0.016
Modification of intensity	77.1	81.9	70.5	0.166	0.135
Modification of form	77.2	78.3	75.6	0.749	0.032

*Percentage of those who answered "yes" to the previous question. [a]Physician advice on physical activity (dichotomous answer: yes/no).
Bold values are p-value < 0.05.

TABLE 4 Risky behaviour among active and inactive before pregnancy respondents.

Variable	All (n = 353) yes (%)	Active before pregnancy (n = 146) yes (%)	Inactive before pregnancy (n = 207) yes (%)	p	Fi
Smoking before pregnancy (occasionally or regular)[a]	28.2	25.0	30.1	0.381	0.056
Smoking in pregnancy (occasionally or regular)[a]	4.4	3.8	4.9	0.693	0.025
Drinking alcohol before pregnancy[b]	79.1	84.6	74.8	0.062	0.119
Drinking alcohol during pregnancy[b]	5.2	5.8	4.9	0.761	0.019

[a]Smoking regularly or occasionally (yes), do not smoke (no).
[b]Drinking alcohol occasionally, a little regularly or a lot regularly (yes), do not drink (no).

There was no difference in BMI between active and inactive women before pregnancy. We found that active woman had significantly higher levels of PA self-efficacy and well-being. According to the recommendation of the Psychiatric Research Unit WHO Collaborating Centre in Mental Health (37), 30.0% of the women surveyed present poor well-being, which is an indication for testing for depression according to ICD-10. It also implies a lower risk of depression among women who were physically active before pregnancy. We observed a higher probability of poor well-being among women who were inactive before pregnancy (OR = 1.873, 95%CI 1.026 to 3.421, p = 0.041). Higher self-efficacy in PA allows people to set, maintain, and achieve daily routines. Physically active women before pregnancy have significantly higher levels of total PA measurement during pregnancy (p = 0.029; r = 0.116) and those related to sports activities and transport during pregnancy (p < 0.0001, r = 0.342 and p = 0.012, r = 0.134 respectively). This is also related to the higher levels of moderate PA among active women surveyed before pregnancy (p = 0.006, r = 0.146).

We then analysed if and how the level of physical activity before pregnancy was related to the willingness to discuss safety and necessary modification of intensity or form of physical activity with a physician or gynaecologist. The results are presented in Table 3.

More than 50% of pregnant women admit that their gynecologist has told them there is no contradiction to PA. At the same time, only 23% of women were asked about PA before pregnancy and less than 40% were encouraged to be active during pregnancy. Women who were active before pregnancy were asked about PA and encouraged to be active more often (p = 0.029; and p = 0.039 respectively). We observed a higher likelihood of being asked about PA before pregnancy (OR = 1.733, 95%CI 1.055 to 2.845, p = 0.030) and being encouraged to be active during pregnancy (OR = 1.584, 95%CI 1.023 to 2.453, p = 0.039) for women who were active before pregnancy. At least 40% respondents asked for advice on PA first. Physically active women were more likely to do so (p < 0.0001). Around 30% of the women surveyed had received recommendations for PA modifications from their doctors, more often active ones (p < 0.0001). Doctors' advice was most often related to modifying the intensity and type of PA, less often about frequency and time.

Physical activity before pregnancy did not differentiate the behaviours related to smoking or alcohol consumption (Table 4).

TABLE 5 Respondents' declaration of changes in risky behaviours and PA during pregnancy.

Variable	Regularly (%)	Occasionally (%)	No (%)	
Smoking before pregnancy	11.3	16.9	71.8	
Smoking during pregnancy	1.2	3.2	95.6	

	Regularly, a lot (%)	Regularly, a little (%)	Occasionally (%)	No (%)
Alcohol before pregnancy	0.8	9.3	69.0	20.9
Alcohol during pregnancy	0.8	0	4.4	94.8

	Much or little lower (%)	No change (%)	Little or much higher (%)	
PA during pregnancy	60.8	26.6	12.6	

Before pregnancy 11% of the women analysed smoked regularly, 17% occasionally, and after getting pregnant respectively: 1.2% and 3.2%. Similarly, 10% of the women analysed drank alcohol regularly before pregnancy and almost 70% occasionally and after getting pregnant: 0,8% and 4,5%, respectively. Regarding declarations of changes in physical activity during pregnancy 61% of the women surveyed declare that their PA had decreased a lot or a little, and only 13% declared that their PA had increased a little or a lot. The rest (26%) did not change their PA level (Table 5).

4 Discussion

Our study identified a weak link in the path toward meeting PA recommendations for pregnant women. Healthcare professionals do not often educate and motivate women to be physically active during pregnancy. This can be easily and cost-effectively changed with health benefits for mothers and children and financial benefits for health care payers.

In our study, far less than half of the surveyed women had received advice about being active during pregnancy. Santo et al. (38) also found that almost a third did not receive advice on physical activity during prenatal care. Obese women were no more likely to receive advice than their normal weight counterparts, indicating the need for targeted physical activity counselling in this population. Similarly, Whitaker et al. (39) found that only around 60% of women surveyed reported receiving advice on physical activity from their provider, which, although consistent with guidelines, was perceived by patients to be limited in scope. In the study by Beckham et al. (40), the authors also found that women did not receive sufficient and clear information about how and why to exercise during pregnancy. Counselling rates during preventive care visits for women of childbearing age vary by overweight/obesity and pregnancy status, as well as by provider specialty (41). Although healthcare practitioners may be in unique position to provide exercise advice to pregnant women, they may not have the necessary knowledge, training, or support to provide specific exercise advice (42).

As the results of our study showed, less than half of the women surveyed had a healthy lifestyle before becoming pregnant, and respondents with more education were more aware of the importance of this factor, including regular exercise. For most pregnant women, engaging in moderate-intensity PA has few risks but many health benefits, including a reduced risk of gestational diabetes and postpartum depression (14). The results of a survey of a population of Polish women by Szatko et al. (43) show that a total of 92.5% of women were aware of the beneficial effects of PA on the course of an uncomplicated pregnancy. Pregnant women were aware that PA reduces the risk of gestational diabetes mellitus and pre-eclampsia, and that moderate exercise reduce the likelihood of operative labour. Higher education was associated with greater awareness ($p = 0.001$). The most common sources of information on PA during pregnancy were the internet (50.0%) and books (38.3%). Doctors and midwives instructed the respondents only in 22.4 and 18.9% of cases, respectively. In our survey, the percentages were slightly higher (encouraging PA 37.5%, recommending for PA 30.7%), but these results indicate that health professionals are not the dominant source of information about PA in pregnancy. A study by Torbè et al. (44) found that only 2% of the 100 pregnant women surveyed identified their pregnancy doctor as a source of information about exercise during pregnancy. Doctors need to strengthen their role as providers of reliable and high quality of information, which would lead to the prevention of many pregnancy complications. The second essential condition for continued physical activity at any stage of life, including pregnancy, is high motivation. This is a condition that should also be address by health professionals, countering family stereotypes. In the analysis by Findley et al. (45), women with a history of pregnancy reported that family members and partners advised them to stop exercising during pregnancy and offered them advice, leading them to a perceived a lack of ownership of their bodies. Studies have shown that well designed lifestyle counselling, provided as part of routine care, leads to improvements in the PA patterns in pregnant women (46–48), and should therefore be a mandatory part of all antenatal and obstetric consultations.

It is noteworthy that in our study such discussions and advice were most often recorded with women who were active before pregnancy, and it was them who initiated such consultations on physical activity, indicating the real passivity of doctors in this regard. Women's attitude can be explained by the results of the study by Moreno et al. (49), which showed that those who regularly engage in some form of physical activity or sport are more interested in exercise and have more positive view of their physical fitness than those who do not engage in sport at all.

It is worth considering the involvement of other professionals who may be caring for the pregnant woman in promoting healthy behaviours. Specialists who promote healthy physical activity habits include physiotherapists. They are the ones that pregnant women turn to for help with back and/or musculoskeletal pain caused by changes in the body during pregnancy. As Sapuła et al. (50) state, in addition

appropriate physiotherapeutic interventions, the formation of health-promoting attitudes in patients is an important task for physiotherapists. In particular, attention and efforts should be focused on inactive women in order to mobilise them, as the current state of affairs is contrary to the recommendations.

Influencing pregnant women in this area is also extremely important for another reason. We have shown that active women have a significantly higher levels of PA self-efficacy and well-being than inactive women before pregnancy. Moreno-Murcia et al. (51) came to similar conclusions, stating that engaging in physical activity and sport in general includes several activities and elements that are present in the well-being and satisfaction of physically active women. These elements evoke positive emotions that enable women to achieve the goals they have set for themselves. As a result, they remain active during pregnancy and are less affected by poor well-being, which can contribute to postpartum depression. The systematic review by Liu et al. suggests that group-based combined exercise and yoga or PA are associated with significant benefits for the quality of life of pregnant women (52). Systematic reviews and meta-analyses by Gong et al. (53) and Lin et al. (54) found that prenatal yoga can effectively reduce depressive symptoms in pregnant women. The positive association between exercise and the prevention of maternal prenatal depression has been demonstrated in some studies with supervised exercise programs and high participant adherence (55, 56). Another systematic review and meta-analysis by Sánchez-Polán et al. (57) also concluded that supervised exercise during pregnancy is and effective tool for preventing and reducing prenatal depression. Of particular note is the study conducted by Perales et al. (58). The study involved 167 expectant mothers and found that while the level of depression was similar in both groups at the beginning of pregnancy, there was a significant difference at the end of pregnancy. The intervention group, which underwent supervised exercise programs, experienced a reduction in depression levels compared with the control group. This result confirms the positive effect of a supervised exercise program during pregnancy on the emotional state of pregnant women. These findings suggest that there is a positive association between an active pregnancy and a more balanced and appropriate emotional state. The effects of exercise during pregnancy may be a beneficial approach to alleviating prenatal depression and promoting the overall well-being of both mothers and their unborn children. Before starting any exercise regimen, pregnant women should see a health professional for personalized advice and professional information support (14). Given the proven protective properties of physical activity in this area, it is worth increasing the promotion of physical activity for this reason alone.

We observed a decrease in anti-health behaviours among pregnant women. Regular smoking decreased by 9.8 percentage points and occasional smoking decreased by 13.8 percentage points. Regular alcohol consumption decreased by 9.2 percentage points, and occasional consumption decreased by 65.5 percentage points. Similar changes have been observed by other researchers as well. In a study by Scheffers-van Schayck et al. (59), about 40% of pregnant smokers quit smoking during pregnancy. Similarly, Jawad et al. (60) found that, overall, women reported improved health behaviours during pregnancy, such as reducing or quitting smoking, drinking alcohol, and taking dietary supplements. These changes indirectly demonstrate the effectiveness of clinicians in reducing these behaviours. In 1999, Jones-Webb et al. (61) conducted a study of the direct effect of medical advice on tobacco and alcohol use during pregnancy. The study found that pregnant women who received advice from their doctors about the risks of using these substances were more likely to abstain. This suggests that medical advice can be a powerful motivator for healthier behaviour during pregnancy (61). Looking more broadly at prenatal care, Evans and Sheu's validation of the adherence pathway model found that effective patient-physician communication was a key factor in promoting adherence among pregnant women (62).

Given the past effectiveness of health professionals in minimizing harmful behaviours in pregnant women, it would be reasonable to expect similar positive outcomes from routine interactions about physical activity. Women in particular often report a lack of such advice (in terms of PA) (63), which is largely limited to walking. Our research also points to deficiencies in this area. Many women in the Ferrari et al. study (63) reported that they followed the advice, and if they did not, it was because the women disagree with the advice or simply did not want to follow it. This may be the result of not having enough well-explained information that is clear and convincing. Existing research shows that UK medical students underestimate the risk of physical inactivity and did not know the physical activity guidelines (64). Other research shows that although medical students are generally active and have a good understanding of the links between PA and health, they lack skills in PA counselling. Improved education of this group is required (65). Therefore, one of the reasons for the low involvement of antenatal physicians in the promotion of physical activity may be their insufficient education in this area during their studies and gynaecological specialization. Now that new, modern recommendations in this area have also been published in Poland (13), this important aspect of education and health promotion for pregnant women should be addressed more intensively at medical universities (66). Medical advice is an essential component of prenatal care, helping pregnant women to make informed decisions to protect both their health and the health of their unborn child. It serves as a powerful tool in reducing tobacco and alcohol use during pregnancy, ultimately contributing to better pregnancy outcomes. It would be worthwhile for physicians to make PA advice more transparent and more personalized, to provide it repeatedly during pregnancy in an understandable and persuasive way, and to take the time to do so. One of the good practices in this area is the intervention strategy to promote prenatal physical activity proposed in the Buffalo City Municipality, Eastern Cape Province, South Africa, where all stakeholders were involved in the creating and development process (67). The medical community is strongly supported by numerous public campaigns and media activities in this area. Promoting physical activity with such tools could also make a significant contribution.

We believe that a strength of our study is the use of validated tool to assess physical activity of pregnant women and the attempt to assess the quality of doctor-patient communication regarding physical activity recommendations. We also recognise the limitations associated with the recruitment to the study. Although it was carried out in a variety of locations, it can be assumed that women who were interested in an active lifestyle during pregnancy were more likely to participate, hence some results may be overestimated. We also believe that a more complete picture would be obtained by surveying doctors themselves in a similar area.

5 Conclusion

In conclusion, one of the weak links in Poland in meeting PA recommendations for pregnant women is the antenatal care provider. Doctors rarely educate and motivate women to be physically active during pregnancy. Doctors' advice, as currently perceived by women, does not appear to be sufficient to help pregnant women meet the recommendations for PA in pregnancy. More research is needed to better understand why so few women are physically active during pregnancy. The majority of respondents reported positive changes during pregnancy in terms of risky behaviours (alcohol consumption and smoking). This was not the case for physical activity, which decreased, indicating an area where education, including counselling provided by doctors, is necessary and essential. Although women's reports are crucial to understand PA behaviour during pregnancy, self-reports alone are not sufficient. Future research would benefit from including providers' perspectives and contrasting these with women's reports. Gathering information from providers should reveal barriers to better understanding of advice and, ideally, guide when and how to intervene to promote optimal PA among pregnant women.

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 Bioethics Committee at Poznań University of Medical Science. 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

IL-K: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. JK: Conceptualization, Writing – original draft, Writing – review & editing.

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Motivational variations in fitness: a population study of exercise modalities, gender and relationship status

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Introduction: Motivation plays a crucial role in determining whether or not a person adheres to an exercise program. The present study aimed to determine the motivational differences between people exercising in fitness alone, in groups/aerobics and with a personal trainer by gender and relationship status.

Methods: The Exercise Motivations Inventory-2 (EMI-2) questionnaire was completed by 830 users of 20 largest fitness centers in Slovenia.

Results: The Kruskal-Wallis test followed by a Dunn post-hoc test revealed that health-related motives such as ill-health avoidance were most frequently associated with exercising with a personal trainer compared to other exercise modalities, especially among females (p = 0.032, M = 4.88) and people in a relationship (p = 0.020, M = 5.18). On the other hand, intrinsic motivations such as enjoyment and stress management were mostly associated with exercising alone (p = 0.002, M = 4.98 and p = 0.021, M = 4.68, respectively). These results were also transferred to females and to some extent to people in a relationship (for enjoyment only). It is expected that intrinsic motivation is related to sustained exercise behavior.

Discussion: Future studies could implement a longitudinal design to test this statement and examine the proposed relationships over a longer period to better understand whether there may be causal relationships between motivation and different exercise modalities depending on different characteristics of participants.

KEYWORDS

motivation, group exercise, personal trainer, recreation, EMI-2 questionnaire, Slovenia

1 Introduction

Physical inactivity remains a significant problem that negatively impacts the physical (Haskell et al., 2007) and mental health of adults (Spalter et al., 2015; Kajtna and Vučković, 2022). One of the fastest growing sectors in physical activity and exercise is the fitness industry (Rodriguez, 2019; Yi et al., 2021), which is particularly popular among young people (Ong et al., 2021). There are around 185 million members and 210,000 clubs worldwide (Rothmann, 2022). In a study conducted by Fernandez (2022), gym members had a lower prevalence of physical inactivity and a higher prevalence of vigorous physical activity than the general population, regardless of age and gender. However, less than 40% of gym members exercise regularly and the dropout rate is high (Sperandei et al., 2016; Kopp et al., 2020; Rand et al., 2020; Gjestvang et al., 2021).

It is known that motivation plays a crucial role in determining whether or not a person adheres to an exercise program (Teixeira et al., 2012). Nevertheless, research on the exercise behaviors of fitness club members is quantitatively and qualitatively limited (Middelkamp and Steenbergen, 2015; Gjestvang et al., 2021). Frederick and Ryan (1993) found that people who engage in sports are driven by interest/enjoyment and competence motivation, whereas people who engage in fitness activities are driven by body-related motivation. Kilpatrick et al. (2005) also distinguish that intrinsic motives such as enjoyment and challenge are responsible for engaging in sport, while motivation for fitness training is more extrinsic and focuses on appearance, weight and stress management. Exercise behavior is determined more by health and fitness motives and also by appearance/weight concerns than by participation in sport. In contrast, social engagement and enjoyment motives were found to be less associated with fitness training, but more motivating for sport participation (Cagas et al., 2015).

Regarding the different types of activities, it was demonstrated that the strongest discriminators were affiliation in team sports, enjoyment in individual racing sport and bowls players, mastery in racquet sports, psychological state in fitness exercisers, and competition/ego in martial artists (Molanorouzi et al., 2015). The three most commonly cited motives for participants in fitness training and recreational activities were strength and endurance, weight management and stress management (Ball et al., 2014; Rodrigues et al., 2022). Rodrigues et al. (2022) found differences between water activities and group fitness classes and cardio/strength activities. Few studies have been conducted with participants involved in extreme conditioning program training. Fisher et al. (2017) suggest that these participants were more likely to report higher scores for intrinsic motives such as enjoyment, challenge, and affiliation, while personal training clients reported higher scores for health-related motives such as positive health, ill-health avoidance, and weight management. The same authors suggest that individuals who exercise one-to-one with a personal trainer have higher health-related motives (e.g., positive health, health pressures, and ill-health avoidance). Similar results were found by Marin et al. (2018), where participants involved in extreme conditioning program training had higher levels of enjoyment, stress management, social recognition, affiliation, competition and weight management. Conversely, resistance training participants indicated a higher motive for appearance.

Although some previous studies have found differences in motivation to participate in sport and fitness training (Whaley, 2003; Kilpatrick et al., 2005), there is a gap in the literature when it comes to motivation to participate in the latter (Ball et al., 2014). Recent studies also agree that future studies should analyze the motivational differences between different exercise activities in more detail (Rodrigues et al., 2022). In a study by Tsitskari et al. (2017), exercise motivation was used to segment gym-goers and conduct further analyses. However, there are no studies in which the motivation to participate in different types of exercise in fitness centers was investigated.

Very few studies compared extreme conditioning program training with group fitness exercise, training alone and also training with a personal trainer using the Exercise Motivations Inventory-2 (EMI-2) questionnaire (Fisher et al., 2017). However, the design of the aforementioned study has some weaknesses. Firstly, the authors obtained the responses via social media. The fact that the authors were not personally present in the fitness centers could have an impact on the honesty of the participants and thus on the reliability and validity of the analyzed data. Although some authors claim that the presence of the researcher has no effect on performance (Wood et al., 2006), there are some other studies that show that the virtual presence of the researcher had a significant positive effect in preventing careless responding (Ward and Pond, 2015). Secondly, the criterion in the mentioned study was that all participants had been exercising for more than 6 months. The study by Maltby and Day (2001) has shown that this is a very important factor in determining motivation to exercise, so we believe that this could bias the results obtained. We believe that all participants should be assessed regardless of their training experience, as extrinsic motivation plays a decisive role, especially in the initial phases of training, while intrinsic motives are crucial for progress in later phases (Dacey et al., 2008; Jones et al., 2020). Another study by Marin et al. (2018) used the EMI-2 questionnaire to assess motivational differences between resistance training and extreme conditioning program training. However, they used a similar approach by creating an online questionnaire and posting it on Facebook, where it remained for 2 months. In a study from China (Rahman et al., 2019), the authors also used the EMI-2 questionnaire to assess the participants' motivation for physical activity for three different group activities: fitness training, sports, and recreational and cultural activities. The drawback of this study was that the participants were predominantly middle-aged and older, mainly 55–64-year-olds and 65–74-year-olds (the inclusion criterion was age 35+). If we truly want to understand the motivational structure of exercisers, we should examine the entire age span and include youth as well. One of the reasons for this is that many studies have shown that the motivation for exercise varies according to age group (Biddle et al., 2003; Trujillo et al., 2004; Caglar et al., 2009; Brunet and Sabiston, 2011; Egli et al., 2011; Molanorouzi et al., 2015; Jones et al., 2020; Box et al., 2021; Grajek et al., 2021; Gut et al., 2022; Rodrigues et al., 2022), so that the assessment of motivational structures between different exercise modalities would lead to biased results in older adults. Another advantage of including young adults in the study is the fact that they can be guided toward a more active lifestyle, if this is not already the case. Furthermore, there is ample evidence that the level of physical activity in adolescents continues into adulthood (Telama et al., 2005; Telama, 2009). It is also worth noting that previous studies have shown that motivations related to weight control and physical appearance were prevalent in women, whereas all aspects related to competition were prevalent in men (Kilpatrick et al., 2005; Pauline, 2013; Vuckovic et al., 2023). Furthermore, to our knowledge, there are no studies that consider relationship status when examining exercise motivation.

For the abovementioned reasons, we designed a study to investigate the differences in motivation for exercise between participants engaged in different fitness training modalities. We applied a direct and holistic approach that considered the gender and relationship status of the participants, thus significantly improving the methodological approach used previously. More specifically, the aim of the present study was to determine the differences in motivational structure between fitness, aerobics, and personal trainer adult clients.

2 Materials and methods

2.1 Participants

We collected data from members of 20 fitness centers in 9 major Slovenian cities (4 from the eastern region and 5 from the western region). The questionnaire was distributed to 2,060 participants. After removing incomplete answers (including attention test), the final number of fully and correctly completed questionnaires for further processing amounted to 830 questionnaires, which corresponds to a response rate of 40.29%.

Table 1 shows the demographic characteristics of the fitness center users.

2.2 Procedures

It is worth noting that all the major fitness centers in Slovenia that we have selected have relatively similar characteristics in terms of facilities, equipment, programs offered, membership conditions and prices. After the participants completed their workout and left the respective centers, we approached them with tablet computers. To encourage their participation, we offered them protein bars and asked them to complete the questionnaire. Before handing over the questionnaire, the procedure was explained in details to address any potential concerns or uncertainties the participants might have.

TABLE 1 Sample characteristics.

	Percentage	n
Gender		
Male	57%	471
Female	43%	359
Age (years)		
Mean	27.3	
Standard deviation	11.3	
Range	18–70	
Relationship status		
Single	49%	405
In relationship	51%	425
Education		
Elementary school degree	2%	18
Secondary school degree	48%	402
High school degree	19%	154
College degree	26%	215
Master's or doctoral degree	5%	41
Occupation		
Student	46%	383
Unemployed	2%	17
Corporate employee	40%	329
Self-employee	11%	90
Retiree	1%	11

All questionnaires were distributed from Monday to Sunday, in the morning, afternoon and evening. Participants signed a consent form before completing the questionnaires via an online cloud platform specifically designed for survey purposes.[1] This study was conducted in accordance with the Declaration of Helsinki. All participants gave written informed consent before participating in the study, and the Ethics Committee of the University of Ljubljana granted ethical approval for data collection (No. 2021-19).

2.3 Instruments

The Exercise Motivations Inventory-2 (EMI-2), developed by Markland and Ingledew (1997) was used to assess the exercise motivation of fitness center members. The EMI-2 scale consists of 51 items and each item is measured on a 6-point Likert scale from zero (does not apply to me at all) to five (applies to me very much), with higher scores indicating higher motivation to exercise. These items form 14 subscales, including: Affiliation, Appearance, Challenge, Competition, Enjoyment, Health Pressure, Disease Prevention, Agility, Positive Health, Revitalization, Social Recognition, Strength and Endurance, Stress Management, and Weight Management. Each subscale is determined by calculating the average of 3 to 4 appropriate items based on the EMI-2 scale scoring key. The EMI-2 is a factorially valid mean of assessing a wide range of motives for participation in sporting activities in adult men and women and is suitable for both athletes and non-athletes (Markland and Ingledew, 1997). The EMI-2 has already been used in the Slovenian population, with Cronbach's alpha ranging from 0.71 to 0.91 (Vuckovic et al., 2023). However, we confirmed the reliability of the 51 EMI-2 items in this study by measuring the Cronbach's Alpha coefficient ($\alpha = 0.801$) and the 14 scales (α ranged from 0.665 to 0.903). In addition, the attention test questions were interspersed in the questionnaire to further increase the reliability and validity of the assessment. All participants who did not answer the attention test questions correctly were excluded from the study. In addition, participants answered questions about their personal life and the type of training they were participating in. For reasons of ecological validity, participants who took part in more than one type of training were also excluded from the study (see section "2.1 Participants").

2.4 Statistical analysis

The Cronbach's Alpha test was used to test the reliability of the EMI-2 scales. The mean scores of the 14 motivational scales were used as dependent variables, while the type of participant engagement (fitness, group training or personal trainer) and participant characteristics such as gender (males vs. females) and relationship status (single vs. in a relationship/married) were used as independent variables. Due to the ordinal and nominal nature of the data, the non-parametric Kruskal-Wallis test was used in this study. In the case of significant differences, the

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Dunn post-hoc test was used for pairwise comparisons. For each significant difference, the effect size was also reported as Pearson's r, with r values of 0.10, 0.30, and 0.50 representing the thresholds for small, medium and large effects respectively (Cohen, 1988). Descriptive statistics were presented as means, standard deviations, and χ^2. All statistical tests were analyzed using the RStudio software (RStudio; Posit, PBC, Vienna, Austria). The alpha level was set at 0.05.

TABLE 2 Motivations of fitness center users by type of exercise.

Motive	Exercise	n	M	SD	χ^2	p
Stress management	Fitness	686	4.68	1.13	7.75	0.021*
	Group exercise	96	4.53	1.20		
	Personal trainer	48	4.27	1.16		
Revitalisation	Fitness	686	5.11	0.96	1.11	0.573
	Group exercise	96	5.11	1.08		
	Personal trainer	48	4.99	1.11		
Enjoyment	Fitness	686	4.98	0.99	12.89	0.002**
	Group exercise	96	4.70	1.15		
	Personal trainer	48	4.45	1.28		
Challenge	Fitness	686	4.48	1.15	7.64	0.022*
	Group exercise	96	4.11	1.27		
	Personal trainer	48	4.35	1.26		
Social recognition	Fitness	686	3.09	1.41	7.38	0.024*
	Group exercise	96	2.69	1.44		
	Personal trainer	48	2.92	1.36		
Affiliation	Fitness	686	3.74	1.40	11.48	0.003**
	Group exercise	96	4.15	1.46		
	Personal trainer	48	3.41	1.40		
Competition	Fitness	686	3.39	1.58	11.45	0.003**
	Group exercise	96	2.80	1.54		
	Personal trainer	48	3.21	1.67		
Health pressures	Fitness	686	2.62	1.33	3.11	0.211
	Group exercise	96	2.78	1.45		
	Personal trainer	48	2.89	1.25		
Ill-health avoidance	Fitness	686	4.51	1.22	10.39	0.006**
	Group exercise	96	4.80	1.25		
	Personal trainer	48	4.88	1.15		
Positive health	Fitness	686	5.26	0.86	2.22	0.330
	Group exercise	96	5.32	0.95		
	Personal trainer	48	5.25	1.07		
Weight management	Fitness	686	4.32	1.25	1.80	0.406
	Group exercise	96	4.46	1.30		
	Personal trainer	48	4.25	1.23		
Appearance	Fitness	686	4.71	0.99	11.38	0.003**
	Group exercise	96	4.37	1.20		
	Personal trainer	48	4.28	1.21		
Strength and endurance	Fitness	686	5.29	0.78	4.09	0.130
	Group exercise	96	5.08	1.00		
	Personal trainer	48	5.00	1.18		
Nimbleness	Fitness	686	4.73	1.13	7.37	0.025*
	Group exercise	96	4.94	1.06		
	Personal trainer	48	5.01	1.19		

M, mean; SD, standard deviation; p, p-value; *$p < 0.05$; **$p < 0.01$.

TABLE 3 Mean ranking scores on exercise motivation between male and female participants.

		Males					Females				
Motive	Exercise	n	M	SD	χ^2	p	n	M	SD	χ^2	p
Stress management	Fitness	433	4.62	1.16	2.68	0.262	253	4.79	1.06	6.90	0.032*
	Group exercise	17	4.49	1.20			79	4.54	1.21		
	Personal trainer	21	4.32	1.04			27	4.23	1.27		
Revitalisation	Fitness	433	5.06	0.98	1.38	0.503	253	5.18	0.91	0.86	0.649
	Group exercise	17	4.75	1.21			79	5.19	1.04		
	Personal trainer	21	4.94	0.98			27	5.02	1.22		
Enjoyment	Fitness	433	5.00	0.99	2.76	0.252	253	4.95	0.99	8.51	0.014*
	Group exercise	17	4.72	1.18			79	4.69	1.15		
	Personal trainer	21	4.69	1.05			27	4.26	1.42		
Challenge	Fitness	433	4.50	1.16	0.53	0.765	253	4.45	1.13	6.87	0.032*
	Group exercise	17	4.41	1.22			79	4.04	1.27		
	Personal trainer	21	4.70	1.09			27	4.08	1.33		
Social recognition	Fitness	433	3.25	1.45	0.17	0.917	253	2.82	1.28	3.40	0.183
	Group exercise	17	3.25	1.55			79	2.57	1.39		
	Personal trainer	21	3.36	1.38			27	2.57	1.27		
Affiliation	Fitness	433	3.81	1.39	4.85	0.088	253	3.62	1.39	11.25	0.004**
	Group exercise	17	4.51	1.30			79	4.07	1.49		
	Personal trainer	21	3.82	1.21			27	3.08	1.47		
Competition	Fitness	433	3.63	1.57	2.14	0.342	253	2.98	1.51	5.49	0.064
	Group exercise	17	3.78	1.49			79	2.59	1.48		
	Personal trainer	21	4.12	1.53			27	2.50	1.43		
Health pressures	Fitness	433	2.65	1.37	5.81	0.055	253	2.56	1.25	2.27	0.321
	Group exercise	17	3.45	1.45			79	2.63	1.42		
	Personal trainer	21	2.83	1.22			27	2.94	1.29		
Ill-health avoidance	Fitness	433	4.47	1.27	2.17	0.337	253	4.57	1.14	6.88	0.032*
	Group exercise	17	4.63	1.52			79	4.84	1.19		
	Personal trainer	21	4.89	0.90			27	4.88	1.33		
Positive health	Fitness	433	5.20	0.88	0.73	0.695	253	5.36	0.82	0.29	0.867
	Group exercise	17	5.10	1.19			79	5.37	0.89		
	Personal trainer	21	5.38	0.73			27	5.15	1.28		
Weight management	Fitness	433	4.22	1.28	0.30	0.860	253	4.50	1.18	0.36	0.836
	Group exercise	17	4.10	1.52			79	4.53	1.24		
	Personal trainer	21	4.20	0.86			27	4.29	1.48		
Appearance	Fitness	433	4.70	0.99	6.62	0.036*	253	4.71	1.00	6.04	0.049*
	Group exercise	17	3.96	1.45			79	4.46	1.14		
	Personal trainer	21	4.38	1.09			27	4.20	1.31		
Strength and endurance	Fitness	433	5.33	0.75	1.25	0.536	253	5.22	0.82	1.05	0.593
	Group exercise	17	4.96	1.19			79	5.11	0.96		
	Personal trainer	21	5.10	0.98			27	4.93	1.33		
Nimbleness	Fitness	433	4.70	1.17	2.97	0.227	253	4.77	1.06	3.75	0.154
	Group exercise	17	4.90	1.19			79	4.95	1.03		
	Personal trainer	21	5.10	0.94			27	4.94	1.37		

M, mean; SD, standard deviation; p, *p*-value; *$p < 0.05$; **$p < 0.01$.

3 Results

Table 2 contains descriptive statistics on the observed variables and the results of the Kruskal-Wallis test for the whole sample.

Post-hoc tests revealed that individuals who exercise alone in the fitness center are significantly more motivated by stress management than personal trainer clients ($p = 0.008$; $r = 0.097$). They are also more motivated by enjoyment compared to group exercise ($p = 0.025$; $r = 0.080$) and personal trainer clients ($p = 0.003$; $r = 0.110$). Similarly, fitness center users are significantly more motivated by challenge ($p = 0.006$; $r = 0.098$) and social recognition ($p = 0.008$; $r = 0.096$) than group exercise users. Users who participate in group classes exercise significantly more out of a sense of belonging than users who exercise in a fitness ($p = 0.004$; $r = 0.100$) or with a personal trainer ($p = 0.002$; $r = 0.250$). We also found that fitness center users are significantly more motivated by competition ($p = 0.001$; $r = 0.120$) than those who attend group classes. We also demonstrated that fitness center users are more interested in their appearance than those attending group classes ($p = 0.010$; $r = 0.092$) or training with a personal trainer ($p = 0.016$; $r = 0.089$), but exercise less because for ill-health avoidance reasons than those attending group ($p = 0.010$; $r = 0.092$) and personal training ($p = 0.030$; $r = 0.080$). Finally, our results show that personal training clients exercise much more for nimbleness reasons than fitness participants ($p = 0.032$; $r = 0.079$).

Table 3 shows the different motivations for exercise between the genders.

Using post-hoc tests, we found that affiliation ($p = 0.028$; $r = 0.103$) and health pressures ($p = 0.020$; $r = 0.109$) motivates males much more to go to group exercise classes than to fitness training. Completely opposite results were found for the motive appearance – males who exercise because of this go to fitness and do not prefer group exercise ($p = 0.029$; $r = 0.103$).

Our results also demonstrate that female fitness center users who exercise alone are motivated by stress management ($p = 0.019$; $r = 0.140$) or enjoyment ($p = 0.009$; $r = 0.156$) are significantly more likely to work out alone in fitness than to go to a personal trainer. Those who exercise for challenge ($p = 0.015$; $r = 0.134$) and competition ($p = 0.049$; $r = 0.108$) are also more likely to exercise in a fitness than in a group, in contrast to those who are motivated with ill-health avoidance ($p = 0.031$; $r = 0.119$). Finally, women who are motivated by affiliation are more likely to participate in group training than in fitness training alone ($p = 0.010$; $r = 0.142$) or with personal trainer ($p = 0.002$; $r = 0.297$).

Table 4 shows how the exercise motives of the single participants and the participants living in a relationship differ in relation to the type of training.

Post-hoc tests showed that singles prefer fitness ($p = 0.017$; $r = 0.123$) or group exercise ($p = 0.041$; $r = 0.299$) rather than training with a personal trainer to cope with everyday stress. They also exercise much more in a group than in a fitness ($p = 0.018$; $r = 0.120$) or with a personal trainer ($p = 0.026$; $r = 0.324$) because of affiliation. Singles also exercise more alone in a fitness than with a personal trainer because of their appearance ($p = 0.007$; $r = 0.141$).

