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New developments in the intention-behavior gap for physical activity – recent trends, controversies, and a critical outlook

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