Members of fitness centers who are in a relationship or married enjoy fitness training more than training with a personal trainer ($p = 0.017$; $r = 0.126$). They also exercise more in the fitness than in groups because they want to be socially recognized ($p = 0.020$; $r = 0.118$). In addition, those who exercise because of affiliation, exercise more in groups than in the fitness ($p = 0.023$; $r = 0.115$) and with personal trainer ($p = 0.037$; $r = 0.212$). And those who exercise for competitive reasons exercise less in groups and more in the fitness area ($p = 0.006$; $r = 0.140$) and with a personal trainer ($p = 0.028$; $r = 0.223$). Finally, avoiding illness is a motive that is more common among users of group exercise ($p = 0.039$; $r = 0.105$) and personal trainer clients ($p = 0.033$; $r = 0.113$) than among users who only exercise in the fitness area.

4 Discussion

The aim of the study was to determine the motivational differences between people who train in fitness alone, in groups/aerobics, and those who train with a personal trainer. We also wanted to investigate whether the motivational structure of the participants differs according to gender and relationship status.

It is important to note that our analysis revealed no significant differences in the motivation scales for revitalisation, weight management, and strength and endurance, regardless of exercise type, gender, or relationship status. In the past, stress management has been shown to be a better motivation for exercise than sport activities (Kilpatrick et al., 2005; Ball et al., 2014), especially for extreme conditioning program training participants (Fisher et al., 2017; Marin et al., 2018). The results of our study show that the motive of coping with stress is more likely to be found among regular fitness center users than among group exercise and personal trainer clients. This was particularly pronounced in singles and females. We can only speculate about the reasons for the obtained results. One of the reasons could be that fitness center users prefer to train alone to cope with the stress rather than focusing on the personal trainer. Sometimes instructors can cause additional stress by requiring their practitioners to stay focused and follow instructions, especially if having a highly committed coach-athlete relationship (Nicholls et al., 2016). Another explanation could be that single people, especially females, minimize their approachability by having the personal trainer work with them. It is known that one of the reasons of going to fitness is socialization (Eriş et al., 2018). It is also known that physical activity can trigger the release of endorphins, which are natural mood boosters, and it can also help to lower levels of stress hormones such as cortisol (Habibzadeh, 2015). Women tend to have higher stress levels due to a variety of factors (Matud, 2004), which may make stress management a more compelling motivation. Finally, we can speculate that single men probably do not prefer to show their weaknesses by having someone tell them what and how to do in front of other people, especially potential "relationship candidates," which is why they do not seek out personal trainer sessions but prefer to work out alone at the gym.

A strong motive for participants in sports (Kilpatrick et al., 2005) such as individual racing (Molanorouzi et al., 2015) and extreme conditioning program training (Fisher et al., 2017; Marin et al., 2018) is to have fun. The results of our study show that enjoyment is a very important motivating factor for women and people in a relationship to exercise alone. If we consider the previously mentioned factor of approachability for females, we could assume that people who are in a relationship may simply

TABLE 4 Mean ranking scores on exercise motivation between single participants and participants in a relationship.

		Singles					In a relationship/married				
Motive	Exercise	n	M	SD	χ^2	p	n	M	SD	χ^2	p
Stress management	Fitness	360	4.70	1.09	5.68	0.059	326	4.66	1.17	3.84	0.146
	Group exercise	33	4.71	1.10			63	4.44	1.25		
	Personal Trainer	14	3.84	1.44			34	4.45	1.00		
Revitalisation	Fitness	360	5.07	0.95	2.64	0.270	326	5.15	0.96	0.17	0.918
	Group exercise	33	5.10	1.08			63	5.12	1.09		
	Personal Trainer	14	4.52	1.43			34	5.18	0.90		
Enjoyment	Fitness	360	5.03	0.99	4.22	0.121	326	4.92	1.00	6.93	0.031*
	Group exercise	33	4.74	1.10			63	4.67	1.18		
	Personal Trainer	14	4.29	1.73			34	4.51	1.06		
Challenge	Fitness	360	4.59	1.08	2.93	0.232	326	4.36	1.20	3.48	0.175
	Group exercise	33	4.30	1.23			63	4.03	1.29		
	Personal Trainer	14	4.13	1.66			34	4.45	1.06		
Social recognition	Fitness	360	3.22	1.36	2.39	0.303	326	2.95	1.45	5.84	0.054
	Group exercise	33	3.06	1.46			63	2.49	1.39		
	Personal Trainer	14	2.70	1.39			34	3.01	1.36		
Affiliation	Fitness	360	3.90	1.35	6.96	0.031*	326	3.58	1.43	6.19	0.045*
	Group exercise	33	4.44	1.35			63	4.00	1.50		
	Personal Trainer	14	3.48	1.43			34	3.38	1.41		
Competition	Fitness	360	3.60	1.55	3.09	0.214	326	3.16	1.58	8.30	0.016*
	Group exercise	33	3.28	1.61			63	2.56	1.45		
	Personal Trainer	14	2.98	1.78			34	3.30	1.65		
Health pressures	Fitness	360	2.56	1.30	0.36	0.835	326	2.67	1.36	3.20	0.202
	Group exercise	33	2.51	1.41			63	2.92	1.46		
	Personal Trainer	14	2.60	0.80			34	3.01	1.39		
Ill-health avoidance	Fitness	360	4.34	1.25	0.65	0.722	326	4.69	1.17	7.85	0.020*
	Group exercise	33	4.46	1.38			63	4.97	1.15		
	Personal trainer	14	4.17	1.52			34	5.18	0.82		
Positive health	Fitness	360	5.22	0.88	0.03	0.984	326	5.31	0.84	2.62	0.270
	Group exercise	33	5.12	1.09			63	5.43	0.85		
	Personal trainer	14	4.79	1.64			34	5.44	0.68		
Weight management	Fitness	360	4.29	1.28	2.34	0.310	326	4.36	1.22	1.53	0.464
	Group exercise	33	4.36	1.22			63	4.51	1.34		
	Personal Trainer	14	3.80	1.26			34	4.43	1.19		
Appearance	Fitness	360	4.78	0.89	9.40	0.009**	326	4.63	1.09	3.72	0.156
	Group exercise	33	4.43	1.21			63	4.34	1.21		
	Personal trainer	14	3.91	1.26			34	4.43	1.18		
Strength and endurance	Fitness	360	5.33	0.74	1.55	0.461	326	5.30	0.82	1.91	0.385
	Group exercise	33	5.13	0.98			63	5.06	1.01		
	Personal trainer	14	4.64	1.73			34	5.15	0.85		
Nimbleness	Fitness	360	4.68	1.11	0.96	0.619	326	4.78	1.14	5.05	0.080
	Group exercise	33	4.87	0.96			63	4.98	1.11		
	Personal trainer	14	4.60	1.73			34	5.18	0.86		

M, mean; SD, standard deviation; p, p-value; *$p < 0.05$; **$p < 0.01$.

want to enjoy time to themselves without having to deal with anyone, including personal trainer. In addition, individuals who pursue an independent fitness routine may place more emphasis on having fun because they have more autonomy in choosing the activities they really like. They can choose exercises that suit their personal interests and bring them pleasure. Personal

trainers or group training programmes, on the other hand, may take a more structured approach that focuses less on individual enjoyment.

Another important reason for participating in an independent fitness routine is the challenge, especially for females. This can be explained by the fact that participants in group exercise classes perform the same exercises, which makes them less challenging. For some, the personal challenge of setting and achieving fitness goals for themselves is a source of recognition and self-satisfaction. They enjoy the sense of fulfilment that comes from overcoming individual challenges. A study by Rodrigues et al. (2022) has shown that group exercise is also known to be less challenging than some individual water activities.

People who are intrinsically motivated are more likely to participate in activities because they enjoy them or feel challenged. By contrast, in personal training or group exercise, extrinsic motives such as external goals or expectations may play more of a role, so the enjoyment or challenge may play a secondary role. Challenge and enjoyment are known to be intrinsic motives (Markland et al., 1992; Frederick and Ryan, 1993; Markland and Ingledew, 1997; Maltby and Day, 2001; Egli et al., 2011; Fortier et al., 2012; Knowles et al., 2015) and generally have a positive influence on exercise participation (Dacey et al., 2008; Teixeira et al., 2012), while some authors also include stress management among the intrinsic motives (Markland and Ingledew, 1997; Maltby and Day, 2001).

Another important finding of our study is that participants, especially in a relationship/married, are more likely to participate in independent fitness activities rather than group activities due to social recognition. Previous studies suggest that social recognition is related to sport participation rather than exercise (Kilpatrick et al., 2005; Ball et al., 2014). Our findings contradict the results of a study by Fisher et al. (2017), which suggest that social recognition may be a motivating factor for participants in group exercise. However, in our case, the number of people who exercise individually is more than 7x times higher than the number of people who participate in group exercise. This means that people who exercise individually in the fitness have more contact with other people and automatically experience social recognition. On the other hand, the results of our study showed that group classes are very important for participants' sense of belonging (affiliation) compared fitness and personal trainer sessions. This is in line with previous studies showing that aerobic exercise participants are primarily motivated by social-health factors (Laverie, 1998; Fisher et al., 2017). Other studies showed that affiliation is a very important motivating factor in sports participants (Kilpatrick et al., 2005; Ball et al., 2014), especially in team sports (Molanorouzi et al., 2015) or even extreme conditioning program training (Marin et al., 2018). In addition, a study from China showed that affiliation is very important when it comes to participating in cultural leisure activities (Rahman et al., 2019). It is common knowledge that people who want to belong somewhere join a group.

The analysis revealed that males are much more motivated by competition than females, which is consistent with previous studies (Morris et al., 1995; Morgan et al., 2003; Egli et al., 2011; Pauline, 2013; Boone and Brausch, 2016; Cho and Beck, 2016; Vučković et al., 2022; Vuckovic et al., 2023). However, there were no significant differences between the different exercise modalities. The results also showed that female fitness practitioners were more motivated by competition than female group exercisers. Previous research on this motive is inconclusive. In a study by Fisher et al. (2017), the authors claim that competition is more important in group training than when training alone or with a personal trainer. At the same time, Rodrigues et al. (2022) argue that the competitive motive is more pronounced in water-based activities than in group training. However, the results obtained could also be explained by the same reason previously given for the challenge - same group exercises are less demanding than individually tailored exercises, so the scope for competition is minimal.

It is known that health-related exercise motives are less associated with sport and more with exercise (Kilpatrick et al., 2005; Ball et al., 2014). Some studies have emphasized the importance of health motives specifically for aerobic exercise (Laverie, 1998) and others for training with a personal trainer (Fisher et al., 2017). The results of our study confirm both - that people who want to avoid poor health are more likely to exercise in a group and with a personal trainer than alone. This is in line with some previous studies, such as a study by Rodrigues et al. (2022), which suggests that health motives are a more important motivational factor for resistance training compared to various water activities. Interestingly, our further analysis showed that this is particularly true for participants who are in a relationship or married. As can be seen, in addition to affiliation, health was also an important motivational parameter for the decision to participate in group training.

It has been shown that appearance is more important for individual fitness users than for those who train in groups or with a personal trainer. Even more interesting is that this motivational factor is more important for single men. Individual training can be more time efficient. They can structure their workouts to fit their schedule, and this time efficiency can be especially important for their work-life balance. Previous studies have shown that physical appearance is more important for participants in exercise than for sport participants (Kilpatrick et al., 2005; Ball et al., 2014). However, the literature on this topic is inconsistent. A study by Marin et al. (2018) associates the motive of appearance with resistance training, while Fisher et al. (2017) argue that appearance is more important for individuals exercising with a personal trainer than for group, individual or extreme conditioning program training participants.

Finally, the results of our study showed that in addition to health-related motives, nimbleness was more important for participants who train with a personal trainer than for who train in fitness alone. This can be easily explained by the fact that personal trainer training sessions are usually conducted by highly qualified experts and are tailored to the specific needs, goals and fitness level of the clients.

4.1 Strengths and limitations

The main strength of our study is that the sample can be considered representative of the Slovenian population exercising in fitness centers. Our study included the 20 largest fitness centers in the country, which are evenly distributed throughout the country. For this reason, our results are significant and valuable for interpretation in the Slovenian population. Secondly, we were physically present during the assessment, so we are confident that the questionnaires were filled out by people who exercise regularly, so there is no room for misuse or misrepresentation. In addition,

although we used the previously used reliable and valid EMI-2 questionnaire, to improve reliability and validity, we introduced "attention check" questions to ensure that the responses obtained were legitimate.

At the same time, some limitations of the study should be noted. Compared to regular fitness center members who exercised alone, a relatively small sample of participants attended group and personal trainer sessions. This finding is natural and was to be expected, but is still worth mentioning. One of the possible reasons for this could be that we surveyed the 20 largest fitness centers and the trend is toward exercising alone, while group and personal trainer sessions are more common in smaller gyms. General limitations also include the fact that this study was a cross-sectional study where data was collected all at once and there was no effective follow-up study. In addition, the intensity and frequency of exercise sessions were not recorded, although the participants exercised regularly. Furthermore, this study cannot be generalized globally due to the cultural and sociological characteristics of Slovenia. Future studies could introduce a longitudinal design to examine the proposed relationships at multiple time points over a longer period to better understand whether there may be causal relationships between motivation and different exercise modalities depending on different characteristics of the participants (gender, age, relationship status, etc.). The frequency and intensity of training as well as training experience should also be taken into account in future studies.

5 Conclusion

The results of our study showed that there are motivational differences between people who exercise in fitness alone, in groups/aerobics, and with a personal trainer, especially when gender and relationship status were taken into account.

Overall, fitness center members who exercised alone were motivated by stress management, enjoyment, challenge, social recognition, competition and appearance. Individuals who worked out in a group felt that affiliation was a very important reason for participating. People who exercised with a personal trainer did so primarily for reasons of disease prevention and nimbleness. These motivation scales were further translated to the participants according to gender and relationship status. Males exercised alone more than in groups, mainly because of their appearance. Females who exercised alone did so primarily for reasons of stress management, enjoyment, challenge and appearance compared to the other options. They also exercised with a personal trainer because they wanted to avoid illness, and in group classes for a sense of belonging (affiliation), just like single people. Individuals who were in a relationship, on the other hand, exercised alone for enjoyment and appearance, in a group for affiliation and with a personal trainer for competition and disease avoidance.

Health-related motives were most commonly associated with exercising with a personal trainer, especially among females and people in a relationship. Since nimbleness was also associated with personal training, this could be an indication of trust in the trainer as an expert in the field, especially when it comes to such serious matters as one's health and physical performance. On the other hand, intrinsic motivations such as enjoyment and stress management were associated with exercising alone. These results were also transferred to females and, to a certain extent, to people in a relationship (enjoyment only). As mentioned earlier, this type of motivation is expected to be related to sustained exercise patterns (McDonough and Crocker, 2007; Markland and Tobin, 2010). The question is whether these fitness center members exercise the longest compared to others because they are inspired by intrinsic motivation. Future research is needed, preferably longitudinal.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the Ethics Committee of the University of Ljubljana. 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

VV: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Writing – original draft, Writing – review and editing. SD: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Visualization, Writing – original draft, Writing – review and 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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Understanding physical exercise among individuals with substance use disorders using an integrated theoretical perspective of the health action process approach and theory of planned behavior

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Introduction: Physical exercise is considered a useful non-pharmacological adjunctive treatment for promoting recovery from substance use disorders (SUD). However, adherence to physical exercise treatments is low, and little is known about what factors are associated with the initiation and maintenance of physical exercise behaviors. The aim of this study was to explore the psychosocial factors underlying these behaviors in individuals with SUD using an integrated theoretical model based on the health action process approach (HAPA) and the theory of planned behavior (TPB).

Methods: A total of 1,197 individuals with SUDs (aged 37.20 ± 8.62 years) were recruited from 10 compulsory isolation drug rehabilitation centers in Zhejiang Province via convenience sampling according to a set of inclusion criteria. Self-reported data were collected to assess task self-efficacy (TSE), maintenance self-efficacy (MSE), recovery self-efficacy (RSE), outcome expectations (OE), action planning (AP), coping planning (CP), social support (SS), subjective norms (SN), attitude behavior (AB), behavioral intention (BI), perceived behavioral control (PBC), risk perception (RP), exercise stage, and exercise behavior in this integrated model. ANOVA and structural equation modeling (SEM) were used to evaluate this model.

Results: One-way ANOVA revealed that the majority of the moderating variables were significantly different in the exercise phase. Further SEM showed that the model fit the data and revealed several important relationships. TSE, RP, SS, AB, and SN were indirectly associated with physical exercise behavior in individuals with SUD through the BI in the SUD initiation stage. In addition, PBC was directly related to physical exercise behavior in individuals with SUD. In the maintenance stage, MSE, AP, CP and exercise behavior were significantly related. Moreover, AP and CP were mediators of BI and MSE.

Conclusion: This study is the first attempt to integrate patterns of physical exercise behavior in individuals with SUD. The HAPA-TPB integration model provides a useful framework for identifying determinants of physical exercise

behavioral intentions and behaviors in individuals with SUD and for explaining and predicting the initiation and maintenance of physical exercise behaviors in these individuals. Moreover, the model provides scientific guidance for the enhancement of physical exercise adherence in individuals with SUD.

KEYWORDS

substance use disorders, physical exercise behavior, health action process approach, theory of planned behavior, behavioral intention, self-efficacy, planning

1 Introduction

Substance use disorders (SUDs), including disorders involving the use of illicit drugs, alcohol, cannabis, or nicotine, have become an important, costly, and intractable global public health problems. The World Drug Report in 2023, published by the United Nations Office on Drugs and Crime (UNODC), states that more than 296 million individuals used drugs in 2021 worldwide, representing a 23% increase over the previous decade; in addition, the number of individuals suffering from SUDs has surged to 39.5 million, a 45% increase in the past decade (Vreugdenhi et al., 2012). Substance abuse not only destroys the health of people with SUDs but also leads to serious social problems that jeopardize the health of others and social stability.

Scholars have explored ways to reduce the risk of relapse from multiple perspectives, with physical exercise being recognized as a potential non-pharmacological adjunctive intervention to reduce the risk of relapse (Wang et al., 2014; Huang et al., 2019; Thompson et al., 2020). In the past decade, research on the topic of physical exercise and SUDs has been popular and has yielded promising theoretical achievements. Recent studies have reported the positive benefits of physical exercise, including promoting physical fitness (Xu et al., 2022), reducing cravings (Zhou et al., 2021), improving mood states (Rawson et al., 2015), and enhancing cognitive functions (Wang et al., 2015), in individuals with SUD. Moreover, the concept that the risk of relapse can be reduced by physical exercise has been implemented in drug rehabilitation practice. In China, a pilot program was started by 24 drug rehabilitation institutions in 2018, and by 2020, 226 compulsory isolation drug rehabilitation centers were established to carry out physical exercise treatment programs, enabling a total of more than 80,000 individuals with SUDs to participate in physical exercise (Feng et al., 2021).

However, outstanding achievements have been made in both theoretical explorations and practical applications regarding the rehabilitative benefits of physical exercise for individuals with SUD. However, the challenging issue of adherence to SUD participation in physical exercise looms large. In one of our 12-week aerobic exercise intervention studies, the rate of adherence of individuals with methamphetamine use disorders to a moderate-intensity aerobic exercise program was only 80.64% (Wang et al., 2017). In another of our studies, individuals with SUDs were asked to participate in 12 weeks of a group-based aerobic exercise program, and the adherence rate was only 82.93% (Zhu et al., 2022). Although the participants involved in these two studies were in compulsory isolation and received organized, supervised, and regular physical exercise, they still had low adherence rates. Moreover, even higher dropout rates have also been observed in physical exercise intervention studies for other SUDs. One study reported that 95 individuals with alcohol use disorders (AUDs) were randomized to participate in a 12-week aerobic or yoga program (at least 3 times per week), and only 49% of the participants completed the supervised exercise program (Welford et al., 2023). Other studies have reported that the prevalence of exercise adherence among people with AUDs is between 50 and 70% (Giesen et al., 2015; Thompson et al., 2020). Although physical exercise is known to have beneficial effects on brain plasticity and cognitive functioning improvements in people with SUDs (Wang et al., 2017, 2020), maintaining a regular physical exercise program is extremely challenging for individuals with SUDs, especially in the early stages of withdrawal. A lower adherence rate is associated with a greater risk of relapse, which can seriously undermine the rehabilitative benefits of physical exercise programs for individuals with SUD. Therefore, the topic of physical exercise adherence in individuals with SUD is a major concern that must be addressed not only for researchers but also for policymakers.

The participation of individuals with SUD in physical exercise is an example of the reshaping of health behavior, a process that can be initiated and maintained by multiple influencing factors. Moderate and major levels of addiction, higher body mass index, and lower educational attainment may be important factors in decreasing adherence to physical exercise participation in individuals with AUDs (Welford et al., 2023). Additionally, individuals with SUD show low compliance and may have difficulty maintaining physical exercise programs due to impairments in cognition and mental health as a result of chronic substance abuse (Abrantes and Blevins, 2019). Furthermore, individuals with SUD may lack sufficient motivation to engage in physical exercise, especially in the early stages of withdrawal (Abrantes et al., 2011). While previous studies have begun to focus on the factors that influence physical exercise adherence in individuals with SUD, they have not systematically identified the factors that influence individuals' initiation and maintenance of physical exercise behaviors, especially psychosocial correlates (e.g., intentions). Few theoretical studies have addressed the initiation and maintenance of physical exercise behaviors in individuals with SUD, but attempts have been made to explain the psychosocial factors that underlie adherence to physical exercise among individuals in other groups from different theoretical perspectives, such as the transtheoretical model (Marshall and Biddle, 2001), self-determination theory (Standage and Ryan, 2020), theory of planned behavior (TPB) (Downs and Hausenblas, 2005) and the health action process approach (HAPA) (Barg et al., 2012; Shen et al., 2012). Of these theories, the TPB and the HAPA are considered more suitable and consistent than the other theories.

The TPB is one of the most commonly used social cognitive theoretical models for predicting health behavior change. The model theorizes that behavioral intention is the most direct factor influencing health behaviors and that it is determined by an individual's behavioral attitudes, subjective norms, and perceived behavioral control; in addition, perceived behavioral control is thought to have a predictive role in the emergence of behaviors (Ajzen, 1985). Behavioral attitudes are individuals' comprehensive assessments of a behavior based on their perception of the outcome of the benefits of the behavior, and positive behavioral attitudes enhance their willingness to participate in the behavior. However, subjective norms focus on normative views formed by significant others' supportive attitudes toward one's participation in a particular behavior. In addition, perceived behavioral control represents an individual's evaluation of the required resources and barriers related to participating in the behavior. Due to its simplicity and ease of implementation, the TPB model has been recognized by numerous scholars in the field of exercise behavior change (Gomes et al., 2018; Gourlan et al., 2019; Ruiz et al., 2021; Hagger and Hamilton, 2023). The theory emphasizes the motivational role of attitudes and embodies the role of the objective environment in the two factors of subjective norms and perceived behavioral control. The TBP bridges the gap between the individual and the environment, transforms the constraints imposed on the individual by factors such as objective social environments and material conditions to the individual's subjective perception, and explains the mechanism of the role of objective environmental factors on behavior. However, the theory has some limitations in explaining the crucial factors of behavioral change, and nearly 50% of the variance in behavioral intention and behavior is unexplained (Sheeran, 2002; Mceachan et al., 2011). In other words, individuals' intentions to choose a new behavior do not lead to actual behavior change, and there is a gap between intentions and behaviors. As a result, the theory is commonly applied to explain and predict behavior. This limitation may be attributed to the fact that the theory is a static theoretical model that fails to adequately account for the cognitive variables involved in the dynamic sequential process of physical exercise behavior (Shen et al., 2010).

Unlike the TPB, the HAPA, which is typical of the stages model of exercise behavior, suggests that people go through multiple stages of health behavior change: before the decision stage (before action and non-intenders), after the decision stage and before the action stage (indictors), and during the action stage (actors). The HAPA suggests that the factors affecting individuals at different stages also differ (Schwarzer, 2008; Schwarzer and Hamilton, 2020). The before-decision stage of action results in behavioral intention, which is determined by risk perception, outcome expectation, and self-efficacy and is also called the motivation stage. In the after-decision and before-action stages, planning plays a crucial role in the realization of health target behaviors [average effect size of 0.65 (Gollwitzer and Sheeran, 2006)]; thus, it is also called the planning stage. Planning consists of two dimensions: action planning, which details when, where and how to perform the behavior (if-condition), and coping planning, in which possible obstacles to the goal are anticipated and ways of overcoming them are identified (then-condition). In this phase, where concrete action planning must be developed to lead to actual behavior, perceptual self-efficacy continues to play an influential role in motivating individuals to achieve goals by planning and attempting to take action, while the perception of risk loses its facilitating role. In the action phase (consisting of the initiation and maintenance phases), engagement and maintenance of the action are regulated solely by self-efficacy, with barriers and available resources (e.g., social support) determining the maintenance, withdrawal, and resumption of the behavior (Schwarzer and Hamilton, 2020). The HAPA also incorporates behavioral intentions and action planning as proximal predictors of true action into the structure of the model, thus forming a continuum of behavioral change encompassing intentions, planning, and true action (Schwarzer, 2008; Schwarzer and Hamilton, 2020). Since its formulation, the HAPA has been widely used in studies related to rehabilitation exercise in patients, and it is considered to provide a useful theoretical framework for evaluating physical exercise intentions and behaviors in the groups involved (Zhang et al., 2019; Schwarzer and Hamilton, 2020; Godoy-Izquierdo et al., 2023). The HAPA has also been used in numerous research studies on patients' physical exercise. Similarly, the HAPA has several limitations; for example, studies have shown that risk perception does not explain the variance of behavior and intention well (Schwarzer et al., 2007; Kaczynski et al., 2008; Zhang et al., 2022), which means that risk perception is a negligible variable because most exercisers do not necessarily engage in or withdraw from exercise because they perceive the presence of risk. Another limitation is that the HAPA does not include social factors that influence exercise behavior or behavioral intentions (Chow and Mullan, 2010).

Given that the existing theories themselves have some shortcomings, some scholars have begun to try to combine multiple theories to construct a comprehensive theory of exercise behavior. Combining social cognitive theories (e.g., the TPB) and stage models of exercise behavior (e.g., the HAPA) to explore study exercise behavior has become a new approach. The HAPA indicates the role of variables mediating the relationship between behavioral intention and behavior, including maintenance self-efficacy and recovery self-efficacy, whereas the TPB fails to address the gap between intention and behavior. Thus, the HAPA has the potential to compensate for this deficiency in the TPB. The construction of an integrated HAPA-TPB model could improve the prediction of exercise behavior and clarify the specific roles of each moderating variable. Several researchers have integrated and revised the TPB and HAPA in the context of Chinese culture (Shen et al., 2010) and have been able to better explain the relationships among the variables involved in the various stages of physical exercise behavior among Chinese people (Zhou, 2014; Zhang et al., 2022).

The TBP is widely used to predict behavioral intentions for addiction treatment in individuals with SUD and is considered an effective screening tool (Savvidou et al., 2012; Zemore and Ajzen, 2014; Moeini et al., 2017; Bonny-Noach et al., 2023). In one such study, Savvidou et al. (2012) used an expanded version of the TPB to examine the social-cognitive predictors of the behavioral intentions of individuals with SUD in physical exercise treatment and found that attitudes and perceived behavioral control were strong predictors of physical exercise intentions. Although this study provided a theoretical framework for factors influencing physical exercise behavior in individuals with SUD, it did not systematically reveal how behavioral intentions influence physical exercise behavior in individuals with SUD due to limitations of the TPB itself. Therefore, the aim of the present study was to determine the factors associated with the initiation and maintenance of physical exercise behavior in individuals with SUD using an integrated HAPA-TPB model. We combined the

relevant research and understanding in the field of exercise behavior and proposed the following main hypotheses: (1) the integrated HAPA-TPB model better predicts exercise behavior in individuals with SUD; (2) there are specificities in the characteristics of exercise behavior in individuals with SUD according to the exercise stage; (3) risk perception, outcome expectation, social support, behavioral attitudes, subjective norms, and action self-efficacy predict intention; and (4) in the integrated HAPA-TPB model, behavioral intention mediates the role of recovery self-efficacy, action planning, and coping planning in maintaining physical exercise behavior.

2 Methodology

2.1 Participants and procedure

A total of 1,235 individuals with SUD were recruited from 10 compulsory isolation drug rehabilitation centers in Zhejiang Province, China, to participate in the survey according to the following inclusion criteria and using a convenience sampling strategy. The inclusion criteria for individuals with SUD were as follows: (1) aged 18 years or older, (2) serving a compulsory isolation time of more than 6 months, and (3) had used drugs in the last 3 months and had used drugs for more than 1 year. Our survey was conducted in a face-to-face format; participants were informed of the aims and objectives of the study and provided with an anonymous, paper-based self-report questionnaire to complete. After missing values were eliminated, data from a total of 1,197 individuals with SUD were ultimately included in the statistical analysis. This study was approved by the Faculty of Sport Science Ethics Review Board (No. TY2022024), Ningbo University, and adhered to the Declaration of Helsinki.

2.2 Measures

The self-report questionnaire consisted of three parts: background information, a questionnaire related to the HAPA, and a questionnaire related to the TBP.

The background information survey mainly included questions on demographic variables such as age, gender, ethnicity and socioeconomic status, as well as substance abuse. The evaluation of the degree of substance addiction was derived from the relevant diagnostic criteria in the *Diagnostic and Statistical Manual of Mental Disorders* (Fifth Edition) (DSM-V).

The physical activity levels of the participants were assessed using the Chinese version of the *Physical Activity Rating Scale-3* (PARS-3) revised by Liang (1994). The PARS-3 examines an individual who is exercising in terms of intensity, frequency, and duration of physical activity. Each aspect is categorized into five levels, with intensity and frequency scored 1–5 on a scale of 1–5, and time scored 0–4, respectively. The exercise score = exercise intensity × exercise time × exercise frequency, and the range of the exercise score was 0–100 points. The retest reliability of the PARS-3 was 0.82 (Liang, 1994).

The stage of exercise is identified by the *Stages of Exercise Diagnostic Scale* (Richert et al., 2011). The scale categorizes exercise stages into three stages by using five items: the unintentional stage, intentional stage and action stage. Items such as "Please think back to the past 4 weeks, did you perform physical activity at least at moderate intensity for 30 min 3 times a week?" Participants were asked to choose one of three options to answer based on the actual situation.

An the *Exercise Self-Efficacy Scale* was used to measure task self-efficacy, maintenance self-efficacy, and recovery self-efficacy (Renner and Schwarzer, 2005). The task self-efficacy subscale consisted of 4 items (Cronbach's $\alpha = 0.8650$), items such as "Please select the level of certainty that you would be able to start participating in regular exercise in each of the following situations." The maintenance self-efficacy subscale consisted of 11 items (Cronbach's $\alpha = 0.848$), such as "Please select the level of certainty you have that you will be able to maintain regular exercise in each situation." The recovery self-efficacy subscale consisted of 4 items (Cronbach's $\alpha = 0.7741$), such as "Please select the level of confidence that you would still be able to restart regular exercise in each case." All 11 of these items are scored on a 5-point Likert scale.

The *Expectation of Outcome Scale* was used to assess positive and negative outcome expectations (Renner and Schwarzer, 2005). Positive outcome expectancy was assessed with 9 items (Cronbach's $\alpha = 0.8857$), and the negative outcome expectancy subscale consisted of 3 items (Cronbach's $\alpha = 0.5636$). Items such as "Please select the confidence level you have in the advantages and disadvantages of participating in regular exercise in each situation" have options that are rated on a 5-point Likert scale.

Risk perception was measured by five items (Cronbach's $\alpha = 0.8818$), such as "If I continue to live as I do now, then my risk of developing diabetes will be high" (Renner and Schwarzer, 2005).

Action planning and coping planning were assessed through the *Planning Scale* (Renner and Schwarzer, 2005). The action planning subscale consisted of 5 items (Cronbach's $\alpha = 0.8832$), such as "For exercise I'm sure I have got a specific plan in place about when I'm going to start exercise." And the coping planning subscale consisted of 4 items (Cronbach's $\alpha = 0.8830$), such as "For exercise I'm sure I have got a specific plan regarding what exercise obstacles I encounter and how I'm going to deal with them." All 9 of these items are scored on a 5-point Likert scale. The Behavioral Intentions Scale consisted of 3 items (Cronbach's $\alpha = 0.8393$), such as "For me, over the next 4 weeks, I'm going to do at least 3 times a week, 20 min or more of physical activity each time" (Fishbein and Ajzen, 2010; Shen et al., 2012). All of these items are scored on a 7-point Likert scale.

The *Subjective Norms Scale* consists of 3 items (Cronbach's $\alpha = 0.8474$), such as "The people who are important to me endorse that I get at least 20 min of physical activity at least 3 times a week," and is scored on a 6-point Likert scale (Fishbein and Ajzen, 2010).

The *Perceived Behavioral Control Scale* consists of 3 items (Cronbach's $\alpha = 0.6457$), such as "Do I have the ability to control my physical activity for 20 min or more at least 3 times a week for the next 4 weeks?," and is scored on a 6-point Likert scale (Fishbein and Ajzen, 2010).

The *Behavioral Intention Scale* consists of 3 items (Cronbach's $\alpha = 0.8393$), such as "Over the next 4 weeks, I plan to do at least 3 physical workouts per week of 20 min or more each," and is scored on a 6-point Likert scale (Fishbein and Ajzen, 2010; Conner, 2020).

The *Exercise Social Support Scale* consists of 5 items (Cronbach's $\alpha = 0.8255$), such as "Friends or family members have offered or said they would exercise with me in the past 3 months," and is scored on a 5-point Likert scale (Hankonen et al., 2010).

These scales used in this study included the Exercise Self-Efficacy Scale, the Expectation of Outcome Scale, the Perceived Risk Scale, the

Behavioral Intentions Scale and the Exercise Social Support Scale, all of which are Chinese localized and revised versions (Shen et al., 2012). The revised Chinese versions of the scales reflect the content measured, and their theoretical concepts are basically in line with those of the original scales; moreover, the revised versions of these scales are widely used in China (Shen et al., 2012; Zhou, 2014; Liu et al., 2015). In addition, the Chinese versions of the scales related to the TBP, including Behavioral Attitudes, Subjective Norms, Perceived Behavioral Control, and Intentions, were revised by Hu and Mao (2008), and the internal consistency coefficients of each scale ranged from 0.72 to 0.81, with good measurement equivalence and better compliance with all dimensions of the TBP.

Based on previous reports of communication with individuals with SUD, we adjusted the sources of social support in the Exercise Social Support Scale to "parents, relatives, friends, rehabilitation partners and rehabilitation staff" and changed "friends" to "rehabilitation partners and rehabilitation staff" in the subjective normative scale to better fit the social context of rehabilitation and physical exercise in which individuals with SUD live.

2.3 Statistical analysis

We evaluated the variability in the characteristics of participants with different addiction type, as well as in the exercise behavior-moderating variables between exercise phases by ANOVA or Chi-square tests with SPSS 28.0. The hypotheses were tested by structural equation modeling in AMOS 24.0. Cronbach's α (>0.7), composite reliability (CR) (>0.7), and average variance extracted (AVE) (>0.5) were used to evaluate the consistency of the data in the measurement model. To assess the overall model fit, χ2/df, RMSEA, NFI, CFI, and IFI were selected as the model fit indicators. Among them, a $\chi^2/df < 5$ and RMSEA <0.08 were needed, with a value closer to 0 indicating a better model fit; an NFI, CFI, and IFI > 0.9 were required, with a value closer to 1 indicating a better model fit (Urbach and Ahlemann, 2010). Finally, we performed mediation effect tests using the bootstrap method (set up for 5,000 iterations) to obtain 95% confidence intervals for the parameter estimates. *p*-values <0.05 were considered to indicate statistical significance, and all tests were bilateral.

3 Results

3.1 Participant information

Information on the relevant characteristics of the participants included in the statistical analysis is described in Table 1. Furthermore, there were significant differences between the three different categories of individuals with SUD in terms of gender, ethnicity, socioeconomic status index, and substance abuse status (all $p < 0.01$).

3.2 Analysis of exercise behavior stages

To further examine the extent to which the moderating variables of the integrated model matched across the different exercise behavioral stages, ANOVA and *post hoc* tests were conducted (Table 2). The results showed that all variables were significantly different (all $p < 0.01$) by exercise stage except for two variables, maintenance self-efficacy and risk perception. *Post hoc* tests revealed significant differences between the before-decision stage and the after-decision before-action stage (all $p < 0.05$), except for the moderating variables of maintenance self-efficacy, recovery self-efficacy, negative outcome expectation, and risk perception. Moreover, except for the maintenance self-efficacy and risk perception variables, significant differences (all $p < 0.05$) were observed between the before-decision and action stages of the after-decision before-action stage. These results suggest the existence of discontinuous features in different stages of exercise behavior.

3.3 Measurement model

The means, standard deviations, Cronbach's values and bivariate correlations for all the model variables are presented in Table 3. The Cronbach's alpha coefficients in each dimension ranged from 0.59 to 0.96, the CR coefficients ranged from 0.70 to 0.93, and the AVE coefficients ranged from 0.50 to 0.82. The results indicate that the measurement model has overall good reliability and convergent validity.

3.4 Structural model

The integrated HAPA-TPB model was estimated and tested using the maximum likelihood method, the standardized path coefficients of each path in the model were checked, and the M_1 model shown in Figure 1 was obtained as follows: $\chi^2/df = 4.33$, RMSEA = 0.053, NFI = 0.919, CFI = 0.937, IFI = 0.937; this model fit the data well. As shown in Figure 1, the integrated model strongly predicted behavioral intentions, explaining 83% of the variance in behavioral intentions, 31% of the variance in action planning, 33% of the variance in coping planning and 12% of the variance in exercise behavior. Task self-efficacy explained 4% of the variance in maintenance self-efficacy, and maintenance self-efficacy explained 48% of the variance in recovery self-efficacy. There was an increase in predictive power compared to that of the HAPA model alone (Shen et al., 2012).

The results of the path analysis of the latent variables in the integrated model are shown in Table 4. Social support ($p < 0.05$), behavioral attitudes ($p < 0.001$), subjective norms ($p < 0.001$), and task self-efficacy ($p < 0.001$) were positively correlated with behavioral intentions, whereas risk perceptions ($p < 0.05$) were negatively correlated with behavioral intentions. Regarding exercise behavior in individuals with SUD, action planning ($p < 0.001$), coping planning ($p < 0.001$), and perceived behavioral control ($p < 0.01$) were positively correlated with exercise behavior, while maintenance self-efficacy ($p < 0.05$) was negatively correlated with exercise behavior. Task self-efficacy ($p < 0.001$) and maintenance self-efficacy were positively correlated. Maintenance self-efficacy was positively correlated with recovery self-efficacy ($p < 0.001$), action planning ($p < 0.01$), and coping planning ($p < 0.01$). Behavioral intentions were positively correlated with action planning ($p < 0.001$) and coping planning ($p < 0.001$). The remaining paths were not significant ($p > 0.05$).

TABLE 1 Demographic characteristics and substance abuse status of the participants included in the study ($n/M \pm SD$).

	Stimulant use disorders	Heroin use disorders	Polydrug use disorders	F/x^2	p-value	Total
Number	820	149	228			1,197
Age (years)	35.92 ± 8.44	40.04 ± 8.31	39.93 ± 8.40	29.97	0.00	37.20 ± 8.62
Gender						
Male	748 (91.20%)	147 (98.70%)	218 (95.60%)	13.68	0.00	1,113 (93.00%)
Female	72 (8.80%)	2 (1.30%)	10 (4.40%)			84 (7.00%)
Ethnicity						
Han	739 (90.10%)	112 (75.20%)	184 (80.70%)	32.09	0.00	1,035 (86.50%)
Minority	81 (9.90%)	37 (24.80%)	44 (19.30%)			162 (13.50%)
Socioeconomic Status	10.99 ± 2.73	9.54 ± 2.46	10.53 ± 2.76	18.81	0.00	10.72 ± 2.74
Marriage						
Single	307 (37.40%)	24 (34.20%)	68 (29.8%)	18.48	0.102	426 (35.60%)
Married	242 (29.50%)	48 (32.20%)	64 (28.10%)			354 (29.60%)
Divorce	226 (27.6%)	41 (27.50%)	78 (34.20%)			345 (28.80%)
Widowed	3 (0.40%)	2 (1.30%)	3 (1.30%)			8 (0.70%)
Cohabite	19 (2.30%)	4 (2.70%)	7 (3.10%)			30 (2.50%)
Separate	2 (0.20%)	1 (0.70%)	4 (1.80%)			7 (0.60%)
No report	21 (2.60%)	2 (1.30%)	4 (1.80%)			27 (2.30%)
Education						
Illiteracy	42 (5.10%)	22 (14.80%)	16 (7.00%)	54.96	0.00	80 (6.70%)
Elementary	171 (20.90%)	59 (39.60%)	59 (25.90%)			289 (24.10%)
Junior	415 (50.60%)	55 (36.90%)	104 (45.60%)			574 (48.00%)
Senior	139 (17.00%)	10 (6.70%)	38 (16.70%)			187 (15.60%)
College and above	53 (6.50%)	3 (2.00%)	11 (4.90%)			67 (5.60%)
Occupation						
Farm Laborer	147 (17.9%)	50 (33.60%)	60 (26.30%)	40.70	0.00	257 (21.50%)
Self-Employed	256 (31.20%)	25 (16.80%)	53 (23.20%)			334 (27.90%)
Manual Worker	180 (22.00%)	44 (29.50%)	49 (21.50%)			273 (22.80%)
Office-bearer	26 (3.20%)	4 (2.60%)	5 (2.20%)			35 (2.90%)
Technical Staff	22 (2.70%)	0 (0.00%)	6 (2.60%)			28 (2.30%)
General Staff	116 (14.20%)	13 (8.82%)	30 (13.10%)			159 (13.30%)
Not Employed	73 (8.90%)	13 (8.70%)	25 (11.00%)			111 (9.30%)
Income (1000yuan/month)	5.64 ± 5.37	3.96 ± 3.31	5.22 ± 5.61	6.69	0.02	5.35 ± 5.23
Drug abuse situation						
Smoking (year)	18.30 ± 8.52	21.91 ± 8.21	22.66 ± 8.24	30.36	0.00	19.58 ± 8.63
Drinking (year)	15.41 ± 9.65	18.14 ± 10.38	17.40 ± 11.15	6.94	0.00	16.13 ± 10.09
Drug use (year)	7.66 ± 5.12	11.01 ± 7.63	13.85 ± 7.21	102.24	0.00	9.26 ± 6.48
Abstinence (month)	13.58 ± 5.24	13.89 ± 5.13	13.33 ± 5.37	0.50	0.61	13.57 ± 5.25
Addiction Score	5.69 ± 3.78	6.76 ± 4.08	8.05 ± 4.02	34.80	0.00	6.27 ± 3.97

3.5 Mediating effects

Further analysis of the mediating effects indicated that task self-efficacy could act on exercise behavior both through maintenance self-efficacy and planning (all $p < 0.001$) and through behavioral intentions and planning (all $p < 0.001$) and could also directly affect exercise behavior by influencing maintenance self-efficacy ($p < 0.05$). Risk perception, social support, attitudes, and subjective norms play a role in exercise behavior through behavioral intentions and planning, including action planning and coping planning (all $p < 0.01$).

TABLE 2 Summary of ANOVA and *post hoc* test results for moderating variables at each stage ($M \pm SD$).

	Before Action stage (BD) (n = 395)	After decision and before action stage (AD/BA) (n = 135)	Action stage (A) (n = 667)	F-value	Turkey HSD	
					BD-AD/BA	AD/BA-A
Task self-efficacy	11.79 ± 3.92	12.96 ± 3.68	15.00 ± 4.06	83.39***	−1.17**	−2.03***
Maintenance self-efficacy	27.95 ± 8.19	29.22 ± 7.94	28.98 ± 10.34	1.73	−1.27	0.25
Recovery self-efficacy	7.37 ± 3.12	7.92 ± 2.79	6.92 ± 3.67	5.68**	−0.55	1.00**
Positive outcome expectations	29.84 ± 9.12	33.00 ± 8.61	35.54 ± 8.06	56.04***	−3.16***	−2.54**
Negative outcome expectations	8.90 ± 2.89	9.48 ± 2.83	10.24 ± 3.12	24.95***	−0.58	−0.76*
Action planning	13.04 ± 5.03	15.60 ± 5.24	17.49 ± 5.45	88.09***	−2.56***	−1.90***
Coping planning	9.83 ± 3.79	11.99 ± 3.86	12.96 ± 4.52	68.09***	−2.16***	−0.96*
Social support	11.92 ± 4.88	14.46 ± 4.89	16.44 ± 5.67	89.08***	−2.54*	−1.98***
Subjective norm	14.61 ± 5.25	16.17 ± 4.39	17.86 ± 4.05	65.11***	−1.56**	−1.69***
Attitude behavior	24.43 ± 8.86	28.53 ± 6.86	30.53 ± 6.36	86.02***	−4.10***	−2.00*
Behavioral intention	14.65 ± 5.33	17.06 ± 4.23	18.38 ± 4.79	71.58***	−2.41***	−1.32*
Perceived behavioral control	9.72 ± 3.55	10.82 ± 3.04	12.02 ± 3.95	47.98***	−1.11**	−1.20**
Risk perception	21.39 ± 8.61	21.76 ± 9.08	20.89 ± 9.28	0.72	−0.37	0.87
Exercise behavior	9.36 ± 12.26	14.18 ± 13.09	18.57 ± 18.93	39.36***	−4.82**	−4.39*

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

Maintenance self-efficacy, behavioral intention, and planning were identified as chain mediating variables of the integrated model and had a significant mediating effect; the values of each mediating effect and 95% confidence intervals are shown in Table 5.

3.6 Impact of exogenous variables in the integrated model

To further explore the possible effects of gender, age, type of addictive substance, degree of addiction and socioeconomic status on exercise behavior in individuals with SUD, this study further analyzed the integrated model by adding these five exogenous variables to the existing model (for details, see Model M2 in Figure 2). The results showed that for individuals with SUD, gender ($p < 0.05$) and age ($p < 0.001$) had significant negative effects on exercise behavior, while no direct effects of addiction level, addiction type, or socioeconomic status were found on exercise behavior. The various fit indices of M2 were $\chi^2/df = 3.99$, RMSEA = 0.050, NFI = 0.906, CFI = 0.928, and IFI = 0.928; this model had good fit.

4 Discussion

Physical exercise is considered a useful non-pharmacological intervention for promoting SUD recovery, and currently, low adherence rates weaken the rehabilitative benefits of physical exercise. Studies investigating the psychological correlates of the initiation and maintenance of physical exercise behavior in individuals with SUD are lacking. The purpose of this study was to test the feasibility and applicability of an integrated HAPA-TPB model for physical exercise behavior in individuals with SUD. The study revealed that the model can explain and predict the initiation and maintenance of physical exercise behavior in individuals with SUD.

The model includes the initiation and maintenance stages of physical exercise behavior in individuals with SUD. Regarding the initiation of physical exercise behavior, the results of the HAPA-TPB integration model indicated that task self-efficacy, risk perception, social support, behavioral attitudes, and subjective norms were indirectly associated with physical exercise behavior in individuals with SUD through behavioral intentions. In addition, perceived behavioral control was directly related to the physical exercise behavior of individuals with SUD. However, positive outcome expectancy, negative outcome expectancy, and perceived behavioral control did not significantly predict behavioral intention. In terms of task maintenance, the results indicated that maintenance self-efficacy, action planning, and coping planning were directly associated with physical exercise behavior in individuals with SUD. Moreover, maintenance self-efficacy was indirectly associated with physical exercise behavior in individuals with SUD through action planning and coping planning.

TABLE 3 Summary of means, standard deviations, Cronbach's α, and bivariate correlation coefficients of the HAPA-TPB composite model variables.

	Mean	SD	Cronbach's α	CR	AVE	TSE	MSE	RSE	POE	NOE	AP	CP	SS	SN	AB	BI	PBC	RP	EB
Task self-efficacy (TSE)	13.71	4.24	0.88	0.88	0.65	1													
Maintenance self-efficacy (MSE)	28.67	9.43	0.88	0.87	0.51	0.18***	1												
Recovery self-efficacy (RSE)	7.18	3.42	0.82	0.83	0.61	0.09**	0.59***	1											
Positive outcome expectations (POE)	33.37	8.87	0.93	0.93	0.57	0.60***	0.20***	0.11***	1										
Negative outcome expectations (NOE)	9.71	3.07	0.69	0.70	0.50	0.44***	0.36***	0.23***	0.69***	1									
Action planning (AP)	15.81	5.66	0.93	0.93	0.74	0.44***	0.26***	0.20***	0.44***	0.29***	1								
Coping planning (CP)	11.82	4.52	0.92	0.92	0.73	0.41***	0.33***	0.30***	0.40***	0.33***	0.72***	1							
Social support (SS)	14.73	5.72	0.90	0.90	0.66	0.30***	0.15***	0.089**	0.33***	0.25***	0.40***	0.37***	1						
Subjective norm (SN)	16.60	4.75	0.91	0.91	0.77	0.47***	0.03	0.00	0.47***	0.25***	0.34***	0.30***	0.34***	1					
Attitude behavior (AB)	28.29	7.83	0.96	0.96	0.82	0.52***	0.03	−0.01	0.51***	0.25***	0.38***	0.32***	0.34***	0.76***	1				
Behavioral intention (BI)	17.00	5.20	0.79	0.82	0.61	0.43***	0.01	−0.02	0.39***	0.18***	0.35***	0.31***	0.30***	0.73***	0.72***	1			
Perceived behavioral control (PBC)	11.13	3.87	0.59	0.70	0.53	0.36***	0.02	0.01	0.33***	0.15***	0.26***	0.20***	0.24***	0.59***	0.60***	0.56***	1		
Risk perception (RP)	21.16	9.04	0.92	0.92	0.53	0.025	0.27***	0.20***	0.05	0.13***	0.04	0.08**	0.09**	−0.07*	−0.06*	−0.08**	−0.08**	1	
Exercise behavior (EB)	15.03	16.91	0.72	0.81	0.57	0.26***	−0.02	−0.03	0.26***	0.16***	0.28***	0.27***	0.16***	0.24***	0.26***	0.21***	0.17***	−0.12***	1

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

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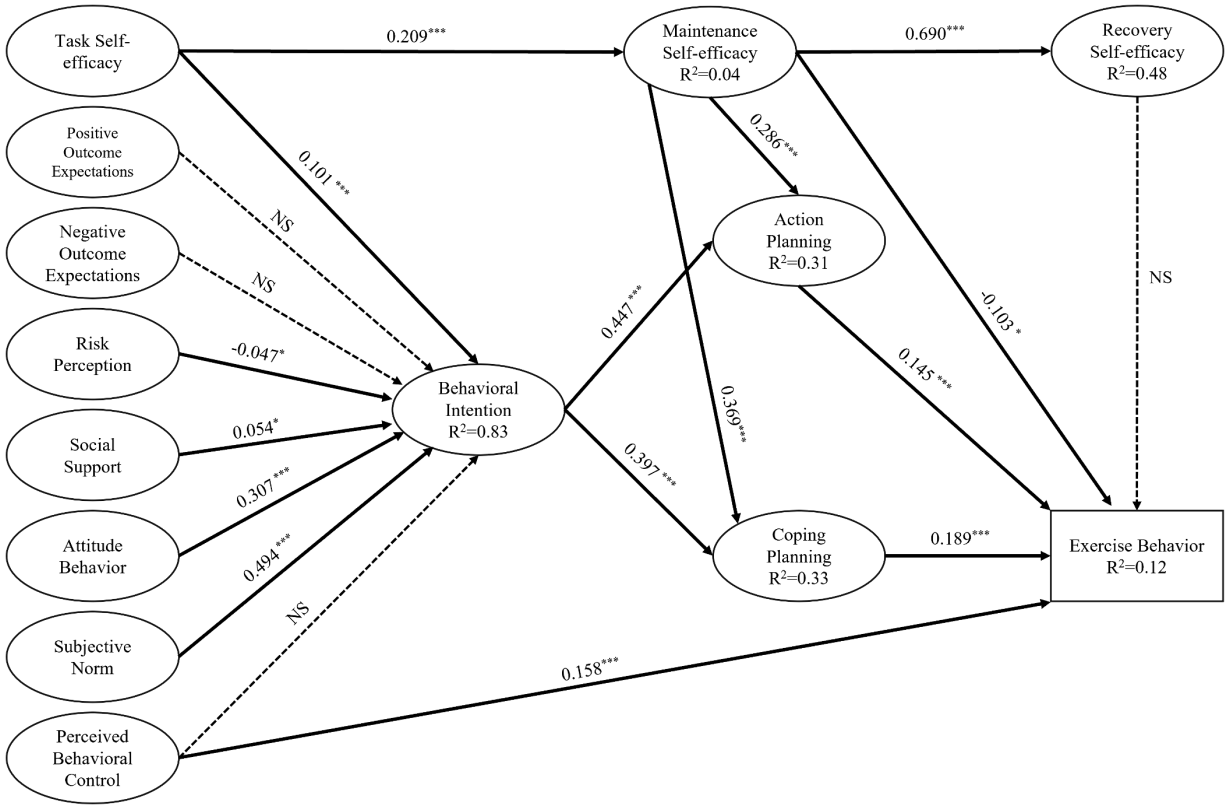

FIGURE 1
Standardized path coefficients for the structural equation model explaining and predicting exercise behavior in individuals with SUDs based on the HAPA-TPB integrated model (M1). Non-significant paths are denoted by NS; $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

4.1 Variability analysis of different exercise phases

According to the HAPA-TPB model, the moderating variables of action self-efficacy, recovery self-efficacy, positive outcome expectancy, negative outcome expectancy, action planning, coping planning, social support, subjective norms, behavioral attitudes, behavioral intentions, perceived behavioral control, and exercise behaviors exhibited significant variability across the different phases of exercise behavior (as shown in Table 2). This finding implies that there is significant discontinuity in these moderating variables at different exercise behavior stages. Moreover, these findings also imply that these moderating variables play an important role in specific exercise phase transitions. Since discontinuity is an important basis for judging a model as a true model, it can be hypothesized that this integrated model is suitable for the prediction of physical exercise behavior in individuals with SUD.

4.2 Factors affecting intentions during the initiation stage

Neither outcome expectations (positive or negative) nor perceived behavioral control significantly predicted behavioral intentions during the behavioral initiation phase of the integrated HAPA-TPB model. These findings are inconsistent with those of several previous studies and theoretical hypotheses (Barg et al., 2012; Savvidou et al., 2012; Schwarzer, 2016; Wang et al., 2023). The possible reasons for this are as follows. First, individuals with SUD are required to complete physical exercise in a compulsory isolation setting in accordance with the established task schedule of rehabilitation institutions, so they are rarely able to exercise their judgment while controlling external conditions. Second, long-term drug abuse causes serious cardiorespiratory impairment in individuals with SUD (Kochetkova et al., 1998). Thus, during early physical exercise interventions, it is difficult for individuals with SUD to quickly experience the beneficial effects of physical exercise due to their physical weakness. Finally, in the context of the social stigmatization of drug addiction, it is difficult for individuals with SUD to gain social acceptance and recognition (Cazalis et al., 2023); as a result, it is more difficult for them to gain positive social appreciation through behavioral changes, such as the adoption of physical exercise habits. Excitingly, however, task self-efficacy, risk perception, social support, behavioral attitudes, and subjective norms significantly predicted behavioral intentions, explaining 83% of the variance, with subjective norms and behavioral attitudes being the top two predictors. This finding implies that the pressures from society and from compulsory isolation rehabilitation institutions regarding exercise behaviors demand that individuals with SUD experience prior to acting, as well as their combined assessment of the behavioral benefits of engaging in physical exercise, are the most important determinants of whether they can form behavioral intentions. Additionally, we observed that task self-efficacy and social

TABLE 4 Results of standardized path analysis.

Relationships	Standardized coefficient (β)	95% CI		*p*-values
		Lower	Upper	
Task self-efficacy → Maintenance self-efficacy	0.209	0.138	0.278	0.000
Positive outcome expectations → Behavioral intention	−0.048	−0.116	0.011	0.107
Negative outcome expectations → Behavioral intention	0.023	−0.017	0.075	0.221
Risk perception → Behavioral intention	−0.047	−0.092	−0.010	0.014
Social support → Behavioral intention	0.054	0.012	0.111	0.014
Attitude behavior → Behavioral intention	0.307	0.193	0.426	0.000
Subjective norm → Behavioral intention	0.494	0.379	0.619	0.000
Perceived behavioral control → Behavioral intention	0.100	−0.028	0.222	0.121
Task self-efficacy → Behavioral intention	0.101	0.051	0.169	0.000
Maintenance self-efficacy → Recovery self-efficacy	0.690	0.631	0.740	0.000
Behavioral intention → Action planning	0.447	0.393	0.516	0.000
Maintenance self-efficacy → Action planning	0.286	0.219	0.343	0.001
Behavioral intention → Coping planning	0.397	0.340	0.468	0.000
Maintenance self-efficacy → Coping planning	0.369	0.297	0.427	0.001
Action planning → Exercise behavior	0.145	0.062	0.227	0.000
Maintenance self-efficacy → Exercise behavior	−0.103	−0.199	−0.007	0.048
Recovery self-efficacy → Exercise behavior	−0.050	−0.153	0.058	0.368
Coping planning → Exercise behavior	0.189	0.095	0.282	0.000
Perceived behavioral control → Exercise behavior	0.158	0.093	0.216	0.001

TABLE 5 Mediating effects.

Path	Effects (β)	95% CI		*p-values*
		Lower	Upper	
Task self-efficacy → Maintenance self-efficacy → Exercise behavior	−0.024	−0.055	0.000	0.047
Task self-efficacy → Maintenance self-efficacy → Action planning → Exercise behavior	0.010	0.004	0.020	0.000
Task self-efficacy → Maintenance self-efficacy → Coping planning → Exercise behavior	0.017	0.008	0.031	0.000
Task self-efficacy → Behavioral intention → Action planning → Exercise behavior	0.008	0.003	0.018	0.000
Task self-efficacy → Behavioral intention → Coping planning → Exercise behavior	0.009	0.004	0.021	0.000
Risk perception → Behavioral intention → Action planning → Exercise behavior	−0.003	−0.009	−0.001	0.008
Risk perception → Behavioral intention → Coping planning → Exercise behavior	−0.004	−0.010	−0.001	0.007
Social support → Behavioral intention → Action planning → Exercise behavior	0.004	0.001	0.012	0.010
Social support → Behavioral intention → Coping planning → Exercise behavior	0.005	0.001	0.013	0.008
Attitude behavior → Behavioral intention → Action planning → Exercise behavior	0.020	0.009	0.038	0.000
Attitude behavior → Behavioral intention → Coping planning → Exercise behavior	0.024	0.011	0.044	0.000
Subjective norm → Behavioral intention → Action planning → Exercise behavior	0.039	0.019	0.069	0.000
Subjective norm → Behavioral intention → Coping planning → Exercise behavior	0.045	0.024	0.084	0.000
Perceived behavioral control → Behavioral intention → Action planning → Exercise behavior	0.008	0.000	0.021	0.061
Perceived behavioral control → Behavioral intention → Coping planning → Exercise behavior	0.007	0.000	0.020	0.064
Total indirect effects	0.174	0.125	0.248	0.000
Total effects	0.341	0.279	0.417	0.000

support were significantly and positively related to behavioral intentions toward SUD. This implies that the beliefs of individuals with SUD in their own abilities and their social support from significant others (e.g., rehabilitation staff) are also important factors in forming their intentions before taking action. In addition, unexpectedly, we observed a significant negative correlation between

risk perception and the behavioral intentions of individuals with SUD. This finding is inconsistent with previous findings on physical exercise behavior acquisition (Schwarzer et al., 2007) but reflects the previously identified strong relationship between risk perception and addictive substance use and withdrawal (Grevenstein et al., 2015). This finding suggested that individuals with SUD who perceive greater risk will have a decreased probability of quitting physical exercise to seek more rapid quitting substance use. Based on the above analysis of the factors influencing behavioral intention, we suggest the following. At the early stage of rehabilitation treatment in compulsory isolation drug rehabilitation institutions, it is necessary for rehabilitation staff, in collaboration with families of individuals with SUD, to increase their endorsement of and support for SUD participation in physical exercise. At the same time, it is also important to increase the knowledge dissemination and guidance of physical exercise for recovery. These strategies can effectively strengthen SUDs' attitudes toward participating in physical exercise independently, increase their ability to develop higher self-efficacy, independently envision strategies to achieve desired outcomes, and prepare their intentions for the upcoming physical exercise.

4.3 Factors affecting exercise behavior during the maintenance stage

In the behavior maintenance stage in the integrated HAPA-TPB model, both behavioral intention and maintenance self-efficacy were significant predictors of planning, together explaining 32% of the variance. The current findings are consistent with a meta-analysis of studies applying the HAPA (Grevenstein et al., 2015). This finding implies that self-efficacy in coping with obstacles one may face when engaging in physical exercise and the intention to engage in that behavior are important factors in the development of a plan among individuals with SUD. Task self-efficacy also indirectly affects planning through behavioral intentions. This indirect effect has been addressed in past studies applying the HAPA (Schwarzer et al., 2007; Barg et al., 2012). Self-efficacy plays an important role in an individual's behavioral change process. Individuals with SUD who have gone through the initiation phase of physical exercise behavior and then transitioned to the maintenance phase will encounter new challenges, and the implementation of self-efficacy interventions can help to improve the maintenance of physical exercise behavior among individuals with SUD. Therefore, we suggest that factors such as the self-efficacy of individuals with SUD and their exercise stage should be fully considered when developing physical exercise interventions so that they can be implemented more accurately to promote the maintenance of physical exercise behavior.

Maintenance self-efficacy and planning were found to be significant predictors of exercise behavior in individuals with SUD during the behavior maintenance phase of the integrated HAPA-TPB model. Consistent with the results of previous studies (Sniehotta et al., 2005a; Luszczynska and Sutton, 2006), our study revealed that maintenance self-efficacy was effective in predicting physical exercise behavior. Among people with SUD, a group that rarely participates in physical exercise prior to rehabilitation treatment through obligatory isolation, having self-efficacy to deal with the barriers that may arise when participating in physical exercise is essential for the maintenance of physical exercise. Taken together, the findings from the present study and the results of previous studies show that self-efficacy positively predicts behavioral intentions, planning, and physical exercise behavior. This result supports the theoretical assumptions of the HAPA-TPB integration model that we set out to develop. However, a positive predictive effect of recovery self-efficacy was not observed in our study, possibly because most of the individuals with SUD involved in this study were in the early stages of physical exercise, and fewer participants had experienced recovery self-efficacy.

4.4 Mediating role of action planning and coping planning

Numerous studies have shown that the gap between behavioral intentions and physical exercise behaviors is a barrier to the maintenance of physical exercise behaviors (Sniehotta et al., 2005a,b) and that programs play a critical role in bridging the gap between behavioral intentions and behaviors (Wee and Dillon, 2022). The role of programs in bridging the gap between behavioral intentions and behaviors is critical. Excitingly, planning was also observed in our study as a mediating variable in the behavioral intention → physical exercise behavior pathway, with planning being responsible for translating behavioral intention into sustained physical exercise behavior among people with SUD. Moreover, we also observed that planning was a mediating variable in the maintenance self-efficacy → physical exercise behavior pathway. To explore in detail the important role of plans in the integrated HAPA-TPB model, we subdivided plans into action planning and coping planning when constructing our theoretical model. In our study, we observed that behavioral intentions drove physical exercise behavior through action planning and coping planning. Through action planning, individuals with SUD have a mental representation of when and where to exercise and behavioral actions related to how to exercise when making physical exercise plans. This increases the effectiveness of physical exercise behavior change. Additionally, with coping planning, individuals with SUD anticipate potential barriers or disruptions (if-condition) and respond to difficulties that may interfere with the execution of physical exercise behavior (then-condition) (Patterson and Mischel, 1976). The contribution of coping planning is particularly important in a fixed and familiar mandatory segregated rehabilitation setting because individuals with SUD can anticipate potential barriers, which also makes it extremely easy to motivate them to make a psychological connection between foreseeable barriers and appropriate alternative planning, which increases the likelihood that they will continue to maintain physical exercise. In summary, it is clear that action planning and coping planning are important mediators of maintaining SUD physical exercise, a behavior that requires long-term maintenance and complex steps. Therefore, we suggest that in the process of rehabilitation treatment for individuals with SUD, especially in compulsory isolation rehabilitation situations, rehabilitation staff should help to formulate a feasible physical exercise plan, including the content, frequency, duration, and exercise schedule. And individuals with SUD need to be able to identify a stable place for physical exercise. Moreover, it is also necessary to help individuals with SUD identify stable places for exercise. Furthermore, it is important to guide individuals with SUD to independently construct coping strategies for various obstacles in the execution of physical exercise. Thus, the intention of individuals with SUD to develop action

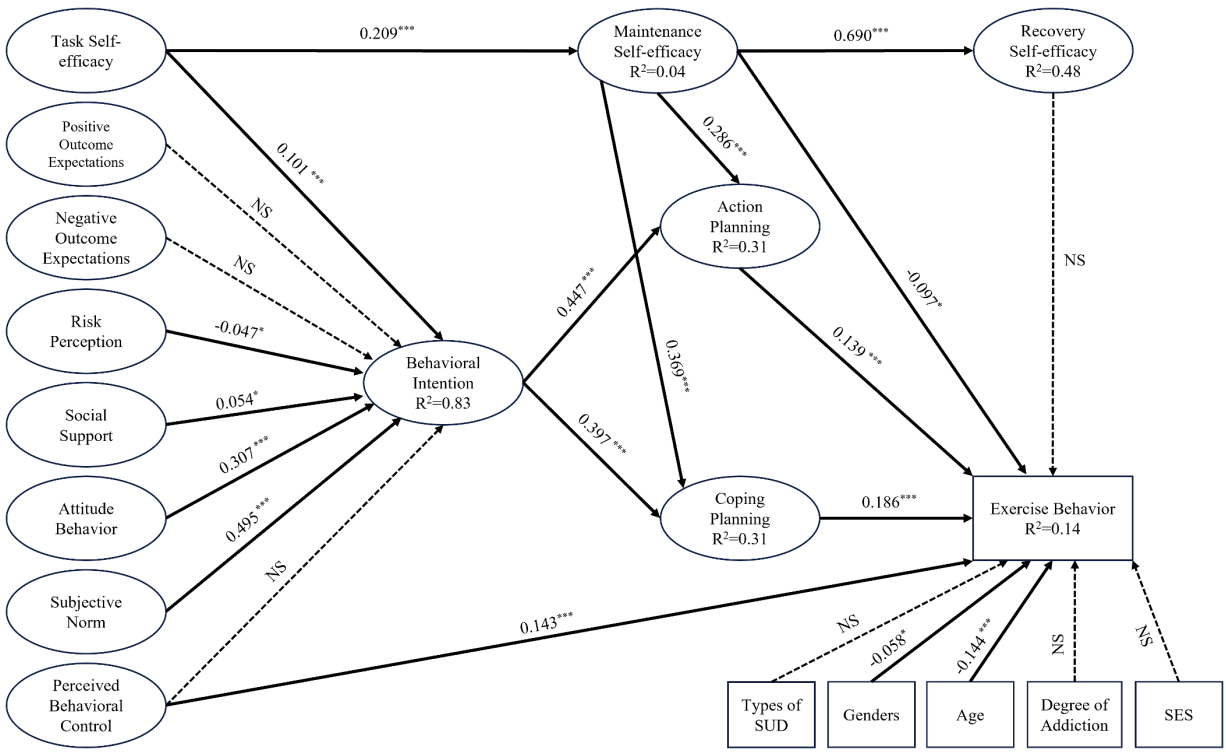

FIGURE 2
Standardized path coefficients of the exogenous variables in the HAPA-TPB integration model for explaining and predicting exercise behavior in individuals with SUDs (M2). Non-significant paths are denoted by NS; $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

planning and their ability to cope with the difficulties of exercise behavior can be improved to promote the maintenance of physical exercise behavior.

4.5 Impact of exogenous variables

Our study also examined the effects of exogenous variables in the HAPA-TPB integration model. The results showed that only gender and age had significant effects on physical exercise behavior in individuals with SUD (β values of-0.058 and-0.144, respectively). Therefore, men with SUD are more likely to form physical exercise habits than women with SUD, although only a small difference exists. Moreover, for all individuals with SUD, the change in physical exercise behavior increasingly decreased with age. These findings are consistent with previous study findings (Hallal et al., 2012; Mao et al., 2020). Therefore, we suggest that during the development of physical exercise behavior in individuals with SUD, it is necessary for rehabilitation staff to provide more social support, more detailed physical exercise program development, and more specific physical exercise guidance to women with SUD and older individuals with SUD to promote the initiation and maintenance of physical exercise behavior in this group. In contrast, addiction type, addiction level, and socioeconomic status did not significantly affect physical exercise behavior in individuals with SUD. Previous studies have concluded that socioeconomic status has a significant effect on physical exercise behavior change (Ford et al., 1991; Cerin and Leslie, 2008; Welford et al., 2023), which was not observed in our study. This may be because the socioeconomic status indices of the respondents in our study were relatively concentrated (as shown in Table 1), and there was no significant difference between the high or low socioeconomic status groups. In addition, the type of addictive drug and the degree of addiction did not significantly affect the results of this integrated model. A possible reason for this difference is that stimulant drugs are more popular than heroin is, and 87.55% of the individuals with SUD in our survey were addicted to stimulant drugs or a polydrug of stimulant drugs or other drugs (as shown in Table 1); alcohol use disorders and tobacco use disorders were not included in our study. To explore the effects of drug addiction-related variables on physical exercise behavior in more detail, further expansion of the survey may be needed.

4.6 Strengths and limitations

This study has several strengths. First, the population studied was unique and indispensable. However, few studies have examined predictors of the initiation and maintenance of exercise behavior in individuals with SUD during physical exercise interventions. This group of individuals, which has become an important public health challenge worldwide, urgently needs to recognize and promote physical exercise based on relevant health behavior theories. Second, this study integrated two classical theories related to health behavior to investigate the determinants of physical exercise behavior in individuals with SUD by considering self-efficacy, behavioral intention, planning, and the exercise stage of physical exercise behavior. This is the first study to investigate the relationship between

HAPA-TPB-related variables and physical exercise behavior in individuals with SUD. Therefore, our study is expected to stimulate additional research focusing on health behavior shaping in the population of people with SUD and to lay the foundation for future theoretical research and provide scientific guidance for rehabilitation practice.

Despite the above findings and strengths, there are several limitations of this study that should be considered. First, our participants were recruited from a compulsory drug rehabilitation center through convenience sampling, which may limit the generalizability of the findings to voluntary drug treatment SUD in community-oriented rehabilitation settings and medical rehabilitation facilities. Future research should investigate the factors influencing behavioral initiation and maintenance during physical exercise interventions in various voluntary drug treatment groups. Second, only 87 women with SUD (7%) were recruited for our survey sample. Although we observed a significant effect of gender on the HAPA-TPB score, this statistical bias may be due to the gender differences in the number of individuals with SUD, and gender was not included as a covariate in the model. Therefore, the sample of women with SUD should be increased in future studies to further validate the validity of the integrated HAPA-TPB model. Third, past exercise behavior or habitual intensity, as well as social cognitive factors, are thought to have direct or indirect effects on behavioral intentions and exercise behavior (Savvidou et al., 2012; Schwarzer, 2016). These factors can be included in future studies on the HAPA-TPB integration model. Fourth, the current study examined only the predictors of physical exercise behavior in individuals with SUD according to the HAPA-TPB integration model through a cross-sectional investigation; therefore, the results could not explain the dynamic effects of the variables of this integration model on chronic physical exercise behavior. Future longitudinal studies should be conducted to investigate the long-term effects of these variables on maintaining physical exercise behavior in individuals with SUD. Fifth, the indicators included in this integrative model were obtained through self-reports rather than direct observation, which may have triggered social approval bias and subjective bias. Therefore, psychological factors associated with SUD should be measured through more objective observation methods and psychological assessments in future studies. It is also expected that the physical exercise behavior of individuals with SUD could be measured by more objective tools, such as an actigraphy monitor based on the 3-axis accelerometer principle. Finally, although the HAPA-TPB integrates physical exercise behavior in individuals with SUD relatively well, the excellent performance of other theoretical models in predicting physical exercise behavior may provide new perspectives, such as self-determination theory (Hagger and Chatzisarantis, 2008; Teixeira et al., 2012) and temporal self-regulation theory, for the explanation of physical exercise behavior in individuals with SUD (Hall and Fong, 2007; Wang et al., 2023).

5 Conclusion

This study demonstrated that the integrated HAPA-TPB model has good applicability and validity for evaluating physical exercise behavior in individuals with SUD. In addition, the integrated model can effectively explain and predict the initiation and maintenance of physical exercise behavior in individuals with SUD. Task self-efficacy, risk perception, social support, behavioral attitudes, and subjective norms are important relational factors for the initiation of physical exercise behavior in individuals with SUD. Behavioral intention is an important mediating variable in the initiation of physical exercise behavior in individuals with SUD. Maintenance self-efficacy and perceived behavioral control are direct factors involved in maintaining physical exercise behavior in individuals with SUD. Action planning and coping planning are indirect factors involved in maintaining physical exercise behavior in individuals with SUD.

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.

Ethics statement

The studies involving humans were approved by Ethics Review Board, Faculty of Sport and Science, Ningbo 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

YM: Writing – original draft, Conceptualization, Investigation, Methodology, Resources. TZ: Conceptualization, Methodology, Writing – original draft. WC: Writing – review & editing, Data curation, Formal analysis, Methodology. HZ: Writing – original draft, Data curation, Formal analysis, Investigation. LT: Data curation, Investigation, Writing – original draft. XWa: Data curation, Investigation, Writing – original draft. ML: Data curation, Investigation, Writing – original draft. XZ: Writing – original draft, Data curation, Investigation. DW: Conceptualization, Funding acquisition, Project administration, Writing – original draft, Writing – review & editing. XWu: Data curation, Investigation, Writing – original draft. SL: Investigation, Writing – review & editing, Data curation. CH: Investigation, Resources, 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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Are cash incentives always king? A randomized controlled trial evaluating hedonic versus cash incentives (TEH-C)

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Introduction: Physical inactivity is a risk factor for obesity and non-communicable diseases. Despite myriad health and non-health benefits resulting from physical activity (PA), most individuals do not meet PA recommendations. Providing an incentive for meeting activity goals may increase activity levels. Classical economists argue that cash is the best incentive. Behavioral economists have posited that hedonic (pleasurable) incentives (e.g., massages, restaurant meals) may be superior to cash when incentives are offered over multiple time periods. To date, no studies have directly compared the effectiveness of cash versus hedonic incentives in promoting PA across multiple time periods.

Methods: We conducted a two-arm, parallel, 4-month randomized controlled trial with healthy adults in Singapore where participants were randomized to either cash or hedonic incentives. Participants could earn up to SGD50 (≈USD37) in cash or hedonic incentives each month they met the study's step target of 10,000 steps daily on at least 20/25 days out of the first 28 days of a month. The primary objective was to compare the mean proportion of months that participants met the step target between the two arms.

Results: By month 4, participants in the cash ($N = 154$) and hedonic incentive ($N = 156$) arms increased their mean daily steps by 870 ($p < 0.001$) and 1,000 steps ($p < 0.001$), respectively. The mean proportion of months the step target was achieved was 90.53 and 88.34 for participants in the cash and hedonic incentive arms respectively, but differences across arms were small and not statistically significant for this or any outcome assessed.

Conclusion: Our findings suggest that both cash and hedonic incentives are effective at promoting physical activity but that neither strategy is clearly superior.

Clinical trial registration: ClinicalTrials.gov, NCT 04618757 registered on November 6, 2020.

KEYWORDS

incentives, rewards, cash, hedonic, randomized controlled trial, steps, accelerometer, physical activity

Introduction

Physical inactivity is a risk factor for obesity and non-communicable diseases (NCDs). It is also a primary driver for rising health expenditures and increased productivity losses (1, 2). By 2030, it is estimated that inactivity will be responsible for INT$520 billion in healthcare expenditures worldwide (3) and INT$34.5 billion due to lost productivity among employees (2).

Despite myriad health and non-health benefits resulting from physical activity (PA) (4), most individuals do not meet PA recommendations (4, 5). One way to increase activity levels is to provide an incentive for meeting activity goals. Classical economic theory suggests that low levels of activity result because individuals do not see the benefits (many of which accrue well into the future) as large enough to offset the immediate costs of the activity, including opportunity costs that may come with forgone earnings or lost leisure time. Incentivizing PA raises the immediate benefits. As shown in several studies, if the incentives are large enough, they will induce greater levels of activity (6–10). If this translates into sustained health improvements, incentives could be cost-effective or even cost saving.

Classical economists argue that cash is the best incentive because it is completely fungible: it could be converted to any non-cash equivalent (11, 12). However, some behavioral economists have posited that hedonic (pleasurable) incentives may be superior to cash when incentives are offered over multiple time periods [11, 13, 14 (Tournament 2)]. The theory of mental accounting explains this hypothesis (15, 16). According to this theory, individuals tend to classify money in a 'cash earnings' account and are prone to spend the earnings on utilitarian items (e.g., groceries, bills) that may provide only low increases in marginal utility. In contrast, hedonic incentives (e.g., massages, movie theater tickets, restaurant meals), when earned, force individuals to apply the incentives to something pleasurable, which has the potential to generate a greater increase in utility than their cash equivalent (11, 17). Hedonic incentives may also trigger positive affect and memories (11, 18). As a result, greater effort may be exerted to earn the incentives in subsequent periods as compared to their cash equivalent (11).

To date, no studies have directly compared the effectiveness of cash versus hedonic incentives in promoting PA across multiple time periods in efforts to test this hypothesis. That is the focus of this effort. We conducted a two-arm individual level randomized controlled trial to test whether modest hedonic incentives are more effective than their cash equivalent in motivating participants to meet monthly step targets over a 4-month period. Our primary hypothesis is that the mean proportion of months that participants meet the step target will be greater in the hedonic incentive arm compared the equivalent cash incentive arm. We also expect mean daily steps and Fitbit® fairly and very active minutes each month to be greater in the hedonic incentive arm compared to the cash incentive arm.

Methods

Study design, recruitment, and participant characteristics

TEH-C (*T*rial *E*valuating *H*edonic versus *C*ash incentives) was a two-arm, 4-month single-blind randomized controlled trial comparing two parallel arms (1:1 allocation ratio): (1) cash incentive, and (2) hedonic incentives. The trial is registered on ClinicalTrials.gov (NCT 04618757). This manuscript conforms to CONSORT reporting guidelines (Figure 1).

General population participants in Singapore were directly recruited via flyers and online advertisements posted on social media platforms (i.e., Facebook and Instagram). All interested participants were directed to the study's website to view more information about the study and to assess eligibility via a screening questionnaire (Screener Questionnaire, Supplementary material). We focused on Singapore's population given that there is a growing emphasis on interventions that can cost-effectively decrease the onset of NCDs. Despite being a highly walkable city with numerous subsidized community-based physical activity programs, 25.1% of Singaporeans are insufficiently active (18). Incentivized physical activity programs have been shown to be effective on an individual level (6, 7) and population level (19). Thus, this population is well-suited for comparing the effectiveness of differing incentive strategies.

Participants were eligible if they were aged between 21 to 70 years, non-pregnant, residing in Singapore, English-speaking, and smartphone-literate. Eligible participants also had to be able to walk up 10 steps without resting, be willing to be randomly assigned to one of the intervention arms and wear a Fitbit® during waking hours throughout the study. Initially, we had used the Physical Activity Readiness Questionnaire (PAR-Q) (20) as screening tool to assess an individual's readiness to safely engage in physical activity. Participants who answered 'Yes' to any of the questions on the PAR-Q (20), which suggests possible risk from increased activity, were deemed 'conditionally eligible' and required written doctor's approval to confirm eligibility. However, this was subsequently changed such that participants who report being on doctor's advice against engaging in moderate-to-vigorous physical activity (MVPA) and/or having a condition that restricts them from engaging in MVPA were deemed 'ineligible'. All others were eligible to enroll.

All interested and eligible participants signed an informed consent document and an oath declaring that they will not cheat when striving to achieve the monthly step goal and that all the incentives they may earn will be obtained solely through their own efforts. This was done to minimize cheating (21). Participants then paid a non-refundable enrolment fee of SGD20 (≈USD14), which was set in place to deter those who were solely motivated to obtain the free activity tracker and were not truly interested in changing their behavior. The enrolment fee amount was determined to be a reasonable amount based on similar activity tracker-based studies in Singapore (6, 7) and was approved by the National University of Singapore Institutional Review Board. Prior to randomization, all participants were required to complete a run-in period by wearing the activity tracker for ≥10 waking hours each day for ≥7 of the past 10 days.

Randomization

Participants who completed the run-in period were randomized with equal probability into either of the two arms (Figure 1) using stratified randomization. Two stratification factors were used, (1) gender and (2) Fitbit®-logged activity levels during the 10-day run-in period with 2 levels: higher activity (at least 5 days with at least 10,000 steps) and lower activity (less than 5 days with at least 10,000 steps).

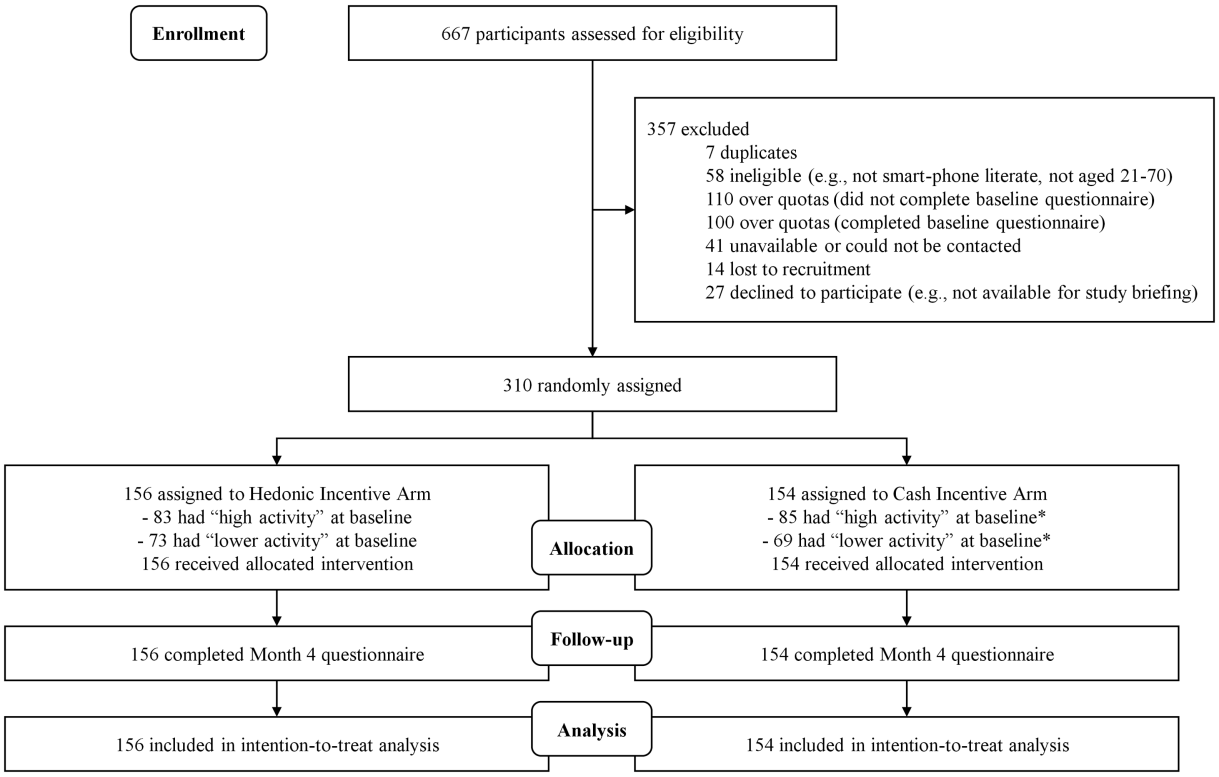

FIGURE 1
CONSORT diagram of TEH-C study participants. *Protocol deviation occured during randomization as 2 participants were randomized incorrectly as 'lower activity' due to oversight/technical errors. Figures shown correctly include the 2 participants in the 'high activity' at baseline group.

Intervention

The incentive amount was set at SGD50 (≈USD37) per month, which was deemed large enough to induce a change in behavior but not so large as to be perceived as unaffordable by prospective payers, which could include employers or governments. Thus, the maximum payout possible was SGD200 (≈USD148) over 4 months. No penalty was incurred if a monthly step target was not met. Instead, participants were encouraged to try again in the subsequent month.

All participants were provided with the wrist-worn Fitbit® Inspire 3 activity tracker upon enrolment but prior to randomization. This tracker automatically links with the Fitbit® app and website. Participants were instructed to try to attain 10,000 steps daily. We selected 10,000 steps/day as a target for the intervention given that it is a simple and commonly supported step-based recommendation (22, 23) that is also displayed on the Fitbit® app and website. To obtain the incentives, we originally set the monthly target to meet this goal on at least 20 days out of the first 28 days of a month. We subsequently increased this target to 25 days a month for the final 190 participants as early data showed that the majority of participants (76.7%) in both arms were meeting the step target, thus reducing the ability to test our hypotheses (Supplementary Table S1).

Participants randomized into the cash arm were awarded SGD50 (≈USD37) each month they met the monthly step target. Those who met the step target were instructed to submit a claim for their incentive payment. This amount was transferred directly into their bank account at month's end or early the next month. Participants randomized into the hedonic arm were reimbursed up to this level for expenses on hedonic activities if they met the same step target. Participants were provided with a list of hedonic incentive options to choose from before the start of each monthly cycle. These included (1) movie tickets and associated expenses (e.g., food and beverages purchased at cinemas), (2) karaoke, (3) manicure / pedicure, (4) massage, (5) dining / food delivery, (6) spa, (7) theme parks and other attractions, (8) video games and associated expenses (e.g., gaming devices and in-game currency), (9) vacation, (10) concerts / musical performances, and (11) other pleasurable experiences which were subject to the research team's approval. Activities or substances that are known to put one's health and wellbeing at risk (e.g., cigarettes, alcohol, gambling), and non-hedonic items (e.g., groceries, consumables) were not eligible. Those who met the step target in the hedonic arm were instructed to submit a claim for their chosen incentive along with a receipt showing proof of expenditure. The claimed amount, up to a maximum of SGD50 (≈USD37), was then reimbursed into their bank account. At any point during the trial, participants in both arms could check their monthly steps progress, claim status, and account balance on our study's website.

Outcomes and assessments

PA outcomes were tracked via the Fitbit®. The primary outcome was defined as the mean proportion of months that participants met the step target out of the 4 months. We chose 4 months as this was the longest duration possible that would allow for testing our hypotheses

and being within the available budget. We also assessed (1) mean daily steps and (2) mean fairly and very active minutes as determined by Fitbit®'s proprietary algorithms. We administered the Global Physical Activity Questionnaire (GPAQ) (24) developed by World Health Organization (WHO) to assess mean daily minutes spent in sedentary behavior and in three domains (1) activity at work, (2) travel to and from places, and (3) recreational activities. This was administered to identify which domain any identified step increase may be coming from. We additionally administered a modified version of the 8-item Physical Activity Enjoyment Scale (PACES) (25) to explore how incentives may impact the experience of engaging in PA. Self-determination theory posits that offering an incentive may undermine the enjoyment of PA (26, 27). This version of the PACES assesses enjoyment of PA on a 7-point scale (1 – *Strongly disagree*, 7 – *Strongly agree*). Scores on all 8 items are summed and averaged, resulting in a score range of 1 to 7 whereby higher scores indicate higher levels of enjoyment. Both the GPAQ and PACES have been validated in Asian populations (28, 29).

Sample size calculation

Data on the variability in the proportion of months meeting the step target (primary outcome) in the presence of incentives is lacking. Therefore, this study was powered to detect a small-to-medium standardized effect size difference of 0.33 (mean difference divided by the pooled standard deviation) in the mean value of the primary outcome between the cash incentive and hedonic incentive arms, with a 80% statistical power and a 5% (two-sided) significance level (30), requiring 292 participants (146 in each arm). The study planned to recruit 310 participants to account for potential attrition.

Statistical analyses

Analyses were conducted on an intention-to-treat basis. Firstly, differences in demographic outcomes between the cash and hedonic incentive arms were assessed using t-test and chi-square tests. We employed generalized linear regressions with identity link function and appropriate distribution function (normal distribution for continuous outcomes and binomial distribution for binary outcomes) to compare outcomes between the cash and hedonic incentive arms, while controlling for gender and baseline PA activity levels (greater or less than 5 days with at least 10,000 steps). Treatment effects, including the proportion of months step target was achieved, daily steps, and daily Fitbit® fairly and very active minutes, were calculated based on activity data pooled over 4 months. Additional sensitivity analyses were performed by imputing missing data for primary and secondary outcomes using the multiple imputation technique with 20 iterations to assess the impact of missing records on the comparison between two arms.

Results

Sample

Figure 1 presents the CONSORT diagram. Overall, 667 participants completed the screener; 310 were eligible and randomly assigned to the two arms. On average, participants were 43.2 years old (SD = 12.9) and 45.8% were male. Most participants (42.9%) reported a monthly household income of ≥ SGD7,000 (≈USD 5,135), were university graduates (76.8%), of Chinese ethnicity (93.9%), and married (52.3%) (Table 1). In comparison, the population in Singapore has a larger percentage of non-Chinese, a lower income, and is less educated (31, 32).

During the run-in period prior to randomization, PA levels were similar between arms. Participants had a mean of 11,900 (SD = 4,400) and 11,700 (SD = 4,050) steps per day in the cash and hedonic arms, respectively (Table 2). In total, 55.2 and 53.2% were in the higher activity group, exceeding 10,000 steps on at least 5 out of 7 days during the run-in period. Participants had a mean of 59.3 and 56.8 Fitbit® fairly and very active minutes a day in the cash and hedonic arms, respectively. These findings suggest that participants are far more active than the typical adult in Singapore (17). There were no significant differences between the arms for any of the demographic variables.

Effect of the incentives on primary and secondary outcomes

As shown in Table 3, participants in both arms increased their mean daily steps during the intervention period compared to baseline. The mean increase was 870 steps (95% CI: 360, 1,370; $p < 0.001$) in the cash arm and 1,000 steps (95% CI: 520, 1,490; $p < 0.001$) in the hedonic arm. Similarly, mean daily Fitbit® fairly and very active minutes increased by 5.86 min (95% CI: 1.66, 10.06; $p < 0.001$) and 9 min (95% CI: 4.71, 13.29; $p < 0.01$) among participants in the cash and hedonic arms, respectively. For both arms, participant responses on the GPAQ suggest that physical activity minutes per day increased in all domains. Only for the travel domain in the cash arm was this increase not statistically significant. Furthermore, while both the cash (mean change from baseline: $\beta = -24.84$; 95% CI: −55.29, 5.61; $p < 0.11$) and hedonic arms ($\beta = -20.32$; 95% CI: −51.48, 10.84; $p < 0.20$) experienced a decrease in minutes spent in sedentary activities, this decrease did not reach statistical significance. Contrary to what self-determination theory would predict, both the cash ($\beta = 0.34$; 95% CI: 0.13, 0.55; $p < 0.01$) and hedonic arm participants ($\beta = 0.40$; 95% CI: 0.19, 0.62; $p < 0.001$) reported an increase in enjoyment of physical activity by the end of the intervention.

However, between-arm comparisons reveal no significant difference for any of the outcomes assessed (Table 3). Sensitivity analysis revealed that the pattern of findings remained unchanged when the model used data with missing records imputed with the multiple imputation technique (Supplementary Table S2).

Discussion

This study investigated the effectiveness of hedonic versus cash incentives in increasing PA levels using a randomized controlled trial design. We found that both strategies were very effective at increasing activity levels when compared to baseline. While these results substantiate the effectiveness of cash and hedonic incentives, between-arm comparisons reveal no meaningful difference for any of the outcomes assessed. Thus, we cannot claim one approach to be superior.

TABLE 1 Participant demographic measures by study arm.

Outcomes		Total	Cash arm	Hedonic arm	*p*
N		310	154	156	
Age, Mean (SD)		43.2 (12.9)	42.6 (13.3)	43.9 (12.5)	0.39[a]
Gender (%)					
	Male	45.8%	45.5%	46.2%	0.90[b]
Ethnicity (%)					
	Chinese	93.9%	94.2%	93.6%	0.83[b]
	Others	6.1%	5.8%	6.4%	
Marital status (%)					
	Married	52.3%	48.7%	55.8%	0.34[b]
	Widowed/ Separated from spouse/ Divorced/Prefer not to say	5.2%	6.5%	3.8%	
	Never married	42.6%	44.8%	40.4%	
Highest education level (%)					
	Up to secondary	6.1%	5.2%	7.1%	0.58[b]
	Post-secondary	17.1%	15.6%	18.6%	
	University bachelor's degree/postgraduate diploma/ degree	76.8%	79.2%	74.4%	
Household income (%)					
	Below SGD 4,000	19%	20.1%	17.9%	0.93[b]
	SGD 4,000–6,999	18.4%	16.9%	19.9%	
	SGD 7,000–9,999	15.8%	14.9%	16.7%	
	SGD 10,000 and over	27.1%	27.9%	26.3%	
	Prefer not to say/Do not know	19.7%	20.1%	19.2%	
Have you ever used a sport and fitness app to track your physical activities? (%)					
	Yes – Using the app now	78.1%	77.3%	78.8%	0.58[b]
	Yes – Used the app before but no longer using	16.5%	18.2%	14.7%	
	No	5.5%	4.5%	6.4%	

[a]*p*-value results based on a *t*-test.
[b]*p*-value results based on a chi-square test.

There are several reasons that could explain the lack of meaningful differences across arms. The most likely could be that individuals do not differentially value these incentive types despite the theory suggesting otherwise. At baseline, when participants were asked to rank their top three preferred incentive choices from a list of tangible and non-tangible incentives with utilitarian or hedonic qualities, the majority chose 'cash payouts', 'vouchers for groceries', and 'vouchers for transportation expenses' in that order (Supplementary Table S3). Other populations have shown a similar preference (32, 33). This suggests a general preference for incentives that have more utilitarian value. Although preferences do not necessarily predict outcomes, offering an incentive that is less preferred by participants could dampen its effectiveness (11). Feedback from participants in the hedonic arm revealed that many did not use the incentives for incremental activities but merely saw them as a way to receive funds for purchases they would have made regardless. This too diminishes the effective of the hedonic incentive strategy.

It is also possible that limitations with our design diluted the effectiveness of the hedonic arm. Unlike cash arm participants, those in the hedonic arm had to spend their own money before being reimbursed. This additional barrier could have created a disincentive but was required by our accounting office to ensure funds were not misallocated. Although possible, only a small number of participants (4.5%) who met the step goal did not submit a claim (Supplementary Table S4). The large increases from baseline coupled with the number of participants (86.5%) who met the step goal and submitted a claim suggests this is unlikely to be driving the results.

Furthermore, our study may have been underpowered to detect differences across arms. Given the high success rate observed early in the study, in efforts to generate greater variability in the primary outcome, we raised the incentive target from 20 to 25 days a month of 10,000 or greater steps. Although this change reduced the percentage of participants who met the monthly target, as expected, we again observe no meaningful difference between arms (Supplementary Table S1). Additionally, given that participants in this

study were found to be more active than the typical adult in Singapore (18), our sample may exhibit selection bias as individuals who are more physically active may have been more likely to enroll into the study. Hence, caution should be exercised when generalizing our study's results.

Given that individuals in both arms greatly increased their step activity during the intervention period, and differences between arms were small and with overlapping confidence intervals, the most likely conclusion is that both strategies are effective, and neither is clearly superior to the other. This finding is consistent with results from a literature review that compares several behavioral economic incentive strategies (e.g., lotteries, deposit contracts) versus cash incentives (13). Although that review did not include hedonic incentives and studies varied along multiple dimensions (e.g., duration, size of incentives, location), their general conclusion was these strategies are effective, at least in the short run, and, as in our case, no single strategy outperformed the others. Our results are also consistent with prior studies that have tested the effectiveness of cash vs. hedonic incentives in other domains, including employee performance and experimental tasks (14 (Tournament 1), 33, 35). These studies also found no differences in effectiveness.

It is worth noting that contrary to what self-determination theory would predict (26, 27), both the cash and hedonic arm participants reported an increase in enjoyment of physical activity at study conclusion based on the PACES scores. Thus, there appears to be no undermining effect of the incentives. This finding is important as increased enjoyment is predictive of habit formation and maintenance (25), thus it is possible that the behaviors could be sustained even after the incentives are removed. Past studies have also suggested that removing hedonic incentives could be less detrimental to performance (17, 35). Testing differential responses to incentive removal could be an area of future research.

Additionally, a limitation of our study is that participants were of higher income and more highly educated than the typical Singaporean. It is possible that cash and hedonic incentives could have differential effectiveness for lower income populations (12). These individuals have less disposable income such that the marginal value of cash may be greater for them. However, they may also experience fewer hedonic pleasures, such that the hedonic arm may be more effective for them. Testing the differential effectiveness of the two interventions in lower income populations could also be an area of future research.

Lastly, future studies may benefit from examining clinical health improvements associated with increases in physical activity. Although establishing clinical health improvements was not the focus of this study, the significant increases in daily steps of 870 steps and 1,000 steps within the cash and hedonic incentive arms, respectively, are comparable to clinically significant levels of step increments (36, 37). Indeed, increases in daily steps of up to 15,000 steps and 20,000 steps have been shown to exhibit an inverse relationship with all-cause and cardiovascular mortality (36). Specifically, every 500-step increment was associated with a 15% decreased risk of all-cause mortality, whereas a 1,000-step increment was associated with a 7% decreased risk of cardiovascular mortality (36). Therefore, examining clinical health improvements in future studies may lend more compelling

TABLE 2 Baseline physical activity levels and enjoyment by study arm.

Outcomes, Mean (SD)	Cash arm ($N = 154$)	Hedonic arm ($N = 156$)
High baseline physical activity level (at least 5 days with at least 10,000 steps), *N* (%)	85 (55.2%)	83 (53.2%)
Mean daily steps (in '000)	11.9 (4.4)	11.7 (4.05)
Mean daily Fitbit® fairly and very active minutes	59.3 (40.07)	56.8 (37.90)
[a]Total physical activity (minutes per day)	84.3 (94.17)	79.1 (94.39)
[a]Activity at work (minutes per day)	12.6 (37.25)	14.9 (41.51)
[a]Travel to and from places (minutes per day)	37.9 (54.76)	35.0 (51.96)
[a]Recreational activities (minutes per day)	33.8 (37.88)	29.2 (42.71)
[a]Sedentary activities (minutes per day)	442.6 (206.50)	441.4 (202.04)
[b]Physical activity enjoyment	4.9 (1.28)	4.7 (1.16)

[a]As measured by GPAQ = Global Physical Activity Questionnaire.
[b]As measured by PACES = 8-item Physical Activity Enjoyment Scale.

TABLE 3 Mean (95% CI) in physical activity levels and enjoyment over 4 months.

Outcomes	Cash arm ($N = 154$)	Hedonic arm ($N = 156$)	Difference[a] (Hedonic Arm-Cash Arm)	SES[a]
Proportion of months step target was achieved	90.53 (86.87, 94.20)	88.34 (84.71, 91.98)	−2.19 (−7.33, 2.95)	−0.10
[b]Change in daily steps from baseline (in '000)	0.87*** (0.36, 1.37)	1.00*** (0.52, 1.49)	−0.02 (−0.49, 0.44)	−0.01
[b]Change in daily Fitbit® fairly and very active minutes from baseline	5.86** (1.66, 10.06)	9.00***(4.71, 13.29)	0.87 (−4.04, 5.78)	0.04
[b,c]Change in total physical activity from baseline (minutes per day)	31.04** (12.01, 50.08)	44.29*** (23.86, 64.73)	9.14 (−16.94, 35.21)	0.08
[b,c]Change in activity at work from baseline (minutes per day)	16.71** (5.23, 28.19)	10.19* (0.82, 19.56)	−3.81 (−18.71, 11.08)	−0.06
[b,c]Change in travel to and from places from baseline (minutes per day)	3.79 (−6.52, 14.11)	17.62*(3.02, 32.23)	11.40 (−4.27, 27.06)	0.16
[b,c]Change in recreational activities from baseline (minutes per day)	10.54** (2.78, 18.30)	16.48** (6.54, 26.42)	1.55 (−10.23, 13.33)	0.03
[b,c]Change in sedentary activities from baseline (minutes per day)	−24.84 (−55.29, 5.61)	−20.32 (−51.48, 10.84)	2.49 (−38.45, 43.43)	0.01
[b,d]Change in physical activity enjoyment from baseline	0.34** (0.13, 0.55)	0.40*** (0.19, 0.62)	−0.13 (−0.39, 0.13)	−0.11

CI, confidence interval; SES, Standardized effect size.
[a]Between arm comparison results based on a generalized linear model adjusted for baseline activity level and gender.
[b]Within arm comparison results are based on the paired t-test.
[c]As measured by GPAQ = Global Physical Activity Questionnaire.
[d]As measured by PACES = 8-item Physical Activity Enjoyment Scale.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

evidence to justify investments toward incentivized physical activity programs.

Notwithstanding, the initial evidence drawn from the findings of this study suggest that hedonic incentives can be a viable and potentially more cost-effective alternative to cash incentives. Although we had set SGD50 (≈USD37) as the maximum hedonic incentive amount to allow participants greater flexibility and freedom to engage in a variety of hedonic activities, hedonic rewards can often be purchased at lower cost than their cash equivalent when purchased in bulk (e.g., spa packages). Therefore, funders of physical activity programs may be able to offer a SGD50-like experience without needing to spend the same amount, making hedonic incentives a more cost-effective and sustainable option than cash incentives. Future programs could leverage on hedonic incentives in designing physical activity programs that are more likely to enhance enjoyment and engagement over time by catering to a wide spectrum of preferences and motivations.

Conclusion

This study demonstrated the effectiveness of cash and hedonic incentives to increase activity levels over a 4-month period. Individuals in both arms greatly increased their step activity during the intervention period relative to baseline. Differences between arms were small and not statistically significant, suggesting that either strategy represents a viable approach for increasing activity levels.

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 National University of Singapore Institutional Review Board (Approval Number: NUS-IRB-2020-65). 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

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

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1354814/full#supplementary-material

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Basic psychological need satisfaction of collegiate athletes: the unique and interactive effects of team identification and LMX quality

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Purpose: The present study sought to understand the relationships between team identification, leader-member exchange (LMX) quality, and the basic psychological need satisfaction of collegiate athletes, as well as the moderating role of coach-athlete LMX quality.
Methods: Self-reported data from 319 collegiate athletes were analyzed using SPSS version 29. The relationships between the study variables were tested by moderation analysis using PROCESS macro model 1.
Results: Regression analyses showed team identification to be positively related to the satisfaction of the needs for competence and relatedness, while LMX quality was positively related to the satisfaction of the needs for competence and autonomy. Furthermore, moderation analyses showed that LMX quality positively moderated the relationship between team identification and the satisfaction of the needs for competence and relatedness.
Conclusion: The results of this study highlight the important role that team identification and LMX quality play in the satisfaction of the basic psychological needs of collegiate athletes. The implications of these results for the optimal functioning of collegiate athletes are discussed.

KEYWORDS

basic psychological needs, student athletes, team identification, coach-athlete relationship, LMX

1 Introduction

Student athletes must cope with a unique combination of demands and expectations. On the one hand, they have to deal with sport-related stressors such as performance pressure, fatigue, and injuries. On the other hand, they must also manage the demands and the workload associated with their academic position (1, 2). This situation forces them to excel in both areas in order to maintain their student athlete status (3). As a consequence of these challenges, mental health and well-being issues are particularly prevalent in the student athlete population [e.g., (4–7)]. More precisely, research has shown that in university environments, the prevalence of athletes living with a mental health problem can reach 18% (3). Moreover, according to Åkesdotter et al. (8), 50% of athletes could experience a mental health issue during their career. These findings highlight the importance of understanding the factors that contribute to the optimal functioning of student athletes.

On that matter, previous studies have consistently shown that the satisfaction of student athletes' basic psychological needs (BPNs) for competence, autonomy, and relatedness plays a key role in terms of promoting their well-being, their performance, their motivation, and their personal growth (9–11). BPNs are described by Ryan et al. as "essential psychological nutrients for individuals' adaptation, integrity, and growth" [(12) p. 1]. Moreover, the satisfaction of these three BPNs has also been negatively related to stress and injuries (12), and to athlete burnout (13–15). While past studies have contributed to clarifying the benefits of BPN satisfaction for student athletes, our understanding of the social factors that relate to the satisfaction of those needs is still very limited (16). To address this important gap, the present study draws from self-determination theory [SDT; (11, 17)], and more specifically from basic psychological needs theory [BPNT; (18)] to investigate the social factors that contribute to the BPN satisfaction of student athletes. Importantly, BPNT posits that social environments can facilitate or hinder the satisfaction of BPNs. Considering that social relationships play a pivotal role in the sport context (19, 20) and that the team and the coach are crucial relational targets for student athletes, our study aims at better understanding the relationships between these two social factors and the satisfaction of the BPNs of student athletes. Specifically, we examine the relationships between athletes' level of team identification (21) and of coach-athlete relationship quality, as captured by leader-member exchange [LMX, (22, 23)], and the level of satisfaction of their BPNs.

While the relation between team identification and BPN satisfaction has not been examined among student athletes, research has shown that teammates are crucial social agents in facilitating athletes' fulfillment of these needs (24, 25). Team identification as defined by Ashforth and Mael (21), refers to the extent to which an individual derives their sense of self from belonging to a team, reflecting their level of connection to that team. In this regard, Greenaway et al. (26) found that social identity gain promoted the satisfaction of the global psychological needs for control, self-esteem, belonging and meaning, while social identity loss thwarted the satisfaction of these needs. These results suggest that student athletes who have greater levels of identification with their team may experience greater need satisfaction. Despite the significance of social identification in sport psychology (27), the specific association between student athletes' level of team identification and the satisfaction of their BPNs for competence, autonomy and relatedness remains unexplored.

Regarding coaches, it appears that the coach-athlete relationship is also crucial in the sport context (28) in terms of creating a positive social environment for athletes (29). Congruently, Chu & Zhang's (30) review of 20 studies shows that positive social environments fostered by coaches and peers are positively related to athletes' satisfaction of their BPNs. In this regard, leader-member exchange (LMX) theory examines the dyadic relational quality between a leader and a member (31). Chen et al. (32) theorized that LMX quality promotes outcomes which significantly overlap with the satisfaction of BPNs, namely, employees' perception of competence and choice. Consistently, manager-employee LMX quality was found to be positively related to the satisfaction of the BPNs for competence, autonomy and relatedness of employees (33). BPN satisfaction was also found to mediate the relationship between LMX quality and well-being among counselors (34). Due to the relational similitudes between the manager-employee and the coach-athlete relationships, similar relations are expected to emerge in the sport context (35). Nonetheless, the relationship between coach-athlete LMX quality and the satisfaction of the BPNs of student athletes is yet to be investigated.

Moreover, coach-athlete LMX quality has yet to be investigated as a moderator of the relationship between team identification and the satisfaction of the BPNs of student athletes. Indeed, since the coach-athlete relationship is embedded within the team context, it may be that the strength of the relationship between team identification and the BNP satisfaction of student athletes depends on the level of LMX quality of the coach-athlete relationship. In response to these shortcomings, the present study examines the unique and interactive relationships of team identification and LMX quality with the satisfaction of the three BPNs of student athletes.

This study makes important contributions to the sport psychology literature. First, by examining the relationship between team identification and the BPNs of student athletes, this study deepens our understanding of the influence of the team as a key social factor promoting the satisfaction of the BPNs of student athletes. Moreover, by exploring the relationship between LMX quality and the satisfaction of the BPNs of student athletes, this study furthers our knowledge of the role of coach-athlete relationship quality in the optimal functioning of student athletes. Lastly, by examining LMX quality as a moderator of the relationship between team identification and BPN satisfaction, this study uncovers the interactive effect of these two key social factors in facilitating the satisfaction of the BPNs for competence, autonomy, and relatedness of student athletes. Practically, our research may help coaches and sports organizations identify the actions they can take to promote the optimal functioning of their student athletes.

1.1 Theoretical background and hypotheses

Self-determination theory is a key theory to understand human motivation and functioning (11). As a metatheory, SDT encompasses six mini-theories, one of which is basic psychological needs theory. According to BPNT, needs are universal and essential nutriments for optimal functioning, and individuals must satisfy three BPNs in order to experience growth, integrity and well-being. First, the need for competence corresponds to the need to feel effective and capable in one's interactions with the environment so as to achieve desired outcomes. Second, the need for autonomy is the need to feel free to choose and organize one's activities and behaviors, as well as endorsing one's decisions and behaviors as coming from oneself. Third, the need for relatedness refers to a need to feel close to others, be part of a group and have reciprocal relationships characterized by respect, care, and support (10, 36–38). In this regard, a key source of satisfaction of these needs is the social environment individuals find themselves in (11, 18).

1.2 Team identification and basic psychological need satisfaction

According to social identity theory (39), one's social identity corresponds to "that part of an individual's self-concept which derives from his/her knowledge of his/her membership of a social group (or groups) together with the value and emotional significance attached to that membership". [(40) p. 255] By extension, social identification is the perception of being one with a group of people (e.g., a team, an organization). Such identification leads to behaviors which are congruent with one's social identity, as well as support for activities and organizations which exemplify it. In light of this, we argue that student athletes' level of team identification will positively influence the satisfaction of their BPNs.

First, regarding the satisfaction of the need for competence, when student athletes perceive that they are key members of their team and that this membership is personally significant to them, they are likely to act and feel in accordance with the norms and values of the team. Integrating parts of a group's values and goals into their self-concept also intensifies the impact of group experiences on individual outcomes (41), such as personally experiencing the successes and failures of their team (42). Thereby, greater team identification is likely to lead student athletes to experience the accomplishments of their team more strongly and personally. In this regard, SDT predicts that such perceived accomplishments will provide student athletes with greater opportunities to feel effective and competent (18). Furthermore, social identification with a group promotes a sense of embeddedness within one's social network and an increase in social support from the group, resulting in greater self-efficacy beliefs (43). Although perceived competence and self-efficacy beliefs are theoretically and statistically distinct constructs, self-efficacy is strongly and positively related to perceived competence in the context of physical exercise (44). Hence, student athletes who identify strongly with their team are likely to feel more embedded within and supported by their social network, which is likely to promote the level of encouragement and positive feedback they receive. According to SDT, such feedback promotes the satisfaction of the need for competence (18).

Second, when it comes to the need for autonomy, previous research shows that identification with a group leads to a higher likelihood of thinking and acting in terms of membership with the group, as well as support for activities associated with it (21, 45). In light of this, student athletes who strongly incorporate their team membership into their sense of self may internalize team concordant goals and behaviors. In this regard, SDT posits that the perception of choice and internal initiation of behavior is key to the satisfaction of the need for autonomy (18). Thus, student athletes who are highly identified with their team may perceive their decisions and behaviors within their sports team as more self-endorsed, resulting in greater satisfaction of their need for autonomy. Conversely, student athletes who do not identify strongly with their team may experience the demands and expectations of their team as sources of control, resulting in lower satisfaction of their need for autonomy.

Third, in terms of the need for relatedness, past scholarship shows that group identification increases group cohesion, cooperation, pro-social behavior and positive outlook on the group (46, 47). Hence, student athletes who strongly identify with their team are more likely to feel valued by their teammates, thereby facilitating the emergence of reciprocal relationships and close social ties. According to SDT, this social connectedness is likely to promote the satisfaction of the BPN for relatedness (18). Moreover, social identification is posited to lead to a sense of belongingness and unity with the group (48) Thereby, student athletes who strongly identify with their team are likely to experience increased satisfaction with their social relations as well as greater feelings of belongingness with their team, resulting in heightened satisfaction of their need for relatedness. In line with this reasoning, we posit:

> *H1: Team identification is positively related to the satisfaction of the need for (a) competence, (b) autonomy, and (c) relatedness.*

1.3 Leader-member exchange quality and basic psychological need satisfaction

Another key social factor in the sport context is the coach. Indeed, the coach-athlete relationship can have an important influence on student athlete outcomes (25, 49–51). In this regard, leader-member exchange (LMX) theory is a model of leadership which examines the quality of the dyadic relationship between a leader and a follower (22, 23). LMX posits that leadership is a partnership between two individuals which develops over time. This relation is initially characterized by contractual, formal and hierarchical exchanges. Then, it matures towards exchanges which transcend self-interest and which are based on reciprocal influence (8). In a high-quality exchange, the leader provides key resources and the member gives support, resulting in a mutually benefiting relationship. In a low-quality exchange, the member does not have access to such important resources and is given fewer opportunities from their leader (52). On this matter, in a social context characterized by a high coach-athlete LMX quality, SDT predicts that the BPN satisfaction of athletes will be supported (18).

Indeed, coach autonomy support has been found to predict BPN satisfaction in multiple sports contexts (53–55). Moreover, coach-athlete relationship characteristics such as quality, interdependence, and rapport have also been positively related to the satisfaction of the BPNs of athletes (25, 49–51). These related concepts are similar to LMX quality in that they capture the reciprocal and non-contractual characteristics of coach-athlete relationships. Thus, based on SDT and past findings, we argue that coach-athlete LMX quality is positively related to the satisfaction of the BPNs of student athletes.

First, SDT states that to satisfy their need for competence, student athletes must perceive that they are effective in influencing their environment (18). This influence often takes the form of contributing to the success of their team, progressing towards valued goals, and overcoming difficulties. On that matter, SDT states that positive feedback is crucial to the perception of being effective in impacting one's environment (18). As the main figure

of authority and leadership in the team, the coach is the most important source of such opportunity and feedback for student athletes. In this respect, high LMX quality relationships are likely to be characterized by superior performance feedback due to their high levels of trust. Moreover, previous work has shown that opportunities to perform are crucial to the perceived sense of competence of student athletes (56). On this point, high quality exchanges provide opportunities for development since leaders in these relations encourage and support followers to engage in challenging tasks (57). Furthermore, since high LMX quality relations are characterized by liking and professional respect (58), they are likely to provide optimal levels of challenges (33). Lastly, leaders engaged in high LMX quality relationships also share positive expectations of superior performance (59) and provide mastery experiences (60), which are also likely to bolster the student athlete's sense of competence. Thus, we argue that greater LMX quality is likely to promote the satisfaction of the need for competence of student athletes.

Second, when it comes to the need for autonomy, SDT posits that individuals must perceive themselves as being able to freely make decisions and to act them out. They need to perceive that they have a choice and that their behavior is self-initiated in order to satisfy this need (18). Since the coach is the formal authority figure in the sport context, he/she is an important source of autonomy or control for the student athlete. In high quality LMX relationships, leaders tend to reduce control and provide more opportunities for members to engage in the decision-making process (33, 61, 62), which is likely to increase the satisfaction of their need for autonomy. Moreover, due to the trust which is characteristic of high LMX quality relations (58) the coach is likely to give more independence to their athlete. Conversely, the impersonal and contractual nature of low LMX quality relations is likely to be experienced by student athletes as stifling their ability to make meaningful decisions and as making them more dependent on their coach's will, thus reducing their perceived autonomy.

Third, SDT states that to satisfy the need for relatedness, individuals need to perceive that they have close and satisfying social ties (18). Consistently, high LMX quality relations are characterized by reciprocal interactions, as well as social and emotional support to followers (33, 63). Characteristic properties of high-quality LMX relationships such as obligation and trust (58) are also closely related to the caring and respectful relations which tend to satisfy the need for relatedness (36). Accordingly, high quality LMX relationships are likely to bolster student athletes' experience of closeness and reciprocity with their coach, promoting the satisfaction of their need for relatedness. Such relations may also provide student athletes with greater access to the coach's social network (64), leading to more stable and satisfying relations with other members of the organization. Conversely, low LMX quality relations produce impersonal and transactional relations which are not likely to generate close and caring relations, resulting in lower satisfaction of student athletes' need for relatedness. Based on SDT and previous findings, we posit:

> *H2: LMX quality is positively related to the satisfaction of the need for (a) competence, (b) autonomy, and (c) relatedness.*

1.4 The moderating effect of LMX quality

As previously discussed, the team and the coach of student athletes are two key social factors influencing the satisfaction of their BPNs. Moreover, due to the embeddedness of the coach within the team, it may be the case that these factors interact in predicting BPN satisfaction. Indeed, SDT states that multiple elements of the social context can support or thwart need satisfaction within a given situation (18). For example, a study by Fraina (65) found positive interactions between the coach and teammates in predicting the BPN satisfaction of athletes. In line with this finding, we argue that when student athletes have a high-quality LMX relationship with their coach, the positive association between team identification and the satisfaction of their BPNs will be amplified. Conversely, when student athletes have a low-quality LMX relationship with their coach, the strength of the relationship between team identification and need satisfaction will be dampened. In other words, we posit that coach-athlete LMX quality moderates the relationship between team identification and the satisfaction of the BPNs of student athletes.

Considering the need for competence, when team identification is high, student athletes may experience their team's successes as coming from themselves (42). However, if LMX quality is low, the coach may not provide the challenges and opportunities to fully take part and internalize the team's victories (33). Moreover, in low quality relationships, the coach may not provide sufficient levels of feedback and personal recognition, which are key for student athletes' perception of being part of team success. Following SDT logic, this situation is likely to reduce student athletes' perception that they are effective in their sport and that they are actively contributing to their team. In other words, low quality LMX relations are likely to dampen the influence of team identification on the satisfaction of the need for competence. Conversely, when LMX quality is high, opportunities to take part in team victories, performance feedback, and recognition from the coach are likely to amplify the influence of high team identification on the satisfaction of the need for competence by making team successes even more salient and personally experienced.

Regarding the need for autonomy, high team identification may increase student athletes' perception of volition in their team since they perceive their behaviors as more consistent with their sense of self. Nonetheless, if LMX quality is low, the coach is likely to exercise more authority and control due to low levels of trust, thus dampening the perception of volition stemming from student athletes' identification with their team. According to SDT, this presence of control is likely to reduce the perceived autonomy of the athlete (18). On the other hand, if LMX quality is high, greater levels of trust are likely to reduce the level of control exercised by the coach, promoting student athletes' perception that their behaviors in the team context are self-endorsed, thus amplifying the impact of high team identification on the satisfaction of their need for autonomy.

Considering the need for relatedness, high team identification may foster student athletes' sense of belongingness (48) and of being valued by their teammates, both of which are predicted by SDT to promote perceived relatedness (18). However, if LMX

quality is low, student athletes may not benefit from the social-emotional support of the coach (63, 64), reducing their perception of being an important member of their team, and dampening the influence of team identification on the satisfaction of their need for relatedness. Conversely, if LMX quality is high, support from the coach is likely to promote student athletes' perception of being socially valued and accepted in their team, thereby amplifying the influence of high team identification on the satisfaction of their need for relatedness. Thus, as shown in Figure 1, we posit:

> *H3: LMX quality positively moderates the relationship between team identification and the satisfaction of the need for (a) competence, (b) autonomy, and (c) relatedness, such that this relationship is strengthened when LMX quality is high and weakened when it is low.*

2 Method

2.1 Participants and procedures

Respondents were recruited to participate in this study via email by their sports department administrator. In terms of eligibility, participants had to be enrolled as collegiate-level athletes at the time of data collection. Only participants who met this criterion received an email invitation to participate in the study. The email contained a short description of the study and a link to the online questionnaire. The informed consent form and our survey were published on the platform Qualtrics. Participants were informed that their participation was completely voluntary and that their answers would remain anonymous. All information that would compromise respondent anonymity was removed from the dataset prior to data analysis. Data collection started in June 2022 and concluded in March 2023. In this period, around 1,000 collegiate athletes received an invitation to participate. Overall, our response rate was 32%.

Our sample consisted of 319 student athletes from two major universities. Student athletes were part of teams in the following sports: track and field (14.4%), swimming (11.6%), rugby (9.7%), soccer (9.7%), volleyball (9.7%), cheerleading (6.3%), badminton (5.6%), tennis (5.6%), basketball (5.6%), football (5.3%), golf (3.4%), cross-country (3.1%), alpine skiing (2.5%), triathlon (2.2%), other (2.2%), hockey (1.6%) and cross-country skiing (1.3%). Athletes were part of masculine ($n = 92$, 29%), feminine ($n = 137$, 43%), and mixed sports teams ($n = 90$, 28%). The average team tenure was 2.4 years ($SD = 1.4$). The coach-athlete relationship spanned 2.4 years on average ($SD = 1.5$). Cross-sectional data was obtained through an online questionnaire including 28 items. Participants were asked to rate each item on a Likert scale ranging from 1 = strongly disagree to 7 = strongly agree.

2.2 Measures

Table 1 reports the internal consistency of measures. Based on Cronbach's alpha, all measures show adequate reliability.

2.2.1 Team identification

We adapted the four-item social identification (FISI) scale to assess team identification (66). More precisely, two items are adapted from Doosje et al. (67): "I feel committed to my sports team" and "I identify with my sports team". The two others are "I am glad to be part of my sports team", and "Being part of my sports team is an important part of how I see myself" (68).

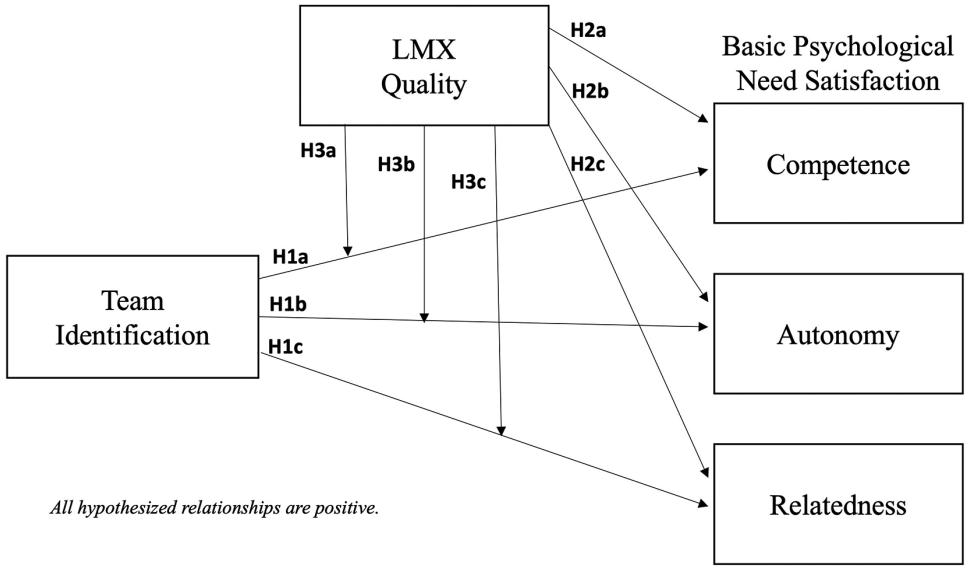

FIGURE 1
Hypothesized research model.

TABLE 1 Means, standard deviations, correlations, and reliability indices.

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Team tenure	2.37	1.44	–							
2. Coach-athlete dyadic tenure	2.41	1.45	.60*	–						
3. Team identification	6.12	.89	.05	.16*	(.78)					
4. LMX quality	5.63	1.33	-.08	.09	.38*	(.96)				
5. Basic psych. need satisfaction	5.44	.76	.05	.18*	.56*	.61*	(.84)			
6. Competence	5.12	1.02	.14	.17*	.38*	.41*	.75*	(.77)		
7. Autonomy	5.18	1.15	-.01	.13*	.29*	.62*	.78*	.32*	(.82)	
8. Relatedness	6.02	.86	-.04	.11*	.63*	.29*	.71*	.35*	.33*	(.85)

M and *SD* are used to represent mean and standard deviation, respectively. Cronbach's alphas are presented in parentheses on the diagonal.
*$p < .05$.

2.2.2 Leader-member exchange quality

We adapted the seven-item Leader-Member Exchange 7 Questionnaire (69) to measure the quality of the dyadic relationship between the coach and the student athletes. To do so, we changed the referent in the original measure, which was the "immediate supervisor", to the "coach". The items were also adapted to fit with the sports context and to facilitate the understanding of items by respondents (i.e., student-athletes). The adapted items are (1) "In general, I know where I stand with my coach", (2) "My coach understands my problems and my needs", (3) "My coach recognizes my achievements and my potential", (4) "My coach is personally inclined to help me solve problems in my sport practice", (5) "I can count on my coach to support me when I need it", (6) "My coach has enough confidence in me that he/she would defend and justify my decisions if I were not present to do so" and (7) "The interactions with my coach are effective". The phrasing of items was adapted to fit with the Likert agreement scale used throughout our questionnaire. Specifically, interrogative items such as "How well do you feel that your immediate supervisor recognizes your potential?" were transformed into declarative items "My coach recognizes my achievements and my potential". Confirmatory factor analysis was conducted in Mplus (version 8.7) using the MLR estimator. The one-factor LMX quality measure showed excellent fit based on CFI, TLI and SRMR, and marginally acceptable fit based on RMSEA [$\chi^2(14) = 57.196$, $p < .001$, CFI = .968, TLI = .953, RMSEA = .098, SRMR = .024].

The questions relating to the two measures above were translated from English to French by two members of our research team who are fluent in both languages. The first author translated the items from English to French. The fourth author compared the items to ensure that their meaning did not change. The translated items were then tested for accuracy in a small subsample of the target population before their administration in the main study.

2.2.3 Basic psychological need satisfaction

We used the 15-item satisfaction of fundamental needs in sports scale [*l'échelle de satisfaction des besoins fondamentaux en contexte sportif*; (16)] to assess the satisfaction of the BPNs for competence, autonomy, and relatedness. Each subscale included five items. Items include "In my sport, I feel free to make choices", "In my sport, I do not feel very competent" (reversed), and "In my sport, I feel at ease with others".

2.2.4 Control variables

Our first control variable is the number of years each collegiate athlete has been part of their sports team (i.e., team tenure). We also controlled for the number of years each collegiate athlete has been in relation with their coach (i.e., coach-athlete dyadic tenure). In past research, tenure is controlled based on researchers' objectives. For example, Chaudhry et al. (70) controlled manager organizational tenure and employee-manager dyadic tenure to determine the level of alignment of perceived LMX between employees and managers. In our case, team tenure can impact student athletes' level of identification with their team, as well as the satisfaction of their BPNs. For coach-athlete dyadic tenure, the length of the relationship can impact LMX quality (71).

2.3 Statistical analysis

In this study, all statistical analyses were performed using SPSS 29.0. Preliminary analyses and tests of hypotheses were conducted as follows. First, descriptive statistics were performed to highlight the characteristics of the sample. Second, principal component analysis using explained variance and correlation analysis using Pearson's coefficient were conducted to detect common method bias. Third, Cronbach's alpha values were computed to assess the reliability of our measures. Descriptive statistics were also conducted to examine the means and standard deviations of study variables and correlation analysis was performed to identify the relations between them. Fourth, the variance inflation factor was calculated to test for the presence of multicollinearity between variables. Fifth, tests of hypotheses were performed through moderation analyses using Process Macro model 1 (72). Team identification was used as the independent variable, LMX quality was used as the moderator, and the satisfaction of the BPNs for competence, autonomy and relatedness were used as the dependent variables. The statistical significance level of all tests was set at $p < .05$.

3 Results

3.1 Common method variance

Since we are using cross-sectional, single-source data, we assessed common method bias before testing our hypotheses.

TABLE 2 Moderation analyses.

	Competence		Autonomy		Relatedness	
	Est.	SE	Est.	SE	Est.	SE
Control variables						
Team tenure	0.16*	0.06	−0.01	0.06	−0.10	0.05
Coach-athlete tenure	0.01	0.06	0.07	0.06	0.07	0.05
Predictors						
Team identification (TI)	0.30*	0.05	0.06	0.05	0.66*	0.05
LMX quality	0.36*	0.05	0.59*	0.05	0.08	0.05
Interaction						
TI × LMX quality	0.11*	0.03	0.00	0.03	0.11*	0.03
R^2	0.28		0.39		0.43	

Standardized estimates are reported.
*$p < .05$.

This was done to verify if the variance of our study variables was true variance, or if it was due to common measurement method. First, we conducted Harman's single factor test (73). This technique uses exploratory factor analysis in which variables are constrained so that there is no rotation. According to Podsakoff et al. (74), if the single factor or one general factor explains more than 50% of the variance, common method bias is present. Results of principal component analysis in SPSS 29.0 revealed that 5 distinct factors from 26 items accounted for 69% of the total variance. The first unrotated factor captured 37% of the variance in our data. Hence, no single factor accounted for most of the variance in the data.

Second, we used the correlation matrix procedure to determine common method bias. According to Bagozzi et al. (75), a substantial correlation ($r \geq .90$) among principal constructs indicates common method bias. By examining the principal constructs in our correlation matrix, we identified the strongest association as that of team identification and the satisfaction of the need for relatedness ($r = .63$). Thus, evidence supports the idea that common method bias is not a major issue in our data. Table 1 presents the means, standard deviations, correlation coefficients and reliability indices for our constructs.

3.2 Test of hypotheses

Moderation analyses were performed with SPSS 29.0, using Process Macro model 1 (72) and a 95% confidence interval. Team tenure and coach-athlete dyadic tenure were controlled for in our model. Before performing our analyses, we calculated the variance inflation factor (VIF) to test for the presence of multicollinearity. Since the VIF score was lower than 2.5 (VIF = 1.2), we considered that there were no multicollinearity problems (76). The results of these analyses are presented in Table 2.

As expected, we found team identification to be moderately related to the satisfaction of the need for competence ($\beta = .30$, (313), 95% CI [0.19, 0.40]), and strongly related to the satisfaction of the need for relatedness ($\beta = .66$, (313), 95% CI [0.56, 0.75]), supporting H1a and H1c. However, no significant relationship was found between team identification and the satisfaction of the need for autonomy, providing no support for H1b. Also, we found LMX quality to be moderately related to the satisfaction of the need for competence ($\beta = .36$, (313), 95% CI [0.26, 0.47]) and strongly related to the satisfaction of the need for autonomy ($\beta = .59$, (313), 95% CI [0.49, 0.68]), supporting H2a and H2b. However, LMX quality was not significantly related to the satisfaction of the need for relatedness, providing no support for H2c. Contrary to H3b, our results did not show LMX quality to significantly moderate the relation between team identification and the satisfaction of the need for autonomy. However, as expected, we found that LMX quality had a small moderation effect on the relationship between team identification and the satisfaction of the need for competence ($\beta = .11$ (313), 95% CI [0.04, 0.17]). LMX quality also had a small moderation effect on the relationship between team identification and the satisfaction of the need for relatedness ($\beta = .11$, (313), 95% CI [0.05, 0.17]).

To fully support H3a and H3c, the form of these interactions should conform to the hypothesized patterns. Therefore, based on recommendations by Cohen et al. (77), the moderating effects were interpreted by plotting the regression equations in relation to two levels of LMX quality, namely, one standard deviation below the mean and one standard deviation above the mean. In line with our expectations, the slope of the relationship between team identification and the satisfaction of the need for competence was stronger for student athletes who had high quality relationships with their coach ($\beta = .40$ *(313),* 95% CI [0.26, 0.54]) than for student athletes who had low quality relationships with their coach ($\beta = .19$ *(310),* 95% CI [0.08, 0.30]). Similarly, the slope of the relationship between team identification and the need for relatedness was stronger for student athletes with high quality LMX relationships ($\beta = .77$ *(313),* 95% CI [0.64, 0.89]) than for student athletes with low quality LMX relationships $\beta = .55$ *(313),* 95% CI [0.45, 0.65]). Overall, H3a and H3c are supported by the results of simple slopes analysis and the results depicted in Figures 2, 3, which means that LMX quality exercised a moderating effect on the relationships between team identification and the satisfaction of the needs for competence and relatedness.

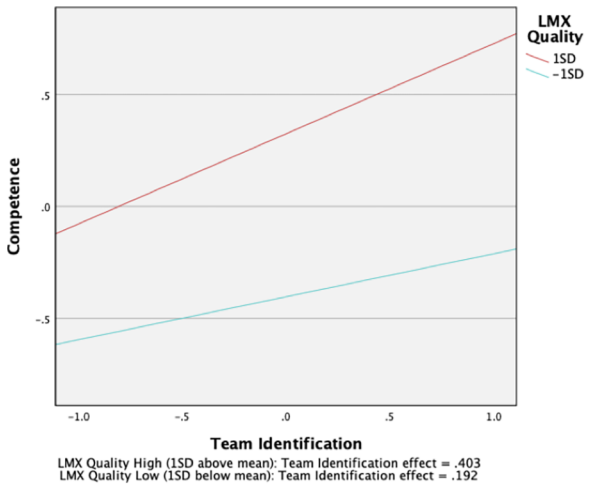

FIGURE 2
Moderating effect of LMX quality on the team identification–competence need satisfaction relationship.

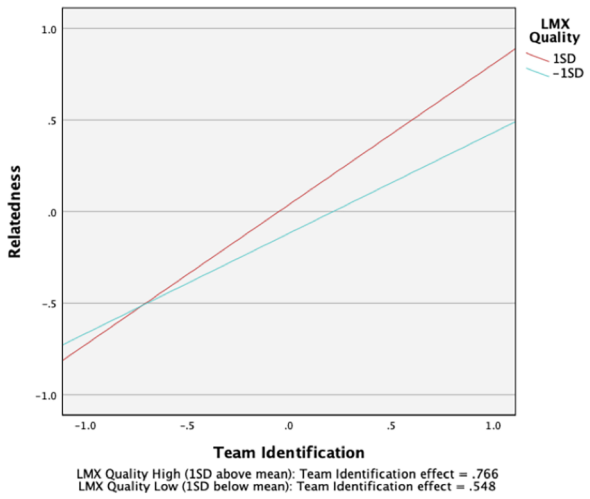

FIGURE 3
Moderating effect of LMX quality on the team identification–relatedness needs satisfaction relationship.

4 Discussion

The objective of this study was to gain a better understanding of the social factors which contribute to the satisfaction of the BPNs of student athletes. Specifically, we examined the unique and interactive effects of collegiate athletes' team identification and coach-athlete LMX quality levels on the satisfaction of their BPNs for competence, autonomy and relatedness. Results showed that team identification is positively related to the satisfaction of the needs for competence and relatedness. Furthermore, our results indicated that LMX quality is positively related to the satisfaction of the needs for competence and autonomy. Moreover, results of this study showed that LMX quality positively moderates the relationships between team identification and the satisfaction of the needs for competence and relatedness, so that the strength of these relationships is amplified when LMX quality is high. Using key social factors within student athletes' environment, our findings suggest that team identification and coach-athlete relationship quality promotes the satisfaction of BPNs. Given that satisfaction of these needs leads to greater well-being, motivation and performance (10, 11), our study contributes to the sport psychology literature by highlighting the importance of student athletes' social environment for their optimal functioning in the sport context.

4.1 Theoretical contributions

Our study makes several key contributions to the discipline of sport psychology. First, despite Rees et al.'s (27) theorizing which highlights social identification as a crucial construct in this field, the relations between team identification and the satisfaction of the three BPNs of student athletes have not been examined in prior research. By showing that team identification significantly relates to the satisfaction of the needs for competence and relatedness among collegiate athletes, our study highlights novel associations with the satisfaction of two BPNs and deepens our understanding of the social factors that promote BPNs satisfaction in the sport context (18, 37). Regarding the nonsignificant relation between team identification and the satisfaction of the need for autonomy, although collegiate athletes strongly identified with their team, this identification was not related to an increased perception that their decisions and behaviors were more volitional. While unexpected, this result aligns with previous findings which showed that the coach, rather than teammates, is the key social factor influencing the autonomy of student athletes (30). Indeed, as the main source of authority in the team, the coach has great influence over athletes' autonomy. In light of our result, it may be that the increased internalization of goals and expectations resulting from greater team identification does not result in a greater sense of autonomy for student athletes. Nonetheless, team identification appears as a new and important social factor which relates to the satisfaction of the needs for competence and relatedness among student athletes.

Moreover, we extend prior scholarship on LMX quality and the satisfaction of BPNs by uncovering their relations in the new context of college sport. Past research in the work context has found a positive relationship between manager-employee LMX quality and the satisfaction of the BPNs for competence, autonomy and relatedness of employees (33, 34). Our findings now suggest that high LMX quality in coach-athlete relationships also promotes the satisfaction of the needs for competence and autonomy among collegiate athletes. This furthers our understanding of the superior-subordinate relationship as a key social factor in the satisfaction of BPNs in the sport context (37, 78, 79). Contrary to findings in the work domain, the relationship between LMX quality and the satisfaction of the need for relatedness was not significant in our study. This result

may be because, even if high LMX relations provide greater socio-emotional support to student athletes (63), the hierarchical distance between the coach and the athletes may hinder the creation of the close ties which are likely to satisfy the need for relatedness of student athletes. This idea is partly consistent with previous research showing that teammates contribute more to the satisfaction of the need for relatedness than the coach (30). Nonetheless, further research is needed to determine the source of the disparity of the associations between LMX quality and the satisfaction of the need for relatedness among employees and student athletes.

Another significant contribution of this study resides in the finding that LMX quality moderates the relationships between team identification and the satisfaction of the BPNs for competence and relatedness of student athletes; a relation that was not examined in prior research. Thus, our study goes beyond highlighting two social factors that promote BPNs satisfaction in the sport context (18, 37) and furthers the application of SDT by showing that complementary social factors have a synergistic effect on the satisfaction of two BPNs among student athletes. Regarding the nonsignificant moderating effect of LMX quality on the relationship between team identification and the satisfaction of the need for autonomy, team identification is not directly related to the satisfaction of the need for autonomy, and it seems that this absence of relation is not conditional on the level of LMX quality of student athletes.

Taken together, our study shows that team identification and coach-athlete LMX quality are both associated with the satisfaction of specific BPNs among student athletes. Notably, neither one of these social factors individually relates to the satisfaction of all three needs; it is only when both team identification and LMX quality are increased that satisfaction of student athletes' needs for competence, autonomy and relatedness is heightened. In other words, in our model, for student athletes to report increased satisfaction of their three BPNs, they have to report an increase in team identification and in LMX quality with their coach. This study thus provides a deeper understanding of the relations between key social factors and the satisfaction of the BPNs which lead to the optimal functioning of student athletes.

4.2 Practical implications

Findings of the present study suggest ways in which coaches and sports organizations may be able to facilitate the satisfaction of the BPNs of collegiate athletes and promote their optimal functioning. Regarding team identification, coaches may encourage and facilitate activities and behaviors which tend to increase collegiate athletes' identification with their team, such as participating in team-building activities and informal meetings, wearing team-branded clothes, and engaging in shared rituals within the sports practice. A key example of identification promoting behaviors is the ritualistic dance that the All Blacks, the national New Zealand rugby team, engage in before every competition. Student athletes' joint participation in such practices is likely to amplify team identification, making membership in the team a key part of their identities.

Regarding LMX quality, coaches may promote high quality relations with as many of their collegiate athletes as possible by expressing liking, trust, professional respect and loyalty to each of them (58). Indeed, by transcending contractual exchanges and engaging in reciprocal relationships with student athletes, coaches may increase the satisfaction of their BPNs. Moreover, collegiate athletes themselves may use these findings to promote the satisfaction of their needs for competence, autonomy and relatedness. By participating in the activities and behaviors mentioned above, collegiate athletes can increase identification with their own team. Further, by treating their coach according to the characteristics of high-quality LMX relations, collegiate athletes can initiate a personal and reciprocal relationship with their coach.

4.3 Limitations and directions for future research

Like all studies, ours has some limitations. First is the cross-sectional nature of our study. Indeed, all of our study variables were collected at a single point in time, which may have led to common method variance (74). Nonetheless, the single factor test (73) and the correlation matrix procedure to determine common method bias we performed provide evidence that this was not a major issue in our study. Moreover, while we considered team identification and LMX quality as antecedents of BPN satisfaction in our model, we recognize that there may be reciprocal relationships between these constructs. Indeed, increased need satisfaction may lead student athletes to strengthen their relationship with their coach, resulting in greater LMX quality. The satisfaction of the need for relatedness may also increase the tendency of student athletes to identify with their team. Nevertheless, the theoretical grounding of our model gives us good reasons to think that it represents the main directionality of the relationships between our constructs. For future research, a longitudinal design would be warranted to better understand the directionality of these relations.

Furthermore, by focusing on coach-athlete LMX quality as perceived by collegiate athletes, we only explored a fragment of this crucial relationship. To get a better grasp of this dyad, future studies may also examine the perspective of the coach. Indeed, examining this relation from the coaches' standpoint could deepen our knowledge of hierarchical relationships in college sport. Moreover, our sample specifically focused on collegiate athletes. Future research may examine student athletes at different levels of competition and education to see if the relations we found are consistent across contexts. The importance of team identification for student athletes' needs satisfaction may be stronger in highly competitive college sport than high-school sports concentration programs. Indeed, due to the highly competitive nature of college sport, the in-group/out-group distinction between one's team and one's opponent team is likely to be greater in our sample than in student athletes at less competitive levels, resulting in higher team identification in our case ($M = 6.12$).

Lastly, we only examined the individual level of analysis and measurement in this study. Indeed, we argue that each collegiate athletes' individual level of identification with their team and LMX quality with their coach are most relevant to the satisfaction of their individual BPNs. However, because of the nested nature of our theoretical framework, team identification and LMX quality could also be examined at the team level. Thus, future studies may investigate our conceptual model at multiple levels simultaneously through multilevel analyses. Indeed, the associations between the aggregate level of team identification and the satisfaction of the BPNs of individual athletes within that team could be examined. Moreover, the level of dispersion in LMX quality within a team could also be investigated in relation to the BPN satisfaction of student athletes[1].

5 Conclusion

In conclusion, this study extends our knowledge of the relations between key social factors and the satisfaction of BPNs in the sports context. Specifically, we examined the unique and interactive associations of team identification and LMX quality with the satisfaction of the BPNs for competence, autonomy and relatedness among collegiate athletes. Our results support a model in which collegiate athletes' level of team identification relates to the satisfaction of their BPNs for competence and relatedness, and their level of coach-athlete LMX quality relates to the satisfaction of their BPNs for competence and autonomy. Our data also supports LMX quality as a positive moderator of the relations between team identification and the satisfaction of the BPNs for competence and relatedness. On the whole, our work extends prior scholarship by highlighting the independent and interactive associations between important social factors and the satisfaction of the BPNs which promote optimal functioning among collegiate athletes.

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 HEC Montreal Research Ethics 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

JL: Writing – original draft, Conceptualization, Data curation, Formal Analysis, Methodology, Investigation, Visualization, Writing – review & editing. FB: Resources, Writing – original draft, Writing – review & editing. DM: Formal Analysis, Writing – review & editing. EB: 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.

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Motivational drivers and Sense of Belonging: unpacking the persistence in Chinese Martial Arts practice among international practitioners

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Background: Chinese Martial Arts (CMAs) have garnered a global following, with their rich historical and cultural heritage transcending geographical and cultural differences, sparking profound interest among an international community. As an increasing number of non-Chinese individuals persist in practicing CMAs, investigating the motivations behind their continued participation has emerged as a compelling question. This study aims to delve deeper into the factors driving international practitioners to sustain their practice of CMAs, thereby broadening our understanding of the global resonance of CMAs.

Methods: Employing Self-Determination Theory, 226 international CMAs practitioners completed the Physical Activity and Leisure Motivation Scale, Perceived Belonging Scale, and Persistence in Practicing CMAs Scale. SPSS 20.0 was utilized for conducting descriptive statistics, common method bias tests, and correlation analyses. Structural equation modeling was performed using AMOS 26.0.

Results: Motivation for Practicing CMAs, comprised of enjoyment, mastery, physical condition, psychological condition, and appearance, has a positive impact on Persistence in Practicing CMAs ($\beta = 0.297$, $p < 0.01$). Sense of Belonging also positively affects Persistence in Practicing CMAs ($\beta = 0.268$, $p < 0.01$). The aforementioned variables account for 22.1% of the variance in Persistence in Practicing CMAs. Furthermore, Affiliation, Competition/Ego, and Others' Expectations were found to have no significant correlation with Persistence in Practicing CMAs.

Conclusion: The formation of persistence in the practice of CMAs among international practitioners is propelled by their ongoing desire for skill mastery, enjoyment, enhanced physical and mental health, body shape improvement, and a Sense of Belonging. The study reveals that a stronger motivation and Sense of Belonging significantly enhance their commitment to CMAs. Recommendations include that international instructors should center their teaching strategies around the practitioners, helping them to find joy in their practice, achieve skill mastery, and foster the development of physical, mental, and aesthetic qualities, alongside virtues and etiquette. Additionally, building a supportive CMAs community and cultivating a sense of ritual are essential. Such strategies are intended to reinforce practitioners' self-affirmation and group identity, thus boosting their Sense of Belonging and encouraging their continued engagement in CMAs.

KEYWORDS

Chinese martial arts (CMAs), persistence in practice, motivation, Sense of Belonging, questionnaire, structural equation modeling (SEM)

1 Introduction

The practice of Chinese Martial Arts (CMAs), with its rich historical and cultural heritage, extends far beyond the borders of China, captivating the interest of international practitioners worldwide (Farrer and Whalen-Bridge, 2011; Lau, 2022). Despite the geographical and cultural distances, a growing number of non-Chinese individuals are not only engaging in CMAs but are also showing a remarkable persistence in their practice (Jennings, 2010). This phenomenon raises intriguing questions about the motivational drivers behind their sustained interest they experience within this traditionally Chinese domain.

Martial arts represent a psychophysical cultural form deeply embedded in the traditions of hand-to-hand combat or weaponry, facilitating psychophysical enhancement and self-actualization through the training of fighting techniques (Cynarski, 2017). Recognizing the multifaceted nature of martial arts research, Cynarski (2017) introduced a comprehensive, interdisciplinary theoretical framework known as the General Theory of Fighting Arts (GTFA). This framework synthesizes three distinct perspectives: the Humanistic Theory of Martial Arts (HTMA), the Anthropology Theory of Martial Arts (AMA), and insights from Sports Science. Presently, research on CMAs has evolved across these three perspectives, encompassing cultural and philosophical discussions (Allen, 2014; An and Hong, 2018; Cibotaru, 2021), pedagogy and dissemination (Jia et al., 2022; Skowron-Markowska, 2022; Han et al., 2023; Ma and Jiang, 2023), as well as the health beneficial effects of CMAs practice (Gorgy et al., 2008; Fong et al., 2017; Zhang et al., 2023). While numerous studies have delved into why individuals participate in martial arts, findings depict a wide array of motivators shaped by varying disciplines and backgrounds of participants. Significantly, consistent key motivational themes have been identified across different martial arts disciplines. Specifically, Self-Determination Theory (SDT), with its intrinsic and extrinsic motivation categorization as outlined by Deci and Ryan (1985), offers a solid theoretical foundation for understanding exercise motivation. Morris and Rogers (2004) have organized eight motives under SDT into intrinsic (mastery and enjoyment) and extrinsic categories (the remaining six motives). Furthermore, they grouped the six extrinsic motives into body–mind (physical condition, psychological condition, appearance) and social motives (others' expectations, affiliation, competition/ego) based on a second-order factor analysis. Mastery, along with the pursuit of physical and psychological health, stands out as pivotal motivators, as evidenced by martial arts practitioners, including those in Tai Chi, Taekwondo, and Karate, prioritizing these for their engagement (Morris and Han, 1991; Morris et al., 1995; Chowdhury, 2012; Witkowski et al., 2013; Molanorouzi et al., 2015; Zeng, 2019). Additionally, the significance of competition and ego in martial arts contexts has been highlighted, distinguishing participant motivations in their respective disciplines (Molanorouzi et al., 2015). Witkowski et al. (2013) reinforced this by noting judokas often cite winning prestigious competitions as a primary motivation. The search for enjoyment also emerges as a primary reason for young practitioners' involvement in these disciplines (Zeng, 2019). Despite the initial insights into these motivational factors, the specific drivers that underpin the long-term engagement of practitioners in CMAs remain unclear. This identified gap underlines the imperative for an in-depth examination of the motivations propelling overseas practitioners to maintain their commitment to CMAs over an extended period.

The relationship between motivation and the maintenance of long-term exercise is a significant topic of study in the fields of sports psychology and health promotion. Research has demonstrated that intrinsic motivations, such as enjoyment, are crucial in driving individuals to persist in their exercise routines (Ryan et al., 1997; Jiang and Wu, 2004; Chu et al., 2009; Zeng et al., 2013; Neys et al., 2014; Lee, 2018; Rodrigues et al., 2020). Furthermore, intrinsic motivation related to competence has also been identified as an important factor in exercise adherence (Ryan et al., 1997; Chu et al., 2009). However, the relationship between exercise persistence and motivations aimed at health, external appearance improvement, and social interaction presents varied results across different studies. For instance, Jiang and Wu (2004) and Chu et al. (2009) found that motivations related to physical and psychological health impact continuous exercise, while Ryan et al. (1997) observed that exercise adherence was unrelated to health motivations. Additionally, Ryan et al. (1997) associated social interaction with exercise persistence, and Jiang and Wu (2004) linked appearance (shaping the body, or gaining (losing) weight) with exercise adherence, whereas Chu et al. (2009) found no significant relationship between social, appearance motivations, and exercise persistence. Research suggests that different motivations are linked to various types of sports activities (Frederick and Ryan, 1993; Morris et al., 1995, 1996; Ryan et al., 1997; Molanorouzi et al., 2015), implying that the relationship between participation motivations and exercise adherence may vary across different sports. This study aims to explore the motivational mechanisms behind the persistence of practitioners of CMAs, drawing upon the aforementioned research to propose the following hypothesis (see Figure 1).

> *H1*: Motivation for Practicing CMAs has a positive effect on Persistence in Practicing CMAs.

Incorporating the Self-Determination Theory (SDT), belongingness is identified as a fundamental psychological need, alongside autonomy and competence, that underpins human motivation and well-being (Deci and Ryan, 2000). The Sense of Belonging, or relatedness, is crucial for motivating self-determined behaviors, driving individuals to seek connections and nurture relationships, thereby fostering a sense of unity and mutual care within groups (Deci and Ryan, 1991). This theoretical perspective underscores the relational need for individuals to feel connected and valued within their social contexts. Partiková and Jennings (2018)

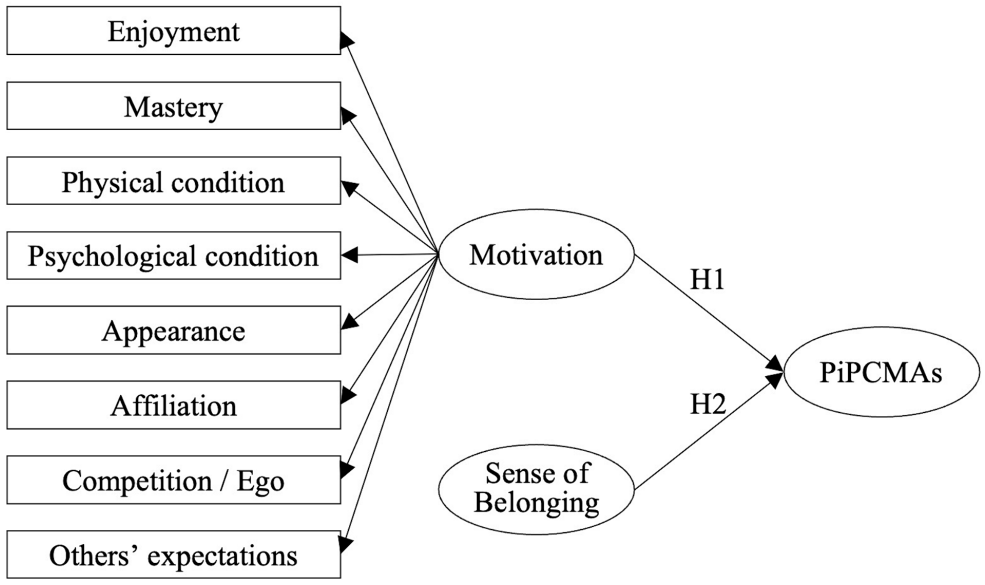

FIGURE 1
Research model. PiPCMA, Persistence in Practicing Chinese Martial Arts.

argue that Kung Fu (referred to in this context as traditional CMAs) as Family – a way of thinking and feeling (and therefore acting) about Kung Fu in terms of family – provides a deep Sense of Belonging for people from a plethora of backgrounds. Kung Fu practitioners find belonging not only in their club but also within a wider group composed of distant cousins, recent seniors, forbearers, and ancestors. Fellow students are seen as siblings, with a responsibility to pass on the art to the next generation and nurture younger or incoming practitioners. Nardini and Scandurra (2021) suggest that practitioners pitted against each other in hand-to-hand clashes actually promote social exchange between opponents, offering them a common framework for collective identification. While these studies, employing qualitative methods, have emphasized the importance of belongingness in martial arts, no research has yet utilized quantitative methods to verify the impact of belongingness on practitioners' long-term engagement in CMAs. Indeed, research in non-CMAs contexts has already found that group cohesiveness is related to individual adherence behavior (Carron et al., 1988). Additionally, Kopanidis (2023) identified the Sense of Belonging as one of the key factors influencing member retention and active participation. Based on this, the following hypothesis is proposed:

> *H2*: Sense of Belonging has a positive effect on Persistence in Practicing CMAs.

In conclusion, applying Self-Determination Theory (SDT) to our research offers a valuable theoretical framework for an in-depth analysis of the complex motivations behind the long-term participation of international practitioners in CMAs. SDT's multifaceted understanding of human motivation, which includes both intrinsic and extrinsic types (Deci and Ryan, 1985), allows us to explore more deeply the various motivations that drive individuals to continue practicing CMAs. Moreover, SDT emphasizes the importance of belongingness, autonomy, and competence (Deci and Ryan, 2000). In an international context, understanding how a Sense of Belonging influences practitioners' commitment to persisting in CMAs is crucial for promoting the global dissemination of CMAs. Additionally, SDT research shows that when individuals' behaviors are driven by intrinsic motivations, they are more likely to maintain those behaviors over time (Ryan et al., 1997). This insight is directly applicable to designing strategies to enhance long-term participation in CMAs and improving practitioners' satisfaction and commitment. By integrating SDT into our study, our goal is not only to reveal the key psychological mechanisms underpinning the enduring commitment of international CMA practitioners but also to provide theoretical and practical insights for fostering sustained engagement in this rich cultural practice.

2 Materials and methods

2.1 Participants

In this study, we initiated data collection by employing Apify's Google Maps Scraper service to gather information on 16,382 Chinese Martial Arts (CMAs) dojos, from which we identified 11,894 entries with website information. To refine our dataset for quality, we removed duplicates due to some dojos sharing the same website, resulting in 8,929 unique website URLs. We then utilized the Octoparse Web Scraping Tool to extract email addresses from the homepage of these websites, obtaining email addresses from 2,374 websites. A survey questionnaire, created via Google Forms, was distributed to these email addresses through a targeted "BCC" (blind carbon copy) email campaign. Additionally, to enhance our data collection, the survey was shared in various Facebook groups dedicated to Chinese martial arts, such as Chinese Martial Art & Kung-Fu Club, Traditional Chinese Martial Arts Community, among others, with prior consent from group administrators. This multi-faceted approach yielded 229

TABLE 1 Demographic characteristics of the study group ($N = 226$).

Demographic Information	Distribution	Percentage (%)	Demographic Information	Distribution	Percentage (%)
Gender	Male	80.1	Ethnicity	White	64.6
	Female	18.6		Asian	15.0
	Prefer not to answer	1.3		Latino	10.2
Age	≤ 24	17.7		Other	10.2
	25–34	25.2	Religion	No Religion	44.7
	35–44	26.1		Christian	37.2
	45–54	22.1		Muslim	4.9
	≥ 55	8.5		Buddhist	3.1
	Prefer not to answer	0.4		Taoist	2.2
Country	United States	24.3		Other	6.2
	Brazil	14.2		Prefer not to answer	1.7
	Italy	9.7	Employment status	Employed	59.3
	Germany	6.2		A student	15.9
	United Kingdom	6.2		Self-employed	14.2
	Canada	4.4		Retired	5.3
	Netherlands	3.5		Other	5.3
	Turkey	3.5	Master is of Chinese descent	Yes	30.5
	Other	28.0		No	63.7
Education level	Bachelor's degree	27.4		Both	5.8
	Master's degree	22.6	Years of practice	< 1 year	7.1
	High school graduate	15.9		1–2 years	8.4
	Some college credit, no degree	8.0		3–5 years	21.7
	Professional degree	6.2		6–10 years	21.7
	Other	19.9		> 10 years	41.1
Martial status	Single	40.7	Watched CMAs competitions	Yes	64.2
	Married	44.3		No	35.8
	Engaged	8.0	Participated in CMAs competitions	Yes	30.5
	Divorced	4.4		No	69.5
	Widowed	0.9	Participated in a CMAs tour	Yes	29.6
	Prefer not to answer	1.7		No	70.4
Ethnic Chinese	Yes	11.9	Participated in CMAs exchange in China	Yes	25.7
	No	88.1		No	74.3

completed questionnaires from international CMAs practitioners. Following a rigorous screening process for patterned responses, inconsistencies, and duplicates, 226 questionnaires were validated for analysis, marking a valid response rate of 98.6%.

2.1.1 Demographic characteristics

Table 1 presents the demographic characteristics of overseas practitioners of CMAs. The age distribution is mainly among four age groups: under 24 years (17.7%), 25–34 years (25.2%), 35–44 years (26.1%), and 45–54 years (22.1%). The sample is predominantly male (80.1%), with females only accounting for 18.6%. Regarding employment status, 59.3% are employed, 14.2% are self-employed, 15.9% are students, and 5.3% are retired. The level of education is generally high, with 27.4% holding a Bachelor's degree, 22.6% a Master's degree, 6.2% a Professional Degree, and 8% having some college credit but no degree, making up a total of 64.2% of the participants having attended university. The study sample includes a wide distribution of countries, predominantly English-speaking ones, such as the United States accounting for 24.3%. The survey being available only in English may influence the participation of non-English-speaking countries, which could also explain the higher level of education among the sample. The sample primarily consists of White individuals (64.6%), followed by Asians (15.0%). Non-Chinese participants account for 88.1%, and Chinese participants for 11.9%. Therefore, the results of this study may better explain the factors influencing the practice of CMAs among

non-Chinese overseas. Respondents practicing for more than 10 years account for 41.1%, 6–10 years for 21.7%, 3–5 years for 21.7%, and 2 years or less for 15.5%, indicating that most of the collected samples have been exposed to CMAs for a significant period. 63.7% of the respondents learned CMAs from non-Chinese masters, 30.5% from Chinese masters, and only 5.8% have studied with both Chinese and non-Chinese masters. 64.2% of the respondents have watched CMAs competitions, only 30.5% have participated in CMAs competitions, 25.7% have come to China for CMAs exchanges, and 29.6% have participated in a CMAs tour (such as visiting the Shaolin Temple, Wudang Mountains, etc.).

2.1.2 CMAs content selection

The survey results indicate a broad array of preferences among practitioners for traditional Chinese Martial Arts (CMAs), with certain styles enjoying particular popularity. Notably, more than 30% of respondents favor Wing Chun (35.4%) and Yang-style Tai Chi (33.6%). Styles preferred by over 20% include Qigong (27.9%) and Shaolin Kung Fu (24.8%), while those chosen by over 10% encompass Xing Yi Quan (19.9%), Baguazhang (17.7%), Chen-style Tai Chi (16.4%), Hung Ga (11.5%), Choy Li Fut (11.1%), Praying Mantis (10.6%), and Qinna (10.6%). Beyond these, a wide range of other styles are practiced by respondents, such as Bajiquan, Wudang Martial Arts, Hakka Kung Fu, Shuai Jiao, Eagle Claw, White Crane, Bak Mei, Zhou Family Praying Mantis, Pi Gua Quan, Cha Quan, Xin Yi Liu He Quan, Emei Fire Dragon Quan, Pi Gua Zhang, Short Weaponry, Lai Tung Pai, and Tith Ngaw Pai, showcasing the rich diversity of CMAs globally. Furthermore, 32.3% of respondents exclusively practice CMAs, yet a significant proportion also engage in other martial arts, including Karate (29.2%), Taekwondo (17.7%), Judo (17.3%), Brazilian Jiu-Jitsu (16.4%), Boxing (15.5%), and Muay Thai (12.4%). This variety in martial arts practices among CMA practitioners abroad highlights the global appeal and diversity of martial arts disciplines.

The essence of CMAs is combat skill, with 90.3% of respondents believing they have learned the application of techniques and improved their fighting skills through studying CMAs. 82.7% feel they have learned martial virtues (Wu De) such as respect, self-discipline, perseverance, commitment, and trust. 81.9% understand the historical background and lineage of the CMAs they studied, 71.7% are aware of the cultural and philosophical foundations of CMAs, such as Yin-Yang and the Bagua, 54.4% have learned etiquette like the fist and palm salute, and only 13.7% are familiar with the master-apprentice ceremony. Additionally, some respondents noted that "language is also an important aspect gained during the learning process of CMAs, having learned to name movements in Cantonese, as well as terms for master, grandmaster, male and female fellow disciples, and counting in Cantonese."

2.2 Instruments

This study incorporated three scales: Motivation for Practicing CMAs Scale, Perceived Belonging Scale and Persistence in Practicing CMAs Scale. To ensure the reliability and validity of the measurement tools, this research primarily utilized scales that have been previously employed in studies, which were then modified according to the research objectives to serve as empirical tools.

- Motivation for Practicing CMAs Scale. Motivation is an intrinsic force influencing behavior. The PALMS (Physical Activity and Leisure Motivation Scale) is a comprehensive tool based on Self-Determination Theory that measures motivation for participating in physical sports activities (Morris and Rogers, 2004). This scale is a condensed version of the 73-item REMM (Recreational Exercise Motivation Measure), categorizing motivation into eight dimensions for participating in physical activities (Rogers, 2000). These dimensions include Enjoyment, Mastery, Physical condition, Psychological condition, Appearance, Affiliation, Competition/Ego, and Others' expectations. Enjoyment motivation is due to finding it fun, enjoyable, and happiness-inducing; Mastery motivation is due to the desire to acquire new skills and improve abilities; Physical condition motivation is for physical health and a robust physique. Psychological condition motivation is for stress relief and relaxation; Appearance motivation is to improve body shape and appearance; Affiliation motivation is for making new friends or spending time with friends. Competition/Ego motivation is to surpass or exceed others; Others' expectations motivation is due to others expecting you to do so. The scale consists of 40 items, with alpha coefficients of all eight dimensions being 0.78 or higher, indicating high structural validity as confirmed through structural equation modeling (Molanorouzi et al., 2014). Items are measured on a Likert 5-point scale, ranging from 1 (Strongly disagree) to 5 (Strongly agree).
- Perceived Belonging Scale. This scale is based on Self-Determination Theory and uses 11 items to measure the perceived Sense of Belonging. The scale's Cronbach's alpha coefficients are all above 0.70, and its construct validity has been verified through Structural Equation Modeling, showing a high level of fit (Allen, 2006). Items are measured using a Likert 7-point scale, ranging from 1 (Disagree strongly) to 7 (Agree strongly).
- Persistence in Practicing CMAs Scale. Derived from exercise adherence, which refers to the individual's tendency to demonstrate enduring, continuous, or effortful behavior during physical exercise (Wang et al., 2016). This study employs the persistence scale by Liu et al. (2011), which has an alpha coefficient of 0.85 and good fit. After revising to suit Persistence in Practicing CMAs, the scale was translated into English through iterative back-translation by bilingual translators (Brislin, 1980). Items are measured using a Likert 5-point scale, with options ranging from 1 (Strongly disagree) to 5 (Strongly agree).

2.3 Analysis

The study utilized SPSS 20.0 and the Structural Equation Modeling (SEM) software AMOS 26.0 to conduct empirical analysis following these steps: First, employing a single-factor method for common method bias test; Second, using confirmatory factor analysis to test reliability and validity as well as the fit of the measurement model; Third, exploring the relationships between variables through correlation analysis; Fourth, assessing the overall fit of the structural model; Fifth, revising and interpreting the results of the model fit.

Additionally, the data underwent the following processes:

- Scale conversion. As the majority of scales used in this study were 7-point scales, the 5-point scale, was uniformly converted to 7-point scales for data analysis. The conversion formula is: $Y = (B - A) \times \frac{x - a}{b - a} + A$, where Y is the function of the converted scale, X is the function of the scale used in the original questionnaire, a and b are the minimum and maximum values of the original scale, and A and B are the minimum and maximum values of the converted scale, respectively.
- Item parceling. SEM analysis typically requires a sample to observed variable ratio of at least 10:1 (Thompson, 2000). Given the difficulty of obtaining overseas sample data and the small sample size and complex model of this study, to meet the sample size requirements for SEM analysis, this study simplified the model by item parceling of first-order latent variables in the second-order model of Motivation for Practicing CMAs, based on the reliability and validity testing of the scales' various latent variables.

3 Results

3.1 Test for common method bias

Given that all data were self-reported by CMAs practitioners, the study first employed Harman's single-factor test to examine common method bias. The exploratory factor analysis with rotation identified nine factors with eigenvalues greater than 1, where the largest factor accounted for 24.067% of the variance. These results are in line with the criteria proposed by Podsakoff et al. (2003), where more than one factor with eigenvalues greater than 1 and the largest factor's variance explanation being less than 40% indicate that severe common method bias is not present in this study.

3.2 Reliability and validity test and analysis of the fit of the measurement model

This study analyses the correspondence between measurement factors and items through confirmatory factor analysis (CFA) (see Table 2).

- Measurement model fit. Items within each latent variable with standardized factor loadings below 0.4 were deleted (Hair et al., 2014); model fit indices were checked, and items causing excessively high chi-square values due to residual correlations, indicating item similarity, were removed (Landis et al., 2009). Ultimately, items a_4, b_1, b_5, c_1, d_3, d_4, e_2, f_3, g_5, h_1, and h_3 from the Motivation for Practicing CMAs scale, items 1, 3, 8, 9, and 10 from the Perceived Belonging Scale, and items 1 and 6 from the Persistence in Practicing CMAs Scale were deleted, thereby achieving a better model fit for each factor (Hair et al., 2014). Factors not annotated with fit indices in the table are due to having only three items, constituting a just-identified model, where the number of data points matches the number of parameters to be estimated in the model, resulting in zero degrees of freedom, also known as a saturated model.
- Internal consistency coefficient (α). This value is a commonly used index for testing reliability, with the formula: $\alpha = \frac{K}{K-1}\left(1 - \frac{\sum S_i^2}{S^2}\right)$, where K is the number of items in the scale, $\sum S_i^2$ is the total variance of the scale items, and S^2 is the variance of the total score of the scale items. The α coefficient ranges from 0 to 1, with DeVellis (2017) suggesting that values between 0.65 and 0.70 are the minimum acceptable; values between 0.70 and 0.80 are quite good; values between 0.80 and 0.90 are very good. Almost all factors in this study had alpha coefficients above 0.70, indicating good internal consistency, with only one factor (Mastery) having an alpha value of 0.687, which is still within an acceptable range.
- Convergent validity is represented by the average variance extracted (AVE), which can be calculated using the formula: $AVE = \frac{\left(\sum \lambda^2\right)}{\left(\left(\sum \lambda^2\right) + \sum \theta\right)}$, where λ represents the standardized factor loadings of the observed variables on the latent variable, and θ represents the error variance of the indicator variables. AVE reflects the extent to which a latent variable construct can explain the variance of its indicator variables. Higher AVE values indicate higher reliability and convergent validity of the construct. Fornell and Larcker (1981b) consider values between 0.36 to 0.5 as the minimum acceptable, and values above 0.5 as ideal. Most factors in this study had AVE values above 0.5, indicating good convergent validity. Only three factors (Enjoyment, Mastery, PiPCMAs) had AVE values below 0.5 but ≥0.36, which is still within an acceptable range.
- Composite Reliability (CR). This value can be calculated using the formula: $CR = \frac{(\sum \lambda)^2}{\left((\sum \lambda)^2 + \sum \theta\right)}$, where λ represents the standardized factor loadings of the observed variables on the latent variable, and θ represents the error variance of the indicator variables. CR indicates whether all items within each latent variable consistently explain that latent variable. Fornell and Larcker (1981a) suggest that a CR value above 0.6 indicates good composite reliability. All latent variables in this study had CR values above 0.6, indicating good composite reliability.

3.3 Correlation analysis of Motivation for Practicing CMAs, Sense of Belonging, and Persistence in Practicing CMAs

Table 3 presents the descriptive statistics and correlation coefficients for Motivation for Practicing CMAs, Sense of Belonging, and Persistence in Practicing CMAs. Correlation coefficients with statistical significance related to Persistence in Practicing CMAs are highlighted in bold, with M ± SD denoting mean ± standard deviation. The bold italic numbers on the diagonal are the square roots of the Average Variance Extracted (AVE) for each variable. The results indicate that there is a significant positive correlation between Persistence in Practicing CMAs and Sense of Belonging ($r = 0.347$,

TABLE 2 Summary of confirmatory factor analysis for each factor in the research model.

Factor	Item	Model parameter estimates				Convergent validity				Goodness-of-fit indexes					
		UFL	S.E.	*t*	*P*	SFL	SMC	C.R.	AVE	χ^2	DF	χ^2/df	GFI	AGFI	RMSEA
Enjoyment (α = 0.726)	Q14a_1	1.000				0.502	0.252	0.740	0.426	0.257	2	0.129	0.999	0.997	0.000
	Q14a_2	1.323	0.243	5.447	***	0.515	0.265								
	Q14a_3	2.687	0.418	6.432	***	0.820	0.672								
	Q14a_5	2.615	0.406	6.440	***	0.718	0.516								
Mastery (α = 0.687)	Q14b_2	1.000				0.584	0.341	0.695	0.434	0.000	0	–	–	–	–
	Q14b_3	1.526	0.252	6.044	***	0.660	0.436								
	Q14b_4	1.637	0.279	5.871	***	0.725	0.526								
Physical condition (α = 0.752)	Q14d_1	1.000				0.821	0.674	0.789	0.560	0.000	0	–	–	–	–
	Q14d_2	1.328	0.151	8.805	***	0.815	0.664								
	Q14d_5	1.122	0.143	7.867	***	0.584	0.341								
Psychological condition (α = 0.854)	Q14g_1	1.000				0.659	0.434	0.858	0.605	0.184	2	0.092	1.000	0.998	0.000
	Q14g_2	1.445	0.146	9.925	***	0.785	0.616								
	Q14g_3	1.584	0.164	9.670	***	0.759	0.576								
	Q14g_4	1.725	0.162	10.616	***	0.891	0.794								
Appearance (α = 0.896)	Q14f_1	1.000				0.797	0.635	0.896	0.684	1.024	2	0.512	0.998	0.989	0.000
	Q14f_2	1.121	0.080	14.021	***	0.857	0.734								
	Q14f_4	1.129	0.086	13.110	***	0.809	0.654								
	Q14f_5	1.173	0.085	13.789	***	0.844	0.712								
Affiliation (α = 0.834)	Q14c_2	1.000				0.656	0.430	0.836	0.563	4.058	2	2.029	0.991	0.955	0.068
	Q14c_3	1.304	0.136	9.613	***	0.801	0.642								
	Q14c_4	1.234	0.141	8.743	***	0.700	0.490								
	Q14c_5	1.300	0.133	9.773	***	0.831	0.691								
Competition/ Ego (α = 0.832)	Q14e_1	1.000				0.518	0.268	0.837	0.570	0.629	2	0.315	0.999	0.993	0.000
	Q14e_3	1.813	0.240	7.563	***	0.802	0.643								
	Q14e_4	1.830	0.241	7.595	***	0.811	0.658								
	Q14e_5	1.949	0.253	7.690	***	0.843	0.711								
Others' expectations (α = 0.787)	Q14h_2	1.000				0.652	0.425	0.793	0.565	0.000	0	–	–	–	–
	Q14h_4	1.305	0.157	8.301	***	0.868	0.753								
	Q14h_5	1.093	0.127	8.594	***	0.718	0.516								
Sense of Belonging (α = 0.902)	Q13_2	1.000				0.771	0.594	0.906	0.619	16.381	9	1.820	0.976	0.944	0.060
	Q13_4	1.152	0.098	11.793	***	0.752	0.566								
	Q13_5	1.221	0.085	14.407	***	0.892	0.796								
	Q13_6	0.816	0.067	12.191	***	0.774	0.599								
	Q13_7	0.806	0.077	10.481	***	0.680	0.462								
	Q13_11	1.007	0.075	13.355	***	0.835	0.697								
PiPCMAs (α = 0.733)	Q8_2	1.000				0.593	0.352	0.743	0.429	0.040	2	0.020	1.000	1.000	0.000
	Q8_3	1.106	0.156	7.108	***	0.645	0.416								
	Q8_4	1.699	0.232	7.309	***	0.839	0.704								
	Q8_5	0.961	0.164	5.865	***	0.493	0.243								

UFL, Unstandardized Factor Loadings; S.E., Standard Error; SFL, Standardized Factor Loadings; SMC, Squared Multiple Correlations; C.R., Composite Reliability; AVE, Average Variance Extracted; df, Degrees of Freedom; GFI, Goodness of Fit Index; AGFI, Adjusted Goodness of Fit Index; RMSEA, Root Mean Square Error of Approximation; PiPCMA, Persistence in Practicing Chinese Martial Arts; *** $p < 0.001$.

TABLE 3 Descriptive statistics and correlation coefficients for factors ($N = 226$).

	M ± SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) PiPCMAs	5.649 ± 1.105	**0.655**	–	–	–	–	–	–	–	–	–
(2) Sense of Belonging	6.256 ± 0.744	**0.347****	**0.787**	–	–	–	–	–	–	–	–
(3) Enjoyment	6.343 ± 0.692	**0.306****	0.362**	**0.653**	–	–	–	–	–	–	–
(4) Mastery	6.079 ± 0.795	**0.422****	0.346**	0.591**	**0.659**	–	–	–	–	–	–
(5) Physical condition	6.155 ± 0.810	**0.345****	0.328**	0.506**	0.583**	**0.748**	–	–	–	–	–
(6) Psychological condition	5.741 ± 1.111	**0.295****	0.277**	0.401**	0.394**	0.576**	**0.778**	–	–	–	–
(7) Appearance	4.507 ± 1.673	**0.150***	0.172**	0.313**	0.451**	0.550**	0.442**	**0.827**	–	–	–
(8) Affiliation	4.405 ± 1.487	0.081	0.307**	0.269**	0.281**	0.273**	0.411**	0.334**	**0.750**	–	–
(9) Competition/Ego	3.149 ± 1.586	0.076	0.169*	0.193**	0.356**	0.241**	0.256**	0.524**	0.406**	**0.755**	
(10) Others' expectations	1.867 ± 1.241	−0.062	−0.002	−0.006	−0.041	0.118	0.162*	0.299**	0.391**	0.567**	**0.752**

The bold numbers on the diagonal are the square roots of the AVE for that variable; PiPCMAs, Persistence in Practicing Chinese Martial Arts; * $p < 0.05$; ** $p < 0.01$.

$p < 0.01$). Additionally, Persistence in Practicing CMAs is positively correlated with aspects of Motivation for Practicing CMAs, including Enjoyment ($r = 0.306$, $p < 0.01$), Mastery ($r = 0.422$, $p < 0.01$), Physical Condition ($r = 0.345$, $p < 0.01$), Psychological Condition ($r = 0.295$, $p < 0.01$), and Appearance ($r = 0.150$, $p < 0.01$). However, there are no significant correlations between Persistence in Practicing CMAs and other motivational aspects such as Affiliation, Competition/Ego, and Others' expectations. Furthermore, comparing the square root of each variable's AVE with the correlation coefficients between that variable and others reveals that the square root of the AVE for each variable is greater than its correlation coefficients with other variables, indicating discriminant validity among the variables in this study.

3.4 Structural model test of the persistence behavior formation mechanism in practicing CMAs

3.4.1 Testing the second-order model of Motivation for Practicing CMAs

Correlational analysis among variables revealed (1) Within Motivation for Practicing CMAs, Affiliation, Competition/Ego, and Others' expectations showed no significant correlation with Persistence in Practicing CMAs, while the other five dimensions of motivation (Enjoyment, Mastery, Physical Condition, Psychological Condition, and Appearance) were all related to Persistence in Practicing CMAs; (2) The correlations among the five motivations for practicing CMAs (Enjoyment, Mastery, Physical Condition, Psychological Condition, and Appearance) were generally moderate ($r > 0.4$) (see Table 3). In SEM, when first-order factors are moderately to highly correlated and all influenced by a higher-order latent trait, a second-order confirmatory factor analysis can be performed (Wu, 2010). Therefore, the study considered Enjoyment, Mastery, Physical Condition, Psychological Condition, and Appearance as first-order factors and Motivation for Practicing CMAs as a second-order factor to test the fit of the Motivation for Practicing CMAs second-order model (see Figure 2).

First, testing whether the second-order model can explain the first-order model. Marsh and Hocevar (1985) argue that a target coefficient (the chi-square value of the first-order factors divided by the chi-square value of the second-order model) closer to 1 indicates greater accuracy of the second-order model. By calculating the target coefficient, it was found that the target coefficient for Motivation for Practicing CMAs is 0.918 (253.067/275.551), indicating excellent adaptability of the second-order CFA index (see Table 4).

Second, testing the fit of the second-order model. The RMSEA of the second-order model for Motivation for Practicing CMAs is 0.071, GFI = 0.885, CFI = 0.922, $\chi^2/df = 2.120$, indicating that the model fits well.

Third, testing the convergent validity and construct reliability of the second-order model. Upon testing, the Average Variance Extracted (AVE) of the second-order model for Motivation for Practicing CMAs is 0.535, greater than 0.5, indicating good convergent validity; the Construct Reliability (CR) is 0.848, significantly higher than 0.6, indicating good construct reliability (see Table 5).

In conclusion, the second-order model of Motivation for Practicing CMAs is acceptable, meaning it can effectively explain the constructs of the first-order factors.

3.4.2 Testing the formation mechanism model of Persistence in Practicing CMAs

Motivation for Practicing CMAs and Sense of Belonging were treated as exogenous variables, while Persistence in Practicing CMAs was treated as an endogenous variable, and the model was fitted using the Maximum Likelihood (ML) estimation method.

- Overall Model Fit Test. The model fit indices were examined from three aspects: absolute fit indexes, incremental fit indexes, and parsimony fit indexes. Among these, the absolute fit indexes showed $\chi^2 = 186.790$, GFI = 0.899, close to 0.9, and RMSEA = 0.071, less than 0.08; the incremental fit indices IFI = 0.931, TLI = 0.916, and CFI = 0.931, all greater than 0.90; the parsimony fit index $\chi^2/df = 2.147$, satisfying the criterion of being less than 3, indicating a good overall fit of the structural equation model.
- Model Path Analysis and Hypothesis Testing. Figure 3 presents the structural model of the persistence behavior formation mechanism in overseas CMAs practitioners. The results indicate that Motivation for Practicing CMAs, composed of Enjoyment, Mastery, Physical Condition, Psychological Condition, and Appearance, has a significant positive impact

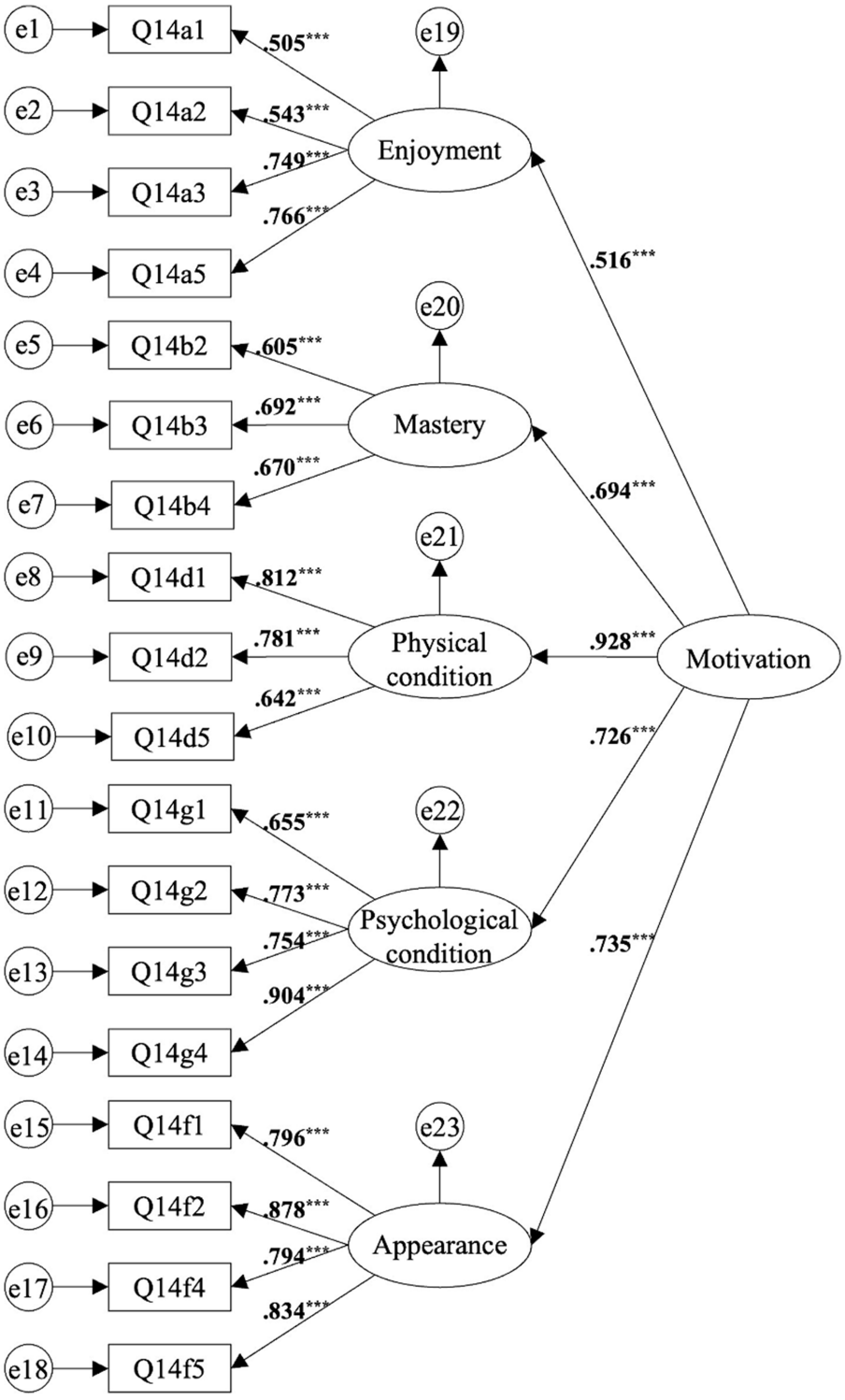

FIGURE 2
Second-order model of Motivation for Practicing Chinese Martial Arts; *** $p < 0.001$.

on Persistence in Practicing CMAs ($\beta = 0.297$, $b = 0.489$, $t = 3.062$, $p < 0.01$), supporting H1; Sense of Belonging also significantly positively affects Persistence in Practicing CMAs ($\beta = 0.268$, $b = 0.189$, $t = 3.141$, $p < 0.01$), supporting H2; the model explains 22.1% of the variance in Persistence in Practicing CMAs (see Table 6).

4 Discussion

This study, grounded in Self-Determination Theory and exploring from a motivational viewpoint, conducted an empirical investigation into the mechanisms behind the persistence behavior of overseas practitioners in CMAs. Our findings reveal that: (1) The motivation

TABLE 4 Goodness-of-fit indexes for alternative models of the second-order Motivation for Practicing Chinese Martial Arts ($N = 226$).

	χ^2	df	χ^2/df	GFI	AGFI	CFI	RMSEA
0. Null model	2027.024	153	13.249	0.323	0.243	0.000	0.233
1. 1 First-order factor	830.427	135	6.151	0.646	0.551	0.629	0.151
2. 5 First-order factors (Uncorrelated)	573.189	135	4.246	0.760	0.695	0.766	0.120
3. 5 First-order factors (Correlated)	**253.067**	125	2.025	0.894	0.854	0.932	0.067
4. 1 Second-order factor	**275.551**	130	2.120	0.885	0.849	0.922	0.071
Reference value	Smaller is better	Larger is better	< 3	> 0.9	> 0.9	> 0.9	< 0.08

df, Degrees of Freedom; GFI, Goodness of Fit Index; AGFI, Adjusted Goodness of Fit Index; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation.
Bold values are key indicators for calculating the target coefficient.

TABLE 5 Confirmatory factor analysis for the second-order model of Motivation for Practicing Chinese Martial Arts.

Second-order factor	First-order factors	Model parameter estimates				Convergent validity			
		UFL	S.E.	*t*	*p*	SFL	SMC	C.R.	AVE
Motivation ($\alpha = 0.763$)	Enjoyment	1.000				0.516	0.266	0.848	0.535
	Mastery	2.315	0.554	4.180	***	0.694	0.482		
	Physical condition	4.310	0.888	4.853	***	0.928	0.861		
	Psychological condition	3.211	0.716	4.482	***	0.726	0.527		
	Appearance	6.223	1.328	4.685	***	0.735	0.540		

UFL, Unstandardized Factor Loadings; S.E., Standard Error; SFL, Standardized Factor Loadings; SMC, Squared Multiple Correlations; C.R., Composite Reliability; AVE, Average Variance Extracted; *** $p < 0.001$.

to practice, encompassed by Enjoyment, Mastery, Physical Condition, Psychological Condition, and Appearance, exerts a significant positive impact on Persistence in Practicing CMAs; (2) A Sense of Belonging significantly positively affects Persistence in Practicing CMAs; (3) Motivational factors such as Affiliation, Competition/Ego, and Others' Expectations do not exhibit a significant correlation with Persistence in Practicing CMAs.

4.1 Conceptual explanation of Persistence in Practicing CMAs

Persistence in Practicing CMAs denotes the level of sustained effort exhibited by practitioners when faced with challenges and obstacles during their training. The evaluation of this concept through standardized factor loadings of survey items (see Table 2) offers insightful revelations about persistence. The findings, ordered by their factor loadings, reveal a hierarchy of persistent elements: the highest loading is observed for the statement "Living without Chinese Martial Arts would be difficult for me" (0.839), underscoring the integral role that CMAs play in the lives of practitioners. This sentiment reflects a deep emotional bond with the practice, suggesting that the absence of CMAs would significantly impact their lifestyle and well-being. Following this, the item "I would feel disheartened if I had to stop practicing Chinese martial arts" (0.645) highlights the emotional investment practitioners place in their training, where the prospect of discontinuation evokes a sense of loss. This emotional investment is pivotal in fostering continued engagement with CMAs, even in the face of challenges. The statement "Despite my limited time, I've never stopped practicing Chinese martial arts" (0.593) illustrates the practitioners' commitment and effective time management, indicating that they prioritize CMAs practice despite competing demands on their time. Lastly, the item "Even though there are difficulties in practicing Chinese martial arts, I am willing to persist in practicing it" (0.493), despite its relatively lower factor loading, underscores the resilience and determination among practitioners. Drawing on the qualitative sociological research by Jennings (2010), which posits that the practice of CMAs among British practitioners transcends mere physical training to encompass broader socio-cultural and psychological commitments, this resilience is further understood as a testament to the practitioners' dedication, where challenges and obstacles do not deter their commitment to CMAs.

In sum, these insights reveal that a blend of emotional attachment, commitment to practice, and resilience against challenges contributes to the high persistence observed among CMA practitioners. Such persistence is not merely a function of habit but a reflection of a profound connection to the art, underscoring its significance in their lives and identities. This analysis not only elucidates the factors underpinning persistence in CMAs practice but also highlights the multifaceted relationship practitioners have with their art, characterized by emotional depth, dedication, and resilience. These insights are pivotal for comprehending and enhancing the global dissemination of CMAs and ensuring its continuous practice among overseas practitioners.

4.2 Explanation of the formation mechanism of Persistence in Practicing CMAs

4.2.1 The impact of motivation on Persistence in Practicing CMAs

Morris's classification divides eight motivational dimensions into three categories: intrinsic motivation (Enjoyment, Mastery), extrinsic psychophysical motivation (Physical Condition, Psychological

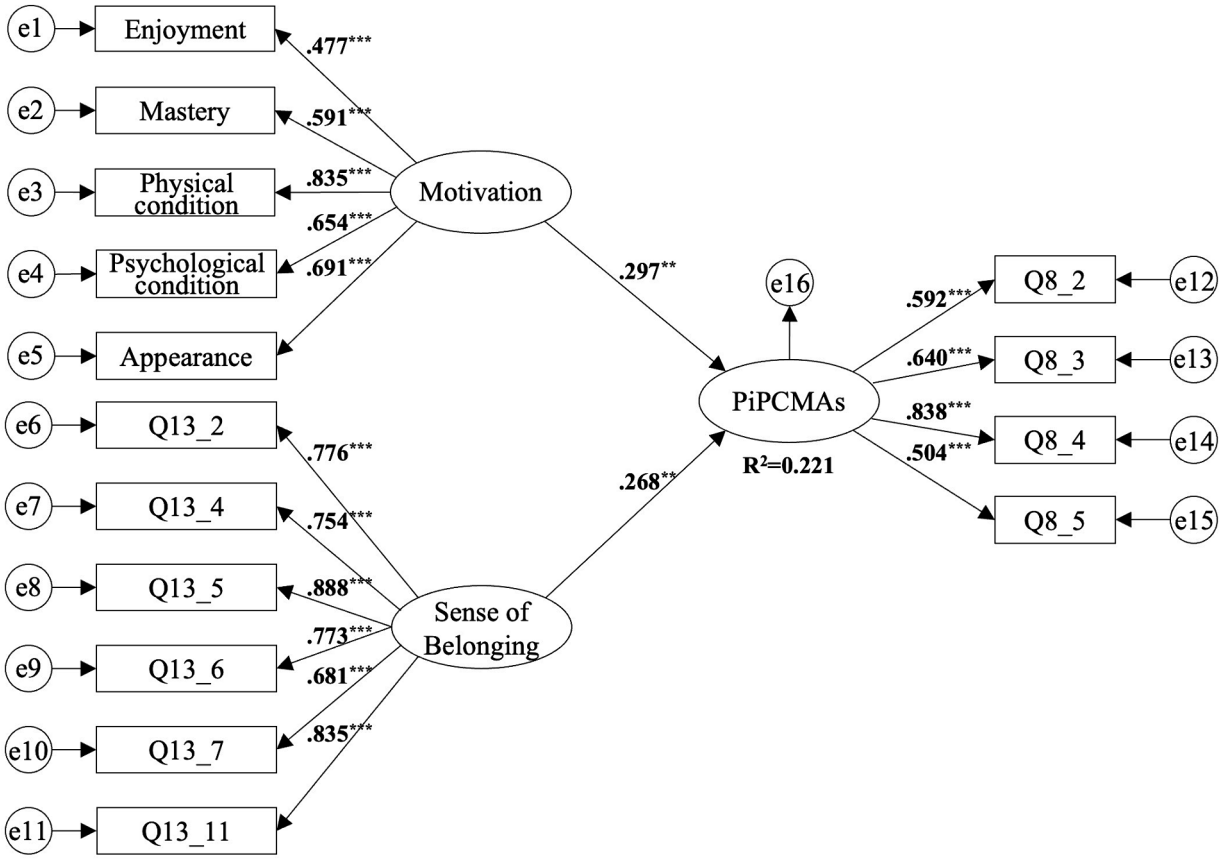

FIGURE 3
Research model path diagram. PiPCMAs, Persistence in Practicing Chinese Martial Arts; ** $p < 0.01$; *** $p < 0.001$.

TABLE 6 Path analysis of the research model.

Paths between latent factors	*b*	S.E.	*t*	*β*	*p*	Corresponding hypothesis	Test result
PiPCMAs ← Motivation	0.489	0.160	3.062	0.297	0.002	H1	✓
PiPCMAs ← Sense of Belonging	0.189	0.060	3.141	0.268	0.002	H2	✓

b, Unstandardized Path Coefficients, represents the direct effect of one variable on another, measured in the original units of the variables; S.E., Standard Error; *β*, Standardized Path Coefficients, indicates the strength and direction of the relationship between variables, measured in standard deviation units, facilitating comparison across different paths in the model; PiPCMAs, Persistence in Practicing Chinese Martial Arts.

Condition, Appearance), and extrinsic social motivation (Affiliation, Competition/Ego, Others' Expectations) (Morris and Rogers, 2004).

The study's results demonstrate a significant positive impact of the composite motivation for practicing CMAs - which includes Enjoyment, Mastery, Physical Condition, Psychological Condition, and Appearance - on the persistence of practice ($\beta = 0.297$, $p < 0.01$). Notably, the order of influence, based on standardized factor loadings, is Physical Condition (0.835), followed by Appearance (0.691), Psychological Condition (0.654), Mastery (0.591), and Enjoyment (0.477). Conversely, extrinsic social motivations such as Affiliation, Competition/Ego, and Others' Expectations show no substantial correlation with the persistence in CMAs practice. This elucidation suggests that while intrinsic and psychophysical motivations significantly foster continued engagement with CMAs, external social pressures and expectations do not markedly affect practitioners' dedication. This insight underscores the complex interplay of personal fulfillment and physical well-being in sustaining CMAs practice, rather than external validation or social affiliations.

4.2.1.1 Intrinsic motivation

The intrinsic motivations for engaging in CMAs, including Mastery (0.591) and Enjoyment (0.477), play a pivotal role in sustaining practitioners' commitment to their training. This finding aligns with Ryan et al. (1997) research, which also identified that persistence among Tae Kwon Do participants was significantly associated with enjoyment and competence motives, underscoring the universal importance of intrinsic motivations in the continuity of martial arts practice.

The significant factor loading of Mastery (0.591) reveals that the drive to enhance skills and competencies is a crucial motivator for individuals to continue their CMAs practice. This motivation highlights the practitioners' dedication to personal improvement and

a profound engagement with CMAs as both an art and a discipline. It reflects a deep-seated interest in mastering intricate skills and gaining an in-depth understanding of CMAs culture. Chu et al. (2009) and Ryan et al. (1997) have highlighted the significance of Mastery motivation - defined as the drive to acquire new skills and enhance personal abilities - in fostering persistence in exercise routines. This motivation for mastery, underscored by both studies, is validated within the context of this investigation, particularly among practitioners of CMAs.

The narrative shared by participants vividly illustrates how the motivation for Mastery underpins the persistence in practicing CMAs. Participants exhibited a deep fascination with the complex technical frameworks, historical evolution, and combat techniques of CMAs, reflecting a commitment that transcends mere cultural appreciation to include a genuine desire for personal growth and self-improvement. For instance, one respondent's pursuit of martial arts styles' "old flavor" exemplifies a passion that extends beyond physical practice to a comprehensive exploration of the culture and history that underlie CMAs. This individual's dedication to learning Chinese characters to interpret ancient texts demonstrates an endeavor to gain a nuanced understanding of the practices, highlighting a search for traditional and cultural roots that signify a profound respect and connection with martial arts beyond mere physicality. This inclination towards understanding the foundational philosophies and historical context of martial arts, as highlighted in the study by Jones et al. (2006), underscores the depth of engagement with CMAs that goes beyond the surface level of physical skills to embrace a holistic appreciation of its cultural significance and personal relevance. Additionally, another participant's fascination with the combat techniques of Shaolin Kung Fu signals a preference for technical mastery and practical application. Conversely, a different respondent expressed a deep emotional bond and identification with learning CMAs, describing each movement and technique as a 'gift'. This perspective reveals a journey of not just acquiring combat skills but also learning valuable life lessons in self-respect, discipline, and resilience, thus portraying it as a comprehensive life lesson. In essence, these examples underscore the pivotal role of Mastery motivation in fostering a sustained commitment to CMAs.

Transitioning from the profound influence of Mastery motivation on the persistence of CMAs practice, it's equally important to consider the role of Enjoyment motivation. The high scoring of Enjoyment ($M = 6.343$) among the motivational factors underscores the intrinsic joy and satisfaction derived from practicing CMAs. This enjoyment is not merely ancillary; as corroborated by prior research, the pleasure experienced during physical activities serves as a significant determinant for the continuation of such practices (Ryan et al., 1997; Lee, 2018; Rodrigues et al., 2020). This study further affirms the vital role of enjoyment in enhancing practitioners' dedication to CMAs, illustrating how the pleasure gained from practice effectively promotes persistence.

In summary, the combination of Mastery and Enjoyment motivations not only deepens practitioners' understanding and identification with CMAs culture but also increases the pleasure and personal satisfaction of practicing CMAs, thus positively affecting the persistence in practicing CMAs. These findings emphasize the importance of focusing on and cultivating intrinsic motivations in the promotion of CMAs, especially in international dissemination, by reinforcing CMAs as a means of skill enhancement and pleasure, to increase audience participation and persistence.

4.2.1.2 Extrinsic psychophysical motivation

Extrinsic psychophysical motivations, encompassing Physical Condition, Psychological Condition, and Appearance, significantly contribute to the persistence in practicing CMAs, as evidenced by standardized factor loadings of Physical Condition (0.835), Psychological Condition (0.654), and Appearance (0.691). These loadings underscore the critical role these motivations play for CMAs practitioners. Initially, the predominant role of Physical Condition reflects the practitioners' acknowledgment of CMAs as a potent physical exercise modality. The health advantages of CMAs, extensively documented and affirmed within the international academic community, have garnered recognition from worldwide health organizations, attracting a global cohort of participants (Cao and Lin, 2020). This has led to a surge in individuals engaging in CMAs to attain enhanced physical health and a more robust physique.

The substantial factor loading of Psychological Condition motivation reveals a dual focus of CMAs practice, aimed not only at physical health enhancement but also at bolstering psychological well-being. Ways of martial arts include certain forms of psychophysical culture, which, based on the tradition of warrior cultures, lead through training in fighting techniques to psychophysical improvement and self-realization (Cynarski, 2017), emphasizing the holistic development achieved through CMAs. Practices, especially those centered around internal regulation and meditation like Tai Chi, are reputed to mitigate stress, bolster emotional stability, and fortify psychological resilience (Wang et al., 2014). Furthermore, complementing these psychological benefits, research by Twemlow and Sacco (1998) highlights another dimension of CMAs' impact on psychological conditioning. It demonstrates how traditional CMAs training significantly contributes to reducing violent tendencies in adolescents. This effect is linked to the training's focus on promoting self-control and nurturing respect for others, illustrating CMAs' practice as a comprehensive development of both moral and spiritual qualities, beyond mere physical activity.

Additionally, the significant factor loading attributed to Appearance motivation reflects a prevalent pursuit among the international audience to refine their physique and appearance through CMAs. In contemporary society, an appealing appearance and a healthy physique are often seen as symbols of personal image and confidence. The proliferation of social media has made this phenomenon even more pronounced, expanding the influence of health and aesthetic standards and intensifying appearance anxieties (Hawes et al., 2020; Deng and Jiang, 2023). Against this backdrop, CMAs, as a comprehensive exercise regimen, effectively help practitioners enhance their physical beauty and overall health. This focus on appearance likely mirrors the prevailing health and aesthetic standards in modern society, showcasing CMAs' ability to fulfill individuals' desires for an attractive physique along with health benefits.

In conclusion, the triad of extrinsic psychophysical motivations – Physical Condition, Psychological Condition, and Appearance - has a positive impact on the sustained engagement in CMAs practice. These factors not only bolster the physical and psychological well-being of practitioners but also cater to their aspirations for an improved appearance, thereby reinforcing their commitment and continuity in CMAs practice. The research findings by Jiang and Wu (2004) corroborate this observation, highlighting the crucial role of these motivational factors in fostering long-term exercise adherence.

These insights hold significant implications for the worldwide propagation of CMAs, advocating for promotional strategies that emphasize the multifaceted benefits of CMAs in enhancing physical health, psychological well-being, and appearance.

4.2.1.3 Extrinsic social motivation

Extrinsic social motivations - Affiliation, Competition/Ego, and Others' Expectations - do not exhibit a significant correlation with the persistence of practitioners in CMAs. While Affiliation is typically considered a key motivator in various sports activities, its influence on the continuity of CMAs practice is minimal. A plausible explanation for this lies in the intrinsic values embedded in CMAs, particularly the ethic of Nature and Man, which fundamentally shapes the practitioner's approach to CMAs. The ethic of Nature and Man, fundamental to traditional CMAs, promotes harmony between humans and nature, fostering independence by encouraging practitioners to value personal insight and resilience over external influences. This philosophy also drives the pursuit of self-improvement and skill mastery, explaining why Affiliation has little impact on the commitment to CMAs practice. Through fostering a strong internal motivation for personal growth, it underlines the importance of self-development in sustaining practice (Li and Guo, 2016). The ethos within CMAs culture, encapsulated by the adage "The master introduces the path, practice is personal," underscores the emphasis on individual commitment and internal enlightenment. This ethos suggests that beyond a certain proficiency level, practitioners are encouraged to internalize and personally refine their skills. Consequently, those with a penchant for solitude and self-motivation might find themselves more aligned with the demands and rewards of CMAs practice.

Furthermore, the Competition/Ego motivation, typically linked to aspirations for superiority and success in competitive sports (Witkowski et al., 2013), has a negligible impact on the dedication to CMAs practice. This observation may indicate that CMAs are internationally recognized more as a medium for cultural engagement and self-improvement rather than as a competitive endeavor. This finding contrasts with the research by Witkowski et al. (2013) and Molanorouzi et al. (2015), where Witkowski et al. noted that judokas often prioritize winning prestigious competitions, and Molanorouzi et al. identified competition/ego as the most significant motivational factor for participation in martial arts like karate, taekwondo, and tai chi. This discrepancy raises interesting questions about the role of competition as a motivational factor in martial arts practice. A possible explanation for the diminished role of competition/ego in our study could be related to the specific styles of martial arts examined. There's a distinction between practitioners of combat sports, such as Judo, and those of form-based martial arts, like Tai Chi. This difference stems from the focus in non-contact disciplines on self-control and self-fulfillment, rather than exclusively on the efficacy of combat. Additionally, this difference may also be related to the cultural contexts underlying these practices. CMAs, with their rich historical and philosophical underpinnings, may attract practitioners with different sets of motivations compared to those drawn to martial arts for competitive success. In particular, the emphasis in many CMAs on internal development, mindfulness, and the cultivation of Qi (vital energy) may appeal more to those seeking personal growth and health benefits than to those motivated by competition. Moreover, the cultural values associated with CMAs, such as harmony, respect, and self-discipline, might further de-emphasize the importance of competition, highlighting the art's role in personal and spiritual development. In contrast, martial arts like karate and taekwondo, though they also embody deep cultural and philosophical principles, might be more closely associated with the competitive sport aspect in international perceptions, thereby attracting practitioners with a stronger orientation towards competition/ego. In conclusion, the variance in motivational factors between this study and that of Molanorouzi et al. (2015) underscores the complexity of martial arts as a global phenomenon and the need to consider the cultural and stylistic nuances when examining practitioners' motivations. It suggests that the pursuit of martial arts, particularly CMAs, transcends the mere desire for competitive success, embodying a deeper search for cultural connection and personal refinement.

Lastly, while the expectation of others may initially motivate some individuals to engage in CMAs, this study reveals that such external pressures have a minimal effect on long-term commitment to CMAs practice. This finding suggests that the sustained practice of CMAs relies more on intrinsic motivation and personal commitment rather than external validation or expectations. This emphasizes the importance of recognizing the unique motivational dynamics that influence persistence in CMAs, suggesting a need for future promotional and educational strategies to highlight the personal and cultural benefits of CMAs practice, tailored to foster long-term engagement.

Overall, the combined influence of motivational factors such as Enjoyment, Mastery, Physical Condition, Psychological Condition, and Appearance forms a multifaceted motivational framework that significantly impacts the persistence of practitioners in CMAs ($\beta = 0.297$, $p < 0.01$). This composite motivation structure underscores that practitioners' dedication to CMAs is not fueled by a singular motive but rather by a synergistic effect of various motivators. This insight underlines the necessity of acknowledging the multifaceted nature of motivation in enhancing the persistence of CMAs practice, especially when promoting CMAs. In the context of global dissemination, it becomes imperative to enrich practitioners' experiences and perceptions related to skill advancement, inner satisfaction, health benefits, psychological welfare, and appearance enhancement.

4.2.2 The impact of Sense of Belonging on Persistence in Practicing CMAs

Sense of Belonging embodies an individual's perception of affiliation with an organization, distinguishing itself from the affiliation motive in CMAs practice. Whereas affiliation involves engaging in CMAs to foster social connections, Sense of Belonging encapsulates the experience of affiliation felt within a group. This concept is evaluated through six indicators, whose standardized factor loadings are as follows: "Other Kung Fu brothers and sisters here like me the way I am" (0.888), "Other Kung Fu brothers and sisters in my group respect me" (0.835), "Other Kung Fu brothers and sisters in my group take my opinions seriously" (0.776), "People in my group are friendly to me" (0.773), "I can truly be myself in this group" (0.754), "Others in the group notice when I'm skilled at something" (0.681). These metrics collectively underscore a pivotal theme: practitioners' desire for acceptance, respect, and validation of their personal worth within the CMAs community.

Our findings demonstrate that a strong Sense of Belonging significantly influences the continuity of CMAs practice ($\beta = 0.268$, $p < 0.01$). Specifically, a heightened sense of organizational belonging is directly linked to increased perseverance in CMAs, aligning with the outcomes of prior research (Carron et al., 1988). This correlation suggests that the support and respect from peers within the CMAs community are crucial factors in bolstering practitioners' dedication to CMAs. Similarly, a study conducted in Melbourne, Australia, found that a Sense of Belonging ($\beta = 0.644$, $p < 0.05$) is one of the key predictors in attracting and retaining members in martial arts clubs, further corroborating our findings that an enhanced sense of organizational belonging is crucial for increasing perseverance in CMAs (Kopanidis, 2023).

Moreover, Sense of Belonging amplifies practitioners' sense of identity and role within their community, thereby fostering deeper commitment and sustained participation in CMAs activities. In Chinese martial arts, which are deeply embedded in cultural traditions, the mentor-disciple relationship is essential in nurturing a Sense of Belonging among practitioners. This dynamic, as highlighted by Levett-Jones et al. (2009), is a key influence on students' feelings of connectedness. The Initiation Ceremony, an integral tradition within this relationship, plays a significant role in strengthening communal ties and shaping a collective identity within the CMA community.

The Initiation Ceremony is characterized by its profound ritualistic elements, beginning with incense offerings to heaven, earth, and the ancestral masters. This act symbolizes respect and the formal acceptance of a new disciple. Following this, the disciple's bows and kowtows to the mentor, adhering to the "three bows and nine kowtows" tradition, further cement the disciple's commitment and reverence. The exchange of the initiation certificate during the ceremony marks the disciple's formal induction into the lineage. The culmination of this ceremony with the offering of tea and the hosting of a banquet by the disciple in honor of the mentor celebrates the establishment of the mentor-disciple bond (Xing and Zhou, 2013).

Participants in the Initiation Ceremony experience a deep moral and ceremonial sense, which transcends mere external formality to reinforce value identification, such as respect for the mentor and commitment to the martial path, fostering trust and unity within the community. This ceremony not only integrates disciples into the lineage, providing them with a Sense of Belonging, responsibility, and mission but also enhances their cultural identity and commitment to the practice. Additionally, CMA schools often honor their founding masters through portraits, and mentors lead disciples in respectful salutations, instilling a sense of reverence and transforming external rituals into internal awareness, which promotes self-affirmation and strengthens the collective identity of the practitioners within their moral community (Lin and Cao, 2020).

Reflecting on Durkheim (2016), the concept that a group bonded by shared values, behavioral norms, or rituals forms a "moral community" is highlighted. This notion is supported by Jennings et al. (2010), who view the martial arts school as a "moral community" akin to a secular religion, where beliefs and practices converge to forge a strong communal identity among practitioners. One respondent vividly described Chinese Martial Arts as providing "meaning or belonging; it's something I can put my mind to, and the more I learn, the more I can learn," encapsulating the profound personal and communal significance of CMAs.

In essence, the Sense of Belonging is integral to sustaining practice within CMAs. The establishment of mentor-disciple relationships, the ritualistic aspects of the Initiation Ceremony, and the formation of a moral community all contribute to a deep Sense of Belonging among practitioners. This belonging not only solidifies their cultural identity but also fuels their continuous passion and dedication to the practice. Thus, in promoting CMAs on an international scale, it is essential to emphasize the importance of these cultural and ritualistic elements to enhance practitioners' Sense of Belonging and ensure their long-term commitment and persistence in the art.

4.3 Limitations and directions for future research

This study aimed to explore the impact of motivations for practicing CMAs on the persistence of such practice and employed a second-order model to aggregate motivation factors significantly associated with persistence (such as enjoyment, mastery, physical and psychological health, and appearance) to understand how these motivations collectively influence the persistence in practicing CMAs. However, this research did not individually explore the differences in the impact of these motivation factors on the persistence of practicing CMAs, necessitating further detailed examination of their specific contributions to persistence in future studies.

Moreover, while this study included 226 participants from various countries and age groups, it did not delve into the potential impact of participants' background characteristics on the research model. Research by Ding et al. (2015) found significant differences in the motivations of CMAs practitioners based on gender, skill level, martial arts style, and membership type. Zeng (2019) further noted that while nationality showed variations in participation motivation, skill level was not a decisive factor. In Ding et al. (2015) study, comparisons were made between the novice group and the advanced group, whereas Zeng (2019) focused on the comparison between medium level and high level. Importantly, in specific traditional CMAs styles, due to the lack of competition and grading/ranking systems, determining a Chinese martial artist's skill level is often challenging. These findings suggest that future research should conduct more detailed analyses of background variables such as gender, age, nationality, and martial arts style to explore how these factors influence the motivation to persistently practice CMAs, providing a comprehensive view of the complex dynamics behind different practitioners' persistence in practicing CMAs.

Lastly, this study accounted for only 22.1% of the variance in Persistence in Practicing CMAs, indicating that other important factors not explored in this research could influence persistence. Therefore, future research could investigate additional variables, such as personal goals, social support, and the interaction between instructors and practitioners, to provide a more comprehensive understanding of the motivation to persistently practice CMAs. By exploring these factors, future research can further promote a deeper understanding of sustained engagement in CMAs practice, thereby contributing to the global dissemination and cultural exchange of CMAs more effectively.

Data availability statement

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

Ethics statement

Ethical approval was not required for the studies involving humans because this study involved non-sensitive, anonymous data collection through public domain research methods, with no potential risk to participants. 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 because implied consent was obtained through completion of the survey, in line with the consent statement provided at the beginning of the survey.

Author contributions

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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.2024.1403327/full#supplementary-material

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Effects of coach-delivered verbal encouragement on the physiological and psychological responses of adolescent players in small-sided basketball games

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Introduction: The confluence of physiological and psychological dynamics is fundamental to athletic performance, particularly in basketball, where physical skill and mental resilience are imperative. While the role of verbal encouragement (VE) as a catalyst for enhancing performance has been explored in various sports disciplines, its specific effects within the basketball have not been adequately examined. Addressing this gap, the current study zeroes in on the influence of coach-delivered VE on the physiological and psychological responses of adolescent basketball players engaged in small-sided games (SSG), providing a focused analysis of how directed encouragement can modulate performance and experience in young athletes. This study aimed to investigate the effects of coach-delivered verbal encouragement on the psychological and physiological responses of adolescent basketball players.

Methods: Sixteen male participants (age: 16.93 ± 0.36 years; height: 176.8 ± 0.8 cm; body mass: 73.43 ± 12.57 kg; BMI: 21.70 ± 3.55) were allocated to a Verbal Encouragement Group (VEG, $n = 8$, mean age: 16.80 ± 0.44) and a Control Group (CG, $n = 8$, mean age: 17.06 ± 0.26). Each participant engaged in four sessions of small-sided games (SSGs) consisting of four players per side in a 14 × 10 m pitch.

Results: The findings revealed significant benefits of coach-delivered verbal encouragement on both the physical and psychophysiological responses of the players ($p < 0.05$), including increased physical enjoyment, positive mood state, lower heart rate, and higher physical activity intensity level.

Discussion: Coaches should incorporate verbal encouragement strategies during SSGs to enhance player performance and optimize both psychological and physiological adaptations.

KEYWORDS

athletic performance, coaching strategies, RPE, profile of mood state, physical activity enjoyment

Introduction

Basketball players require robust physiological capabilities, such as endurance, strength, agility, and motor skills, to perform the physically demanding actions of the game, from sprinting and jumping to precise ball-handling (Maggioni et al., 2019; Zhang et al., 2019; Papla et al., 2022; Kumari et al., 2023). Equally important are psychological strengths, including mental skills and mental toughness, which enable them to make tactical decisions, communicate effectively, and remain resilient under the high-pressure conditions of competitive play. Previous research highlighted that interpersonal aspects in sports may include communication, and collaboration with coaches, teammates (Bowles and O'Dwyer, 2022; Nunes et al., 2022).

Body of evidence supports the effectiveness of small-sided games (SSGs) as a meth-od for simultaneously enhancement of physical and physiological capacity, as well as technical and tactical skills of basketball players (Matthew and Anne, 2009). These games are recognized as a highly effective strategy for enhancing the endurance of basketball players, given the sig-nificant correlation between aerobic power and the ability to consistently exert high-intensity efforts during such games (Aguiar et al., 2015; Selmi et al., 2017, 2018; Bujalance-Moreno et al., 2019). Additionally, employing positive verbal encouragement in communication contributes to cultivating a supportive team environment, thereby enhancing collaboration, cohesion, and overall team performance." Considering their capacity to simultaneously promote the development of muscular, physiological, and technical-tactical qualities essential for competitiveness, prior studies have suggested that SSGs emerge as a notably valuable training technique in basketball (Clemente et al., 2020). Utilizing positive verbal encouragement in communication plays a pivotal role in fostering a supportive team environment, thereby reinforcing collaboration, cohesion and overall team performance (Sahli et al., 2023).

Further research has consistently shown that VE has a positive impact on the psychological state of athletes. This effect enhances their selfconfidence, motivation and con-centration during training and competition (Selmi et al., 2017; Aydi et al., 2022; Sahli et al., 2023).

An expanding body of research contends that verbal encouragement from coaches can enhance motivation and physical performance across various contexts and activities, including Small-Sided Games (SSGs) (Rampinini et al., 2007; Selmi et al., 2017; Sarmento et al., 2018). It is noteworthy that the verbal guidance provided by a coach can exert a notable influence on team performance (Cushion and Jones, 2001), making coach speech a subject of prior research focus (Lorenzo et al., 2015). Intriguingly, athletic performance has demonstrated a significant improvement under verbal encouragement not only during SSGs but also in competitive settings (Mazzetti et al., 2000).

An expanding body of research contends that VE from coaches can enhance motivation and physical performance across various contexts and activities, including SSGs (Rampinini et al., 2007; Selmi et al., 2017; Sarmento et al., 2018). It is noteworthy that the verbal guidance provided by a coach can exert a notable influence on team performance (Cushion and Jones, 2001). Therefore, the coach speech has been the focus of earlier research (Lorenzo et al., 2015). Interestingly, athletic performance has demonstrated a significant improvement under VE not only during SSGs but also in competitive settings (Mazzetti et al., 2000).

The compelling evidence supporting the efficacy of VE during SSGs, along with the important role motivation plays in trainings (Hidi and Harackiewicz, 2000) are major catalysts for this research. The present study, aimed to examined the impact of coach VE during SSGs on physiological and affective aspects of adolescent basketball players during trainings or competition.

This study is motivated by the imperative to explore the effects of Experiential Learning (EV) within the niche of sport science education. While existing research has delved into the influence of EV on professional athletes spanning different age groups, as well as on physical education students at earlier educational stages like elementary school, there exists a dearth of comprehension regarding its impact on sport science students. We posit that the consistent and iterative provision of EV by the instructor will result in noteworthy enhancements in performance, perceived effort, and psychological responses among sport science students.

Materials and methods

Ethical approval

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was fully approved by the research ethics committee of the High Institute of Sports and Physical Education of Kef. Additionally, this research adheres to ethical guidelines for research practices in sports medicine and exercise science (Guelmemi et al., 2024).

Participants and study design

Before recruitment, we used the free software GPower version 3.1.9.6 (Germany) for determining the optimal sample size. Thus, a power analysis for a repeated measures ANOVA was conducted, focusing on a within-between interaction. The analysis was predicated on an anticipated effect size (f) of 0.4, indicative of a moderately large effect, with an alpha error probability set at 0.05 and a desired statistical power of 0.8. The experimental design comprised two groups, each subjected to two measurements, with an assumed correlation of 0.5 between these measurements. No correction for sphericity ($\varepsilon = 1$) was applied.

The power analysis yielded a noncentrality parameter (λ) of 10.24. Additionally, the critical F-value was calculated to be 4.60, serving as the F-distribution's cut-off point for null hypothesis rejection. To reach the predetermined power, a sample size of 16 was deemed necessary, as reflected by the actual power computation of 0.85, marginally surpassing our target. This sample size is considered sufficient to detect the expected effect size with the specified power.

In this randomized controlled design, 16 male basketball players (age: 16.93 ± 0.36 years; height: 176.8 ± 0.8 cm; body mass: 73.43 ± 12.57 kg; BMI: 21.70 ± 3.55) were randomly assigned to two groups (eight players per group). Players were first stratified based on a baseline assessment of their technical abilities, including dribbling speed, shooting accuracy, and defensive skills. Players were then randomly assigned to either the Verbal Encouragement Group (VEG) or the Control Group (CG) within each skill tier using a computer-generated random number sequence to ensure balanced skill levels.

The control group (SSGNE) and the experimental group (SSGE) were constituted accordingly. These participants were recruited from the Ain Drahm basketball team. Throughout the study, participants engaged in three training sessions per week, with each player required to partake in four sessions of small-sided games (SSG). The SSG sessions were conducted on half of a basketball court measuring 14 × 15 m, accommodating two 4v4 SSGs, with the same players consistently involved. Notably, unlike the control group (SSGNE), the SSGE group received verbal encouragement from the coach, both defensively and offensively. Among the verbal encouragement group, the physical education teacher encourages the students using specific instruction related to team sports (Andreacci et al., 2002). Using a cheer every 20 s, the teacher became accustomed to the Protocol (Sánchez-Sánchez et al., 2017). All participants had no reported injuries or illnesses before or during the study. Participants and their parents voluntarily agreed to participate in the study and gave written informed consent after a detailed explanation about the aims and risks involved in the research.

Procedures

This study was conducted during the 2022–2023 mid-season. Prior to SSGs, anthropometric characteristics were collected (Table 1). Before beginning the experimental testing, anthropometric measurements were taken.

All participants underwent a standardized 15-min warm-up comprising low-intensity running, coordination movements, and dynamic stretching, including high knee lifts, butt kicks, straight-line skipping, etc., followed by a series of 3 × 10 m sprints. 3 min of recovery separated the warm-up from the beginning of the SSG.

The 4 experimental sessions comprised 4-a-side and were conducted on distinct days, each with a one-week interval between sessions. All experimental sessions took place on the same indoor basketball room. The pitch measuring 14 × 15 m and at a consistent time of day (between 5:00 and 6:00 PM) to mitigate the impact of circadian variations. The training consisted of three SSG sets of 4 min duration each, with 90 s of passive rest between sets. Four training sessions were conducted on different days (twice a week), during each players took part in three sets of SSGs. During each experimental session, participants were divided into two groups, with 8 students (4 vs. 4) per-forming SSGs on the half basketball field under teacher verbal encouragement, while the other eight performed SSGs with no verbal encouragement on the other half of the court. HR was monitored throughout each training session. RPE was recorded, and the PACES was completed 5 min after the end of each SSG. The profile of mood state (POMS) recorded before and after each training session. Players were familiarized with the RPE scale, PACES scale, POMS questionnaire and the Small-Sided Game (SSG) regimen before the study commenced. Data for each SSG session were consistently collected by the same group of researchers.

TABLE 1 Demographic and anthropometric characteristics of participants (mean +/− standard deviation) ($n = 16$).

	Age (year)	size (cm)	weight (kg)	Waist size	BMI
Mean	15.92	1.84	74.42	83.71	21.70
Standard deviation	0.35	0.06	12.56	10.60	3.55

BMI, body mass index.

Small-sided games

The two groups participated in a 4vs4 SSG on a half basketball field, with (SSGE) or without teacher verbal encouragement (SSGNE) (Table 2). The duration of each Small-Sided Game (SSG) was precisely regulated, consisting of 3 bouts lasting 4 min each, with 90 s of passive recovery between bouts. The players were instructed to exert maximum effort during the games while aiming to maintain possession of the ball for the longest possible duration.

Each bout commenced with the ball in the air. In the SSGE condition, two coaches strategically positioned around the pitch facilitated game continuity by providing new balls when necessary. Importantly, they actively encouraged players using team sports related terminology such as "Go," "Good job," "Excellent," "Come on, push it," and "Keep it up," "Let us go!" "Stay focused and keep pushing!" "Keep your head in the game!" "Let us see some hustle out there!" "Great shot, keep firing!" "Nice move!" "Defense! Lock it down!" "Great maneuver; repeat that" (Lorenzo et al., 2015). The week before data collection, the coach was familiarized with the verbal encouragement procedure. Sánchez-Sánchez et al. (2017) device was used to continuously track the verbal encouragement level each 20 s.

Load of the small-sided games

Following training in device utilization, player's heart rate was measured throughout the various SSGs using individual heart rate monitors (Polar Team Sport System, Po-lar-Electro OY, Kempele, Finland). The highest heart rate recorded during each session was the maximum heart rate (HR max). PER was measured using the 10-point scale proposed by Foster et al. (2001), 1 min after each set corresponding to each SSG format. The scale was thoroughly explained to the participants. The question "How did it go and how did you feel about the exercise? was addressed to each player individually in the absence of peers, all while being blinded to the points awarded to each of them (Table 3).

Enjoyment of physical activity

The assessment of players' enjoyment of physical activity (PACES) utilized an 18-item scale gaging the perceived benefits of engaging in physical activity (Sánchez-Sánchez et al., 2017). Partici-pants employed a 7-point bipolar rating scale, ranging from 1 (It's very enjoyable) to 7 (It's not fun at all), to express 'how they feel right now about the physical activity they did.' Note that the scores for 11 items were reversed. The cumulative scores of all items were then summed to derive the overall physical activity enjoyment score, spanning from 18 to 126. Higher PACES scores are indicative of elevated enjoyment levels. Each student received an individual paper copy of the scale (Hopkins et al., 2009).

TABLE 2 Small-sided games practiced by the students.

Variables	Teachers' encouragement						Format	Field size
	with encouragement			without encouragement				
	before	during	after	before	During	After		
POMS	×		×	×		×	4vs.4	14 × 15 m
PACES			×			×		
RPE			×			×		
FC		×			×			

TABLE 3 Results of two-factor (ANOVA): games factor (SSGE and SSGNE), session's factor and their interaction on PACES, RPE, and HRmax.

Variables	Sessions			Game			Interaction		
	F	Sig	E.S	*F*	Sig	E.S	*F*	Sig	E.S
Paces	3.717*	0.022	0.271	0.123	0.733	0.012	1.681	0.192	0.144
RPE	4.770**	0.008	0.323	1.966	0.191	0.164	9.724***	0.000	0.493
HRmax	0.512	0.677	0.049	5.233*	0.045	0.344	0.512	0.677	0.049

Profile of the mood-state

The Profile of Mood States (POMS) questionnaire, consisting of 65 items, was used to evaluate six different components of mood states: tension-anxiety, depression-depression, hostility-anger, vigor-activity, fatigue-inertia, and confusion-perplexity. Each item was rated on a 5-point Likert scale, where 0 represented "Not at all" and 4 represented "Extremely." The total mood disturbance score (TMD), which is the sum of the T-scores for each of the six POMS subscales, can be calculated by adding the T-scores for the five sub-scales measuring negative mood, deducting the *T*-score measuring positive mood, and adding a constant of 100 to prevent negative numbers [TMD = ((Anger + Confusion + Depression + Fatigue + Tension) - Vigor) + 100]. Participants responded to the POMS questionnaire individually.

Statistical procedures

Data is presented as Mean (M) and standard deviation (SD). The Kolmogorov–Smirnov test was used to verify the normality assumption before using parametric tests. The effects of play (SSGE and SSGNE), time (pre- and post-training session), and their interaction on the POMS score were examined using a two-factor analysis of variance (ANOVA). (2) The interaction between "sessions," "the effect of play" (SSGE and SSGNE), and "PACES, RPE, and HRmax." To compare the physiological and psychological out-comes following the two game modalities (with and without encouragement), the independent samples *t*-test was used. A rigorous assessment of the differences between SSGE and SSGNE was conducted using the magnitude of change expressed by Cohen's d coefficient (Cohen, 1992). According to Hopkins et al. (2009), magnitude scales with values between 0 and 0.20, >0.20 to 0.50, >0.50 to 0.80, and > 0.80 were categorized as trivial, small, medi-um-sized, and large, respectively. The significance level was set at $p < 0.05$, and analyses were carried out using the Statistical Package for the Social Sciences (v26.0, SPSS, SPSS Inc., Chicago, IL, USA).

Results

Physiological responses

A significant effect of the sessions factor ($p = 0.02$, ES = 0.27) on PACES scores (Table 3).

The results presented in Table 3 show significant effects of the session factor ($p = 0.008$, ES = 0.34) and interaction factor (sessions * games) ($p = 0.045$, ES = 0.14) on the RPE scores. Concerning the HR max, there is a significant effect only on the games factor ($p = 0.045$, ES = 0.34) (Table 3).

The results illustrated in Table 4 showed significant differences between SSGE and SSGNE for the variables HRmax in sessions S2 and S4 ($p = 0.025$, ES = 0.60; $p = 0.017$, ES = 0.63), and for the RPE score in session S4 ($p = 0.032$, ES = 0.58).

Physical enjoyment

The analysis of PACES scores across small-sided games, with encouragement (SSGE) and without encouragement (SSGNEE), revealed no statistically significant differences (Table 4).

Mood state

We found a significant main effect of Time on the 6 mood states tension (S4: $p = 0.001$), confusion (S3: $p = 0.05$), anger (S1: $p = 0.05$, S2: $p = 0.048$), depression (S1: $p = 0.028$, S3: $p = 0.045$, S4: $p = 0.042$), fatigue (S1: $p = 0.001$, S2: $p = 0.003$ and S4: $p = 0.034$), Vigor (S2: $p = 0.02$, S3: $p = 0.005$ and S4: $p = 0.04$) and on TMD (S2; $p = 0.027$, S3; $p = 0.002$ and S4; $p = 0.038$), as well as a significant effect of the interaction (time * games) on TDG in session S3 ($p = 0.009$, ES = 0.508) (Table 5).

The comparison of the different mood states before and after SSG showed a significant difference of the 6 mood states at SSGE: Tension (S4; $p = 0.001$), Confusion (S3: $p = 0.001$), Anger (S1: $p = 0.03$, S2:

TABLE 4 Comparison of PACES, RPE, and HR max between small-sided games with encouragement (SSGE) and small-sided games without encouragement (SSGNE).

Variables		With ENC.		Without ENC.		*T*	*p*	E.S
		M	SD	*M*	SD			
Paces	S1	5.84	1.84	5.00	2.00	0.752	0.469	0.21
	S2	4.67	1.22	5.17	1.73	−0.582	0.574	0.16
	S3	4.17	1.48	4.84	1.17	−0.869	0.405	0.24
	S4	3.84	1.17	4.50	1.05	−1.040	0.323	0.28
RPE	S1	76.84	6.86	76.50	6.54	0.086	0.933	0.02
	S2	81.84	6.18	77.17	7.99	1.132	0.284	0.31
	S3	83.67	6.25	76.17	9.54	1.611	0.138	0.42
	S4	84.00	6.32	74.00	7.50	2.495	0.032	0.58
HRmax	S1	188.00	11.15	183.00	11.55	0.762	0.463	0.21
	S2	192.33	5.17	182.00	8.07	2.641	0.025	0.60
	S3	191.00	7.09	181.67	10.70	1.779	0.106	0.45
	S4	190.83	6.62	180.17	6.34	2.852	0.017	0.63

M, mean; SD, standard deviation; ES, effect size.

$p = 0.048$), Depression (S1: $p = 0.028$, S3: $p = 0.045$ and S4: $p = 0.042$), Fatigue (S1: $p = 0.001$, S2: $p = 0.003$ and S4: $p = 0.034$), Vigor (S2: $p = 0.022$, S3: $p = 0.005$ and S4: $p = 0.041$) as well as the SSGNE: tension (S4: $p = 0.012$), anger (S3: $p = 0.041$), depression (S2: $p = 0.013$), Fatigue (S2: $p = 0.001$, S3: $p = 0.001$and S4: $p = 0.003$) (Tables 6, 7).

Discussion

The present study examined assessed the effect of the sports teacher's verbal encouragement on the physiological responses, mood state, physical enjoyment and technical-tactical skills of adolescent basketball players during SSGs. The main findings of the present study are that (1) SSGE significantly heightened physiological responses compared to SSGNE, and (2) participants reported a notably improved mood state following SSGE in contrast to SSGNE.

The current investigation demonstrates that verbal encouragement from a sports teacher has a beneficial effect on the physiological responses observed during Small-Sided Games (SSGs). These results support earlier research suggesting that coaches might improve players' physical and psychological-physiological reactions during basketball drib-bling drills by using verbal cues (Garcia-Rubio et al., 2014). Our results unequivocally show that players can be-come more motivated after verbal support from teachers, and that higher motivation can lead to increased physical effort and the ability to maintain a high work rate during small-sided games. This pattern of outcomes is also consistent with what Rampinini et al. (2007) reported. Rampinini et al. (2007) examined the effects of verbal encouragement on different physiological responses in a number of small-sided game formats on small, medium, and large fields, including 3 vs. 3, 4 vs. 4, 5 against. 5, and 6 vs. 6. Researchers Rampinini et al. (2007) looked into how different physiological reactions were affected by verbal encouragement. They showed that HR and RPE values were significantly higher during gaming sessions when verbal encouragement was provided. Similar beneficial effects were observed when Selmi et al. (2017) examined the physiological reactions of young soccer players to verbal encouragement from coaches during 4 vs. 4 SSG.

Coach verbal encouragement has also been shown to have a positive impact during basketball games (Garcia-Rubio et al., 2014). Furthermore, Edwards et al. (2018) reported that verbal encouragement improved performance and motivation during endurance activities, resulting in significant implications for health, adherence, and physical performance when using a hands-on intervention. These findings may lead to the conclusion that motivation, which can be positively influenced by teacher or coach verbal encouragement, can affect the physiological responses and internal intensity arising during SSGs.

The results of the current investigation showed that there was no discernible difference in the physical enjoyment of activity between SSGE and SSGNE. Nonetheless, PACES scores were significantly impacted by the session component. Our results conflict with those of Kilit et al. (2019), who hypothesized that verbal encouragement positively affects participants' physical satisfaction and commitment to exercise. Numerous studies have shown that physical enjoyment plays a role in the favorable feelings associated with physical activity (Selmi et al., 2020). The PACES scale has been shown to be useful in assessing athletes' experiences of physical pleasure in a number of studies (Selmi et al., 2020). As Selmi et al. (2017) demonstrated, providing encouragement during training activities can increase athletes' motivation and good actions. One of the primary elements influencing the desire to engage in physical activity.

The findings of the present study demonstrated a significant positive impact of coach verbal encouragement on mood state during SSGs. In line with our findings, Selmi et al. (2020) found that during integrated training, players generally reported significant improvements in their mood state following exposure to coach verbal encouragement. The POMS is frequently used to assess participants' psychological responses during physical activity and training.

In our study small-sided SSGE and SSGNE games lead to a decrease in TMD (tension: S4: $p = 0.001$and ES = 0.17), vigor (S2: $p = 0.022$, ES = 0.23, S3; $p = 0.005$, ES = 0.23, S4; $p = 0.041$, ES = 0.18). This indicates that coach verbal encouragement can trigger positive mood state during basketball SSGs. These findings are in line with those presented by Sparkes et al. (2020), who looked at how SSG affected mood. Increased vigor and decreased tension are typically associated with decreases in TDG following SSGE. We believe that the motivational aspects of SSGs in this study may help explain the decreases observed in TDG. More importantly, coaches' verbal encouragement combined with basket-ball specific training seems to improve mood state.

Overall, the results about students' subjective perceptions of exercise and their enjoyment of physical activity point to EV as having a major influence. It appears that students not only put up more effort under EV, but also felt the experience more pleasurable and re-warding, as seen by the combination of higher perceived effort and greater enjoyment. It is significant to highlight that although the data show the benefits of exercise, more research is needed to determine the precise processes underlying these benefits. However, the relationship between coaches and athletes, as well as teachers and students, significantly influences the effectiveness of verbal encouragement (VE). A foundation of trust and rapport ensures that encouragement is received as constructive, fostering a receptive and

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TABLE 5 Results of two-factor ANOVA: "Games" factor (SSGE and SSGNE), "Time" factor (pre- and post-training session) and their interaction on the POMS score.

Variables		Time			Game			Interaction		
		F	SIG	E.S	*F*	SIG.	E.S	*F*	SIG	E.S
Tension	S1	4.71	0.055	0.320	10.001	0.970	0.000	10.18	0.304	0.105
	S2	13.85	0.004	0.581	0.054	0.823	0.005	10.54	0.243	0.133
	S3	9.15	0.013	0.478	0.00	1.000	0.000	20.29	0.162	0.186
	S4	49.00	0.000	0.831	0.08	0.784	0.008	10.00	0.341	0.091
Confusion	S1	6.64	0.028	0.399	0.002	0.962	0.000	0.09	0.780	0.008
	S2	3.74	0.082	0.272	0.05	0.837	0.004	0.60	0.458	0.056
	S3	9.56	0.011	0.489	0.01	0.929	0.001	0.15	0.707	0.015
	S4	0.42	0.5	0.040	0.15	0.709	0.015	00.05	0.835	0.005
Anger	S1	14.31	0.004	0.589	0.61	0.453	0.057	0.050	0.828	0.005
	S2	5.07	0.048	0.336	0.39	0.547	0.037	30.53	0.090	0.260
	S3	9.31	0.012	0.482	0.05	0.827	0.005	0.08	0.787	0.008
	S4	4.50	0.060	0.310	0.56	0.475	0.052	0.50	0.496	0.048
Depression	S1	15.21	0.003	0.603	0.005	0.946	0.000	1.7	0.223	0.195
	S2	13.26	0.005	0.570	0.22	0.655	0.021	0.42	0.535	0.040
	S3	10.91	0.008	0.522	0.84	0.381	0.077	2.73	0.130	0.214
	S4	3.92	0.076	0.281	0.50	0.497	0.047	1.74	0.217	0.148
Fatigue	S1	15.42	0.003	0.036	0.26	0.625	0.025	0.07	0.799	0.007
	S2	66.82	0.000	0.870	1.43	0.260	0.125	1.37	0.270	0.120
	S3	11.40	0.007	0.533	4.44	0.062	0.307	0.93	0.358	0.085
	S4	16.85	0.002	0.628	0.93	0.357	0.085	0.29	0.604	0.028
Vigor	S1	0.38	0.553	0.226	0.160	0.697	0.016	0.17	0.691	0.016
	S2	13.18	0.005	0.569	0.29	0.606	0.028	4.42	0.062	0.306
	S3	22.24	0.001	0.690	0.07	0.807	0.006	9.31	0.12	0.482
	S4	8.46	0.16	0.458	0.45	0.518	0.043	4.55	0.059	0.313
TMD	S1	2.92	0.118	0.226	0.146	0.710	0.014	0.02	0.917	0.001
	S2	13.33	0.004	0.571	0.11	0.747	0.011	2.45	0.149	0.197
	S3	38.58	0.000	0.794	0.42	0.532	0.040	10.33	0.009	0.508
	S4	6.60	0.028	0.397	0.83	0.385	0.076	2.62	0.137	0.207

positive learning environment. Effective communication tailored to individual needs enhances motivational impacts, with consistency and authenticity in encouragement crucial for building confidence and self-esteem. An open feedback loop allows for adjustments in coaching or teaching methods, while cultural sensitivity ensures the relevance of encouragement. Empowering athletes and students promotes autonomy, boosting intrinsic motivation. Over time, sustained positive interactions help solidify these relationships, enabling continuous personal and performance development, illustrating that VE is more than motivational words, it's a strategic approach to nurturing growth and excellence in sports and education. Moreover, Future studies should examine variables including the frequency and timing of EV, individual variations in how they react to encouragement, and possible interactions between EV and other performance enhancing techniques.

Finally, since the mental skills in sports are always linked to the social and cultural environment (Guelmemi et al., 2015; Eubank et al., 2017; Gill et al., 2017) it would be beneficial to exam the effect of VE in various cultures and contexts.

It is important to consider various constraints when interpreting the current findings. First of all, the tiny study sample was a result of the challenge of finding a lot of subjects who were all the same. Additionally, a single SSG format and a single age cohort of soccer-specialist pupils were used in the assessment. To in-crease the applicability of the current findings, future studies comparing the two SSG conditions should use participants of varying ages and varying levels of SSG intensity deter-mining variables (i.e., different game rules, duration of each bout, pitch size, number of players, and the presence of goalkeepers). Lastly, it would be fascinating to link these reactions to technical time-motion parameter elements (such as distance traveled, number of sprints, high-intensity runs, etc.) since physical.

As practical implications, the study provides several important implications for sports training and coaching:

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TABLE 6 Comparison of different mood states before and after small-sided games with encouragement (SSGE).

Variables		Before		After		*T*	*p*	E.S
		M	SD	*M*	SD			
Tension	S1	11.33	6.80	10.33	6.77	2.236	0.076	0.07
	S2	10.33	6.08	8.50	6.41	4.00	0.10	0.06
	S3	12.33	5.42	10.33	5.75	2.449	0.058	0.17
	S4	11.00	6.69	9.66	6.37	6.325	0.001	0.10
Confusion	S1	8.50	3.95	6.67	2.74	2.076	0.093	0.14
	S2	8.33	3.50	6.83	3.25	0.696	0.518	0.08
	S3	8.33	3.50	6.83	3.31	6.708	0.001	0.21
	S4	8.16	2.56	8.00	3.03	0.415	0.695	0.02
Anger	S1	16.50	9.44	15.00	8.74	3.00	0.030	0.08
	S2	15.00	5.40	13.16	4.16	2.607	0.048	0.18
	S3	12.66	2.80	11.83	3.48	1.746	0.141	0.13
	S4	11.16	2.92	9.83	2.13	1.865	0.121	0.25
Depression	S1	11.00	5.66	8.67	4.23	3.070	0.028	0.22
	S2	10.33	4.36	8.66	3.50	2.331	0.067	0.20
	S3	9.16	3.54	7.66	2.33	2.666	0.045	0.24
	S4	9.16	2.56	8.33	2.33	2.712	0.042	0.16
Fatigue	S1	6.84	1.17	8.00	1.27	−7.000	0.001	0.42
	S2	6.50	1.22	8.50	1.04	−5.477	0.003	0.66
	S3	6.66	1.03	7.50	1.04	−1.536	0.185	0.37
	S4	8.16	0.75	10.33	1.75	−2.892	0.034	0.62
Vigor	S1	20.33	5.89	20.50	6.30	−0.107	0.919	0.01
	S2	22.33	4.88	24.83	5.49	−3.273	0.022	0.23
	S3	22.33	4.92	24.66	4.80	−4.719	0.005	0.23
	S4	23.33	5.75	25.50	5.54	−2.735	0.041	0.18
TMD	S1	128.84	19.78	126.00	14.00	0.996	0.365	0.08
	S2	124.66	14.81	117.83	12.18	3.091	0.027	0.21
	S3	120.83	10.53	113.50	10.96	6.102	0.002	0.32
	S4	118.33	8.50	115.66	7.14	2.803	0.038	0.22

M, mean; SD, standard deviation; ES, effect size.

The findings suggest that verbal encouragement from coaches can significantly enhance players' performance metrics such as heart rate and perceived exertion levels. This indicates that strategic verbal cues during training can help players maintain higher intensity levels and improve overall game performance.

The study also highlights the psychological benefits of verbal encouragement, showing improved mood states among players receiving encouragement. This suggests that verbal encouragement not only enhances physical performance but also positively impacts athletes' psychological well-being, which can be crucial for their overall development and performance consistency.

For coaches, the study underscores the importance of incorporating motivational strategies into their coaching routines. Understanding the positive impact of verbal encouragement can help coaches better engage with their athletes, fostering a supportive environment that enhances both skill development and mental resilience.

The implications for training design suggest that integrating verbal encouragement into regular practice sessions can lead to better engagement and performance from athletes. This could influence how training sessions are structured, emphasizing not just the physical but also the motivational aspects of sports training.

Given the observed improvements in mood and cohesion, coaches might also use verbal encouragement to foster better team dynamics and collaboration among players. This could be particularly useful in team sports where cooperation and team spirit are crucial for success.

Conclusion

The present study explored the impact of coach verbal encouragement on adolescent basketball players' performance, encompassing physiological markers such as heart rate (HR) and ratings of perceived exertion (RPE), as well as psychological factors

TABLE 7 Comparison of different mood states before and after small-sided games without encouragement (SSGNE).

Variables		Before		After		*T*	*p*	ES
		M	SD	*M*	SD			
Tension	S1	11.16	8.47	10.83	8.28	0.791	0.465	0.01
	S2	11.50	8.78	10.83	8.56	1.581	0.175	0.03
	S3	10.66	8.06	9.00	8.40	2.000	0.102	0.04
	S4	12.00	8.00	10.00	8.48	3.873	0.012	0.06
Confusion	S1	8.33	3.38	6.66	3.80	1.581	0.175	0.10
	S2	8.33	3.20	7.16	2.22	2.445	0.058	0.20
	S3	8.33	3.50	7.16	2.13	1.400	0.220	0.19
	S4	8.83	2.63	9.50	2.58	0.500	0.638	0.06
Anger	S1	13.00	6.16	11.66	5.31	2.390	0.062	0.11
	S2	12.50	4.67	12.33	4.45	0.307	0.771	0.01
	S3	13.33	5.92	12.33	5.24	2.739	0.041	0.08
	S4	12.33	4.76	11.66	3.98	1.085	0.328	0.07
Depression	S1	10.16	7.83	9.00	6.72	2.445	0.058	0.07
	S2	11.33	5.39	10.16	5.45	3.796	0.013	0.10
	S3	10.33	3.38	9.83	3.37	2.236	0.076	0.07
	S4	9.83	2.48	9.66	2.58	0.415	0.695	0.03
Fatigue	S1	7.59	3.61	8.83	3.43	−2.169	0.082	0.17
	S2	8.83	4.07	10.33	4.22	−6.708	0.001	0.17
	S3	9.33	3.50	10.83	3.37	−3.503	0.017	0.21
	S4	10.83	3.31	11.50	3.72	−2.988	0.031	0.14
Vigor	S1	21.00	2.09	21.83	2.04	−1.746	0.141	0.19
	S2	22.00	2.60	22.66	2.73	−1.581	0.175	0.12
	S3	22.66	2.73	23.166	3.31	−1.464	0.203	0.09
	S4	22.33	4.41	22.66	4.13	−1.000	0.363	0.03
TMD	S1	124.16	23.59	121.66	23.38	1.946	0.109	0.05
	S2	125.50	23.20	123.16	22.53	1.941	0.110	0.05
	S3	124.33	21.24	122.00	18.89	2.360	0.065	0.05
	S4	126.50	20.24	124.66	17.71	0.714	0.507	0.02

M, mean; SD, standard deviation; ES, effect size.

like enjoyment of Physical Activity Enjoyment Scale (PACES) activities and mood state. Our findings revealed significant positive effects of verbal encouragement on the RPE scores, mood state (measured by the Total Mood Disturbance index), and technical performance, particularly in passing and running shots. These results emphasize the crucial role of verbal support from coaches and physical education instructors during small-sided matches, not only in enhancing physiological responses but also in nurturing a positive mental attitude among players. To comprehensively understand the external load in such games, future research should consider integrating additional variables such as travel distance, speed zones, and acceleration/deceleration patterns. However, it's vital to acknowledge the limitations of our study, including the need for a larger sample size to improve generalizability and the caution required when extending findings beyond young basketball players. Moreover, the relatively small sample size may influence the reliability of our results and should be taken into account during interpretation.

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 committee of the High Institute of Sports and Physical Education of Kef. 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

AK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration,

Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. FS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. HG: Data curation, Formal analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. RL: Funding acquisition, Methodology, Supervision, Validation, Visualization, Writing – review & editing. OS: Data curation, Formal analysis, Methodology, Supervision, Validation, Visualization, Writing – review & editing. HS: Methodology, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. NJ: Supervision, Validation, Visualization, Writing – review & editing. AR: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. MZ: Project administration, Supervision, Validation, Visualization, Writing – review & editing. MH: 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.

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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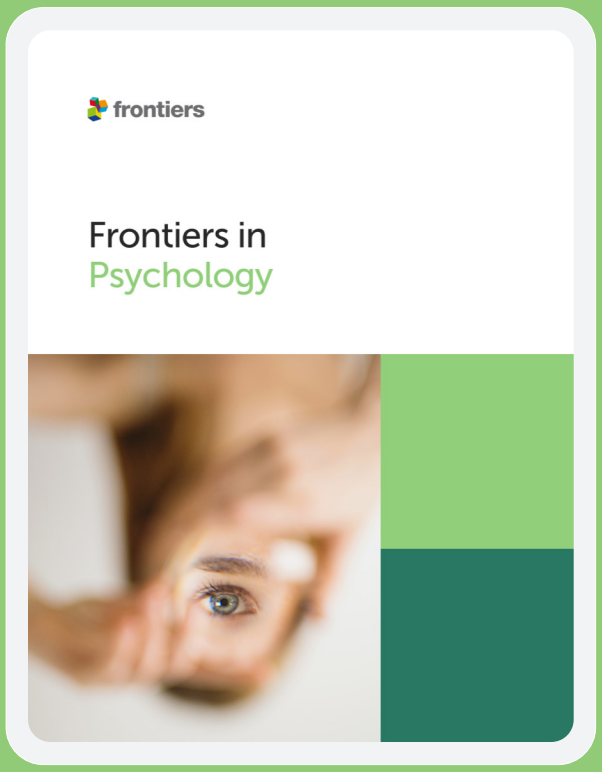

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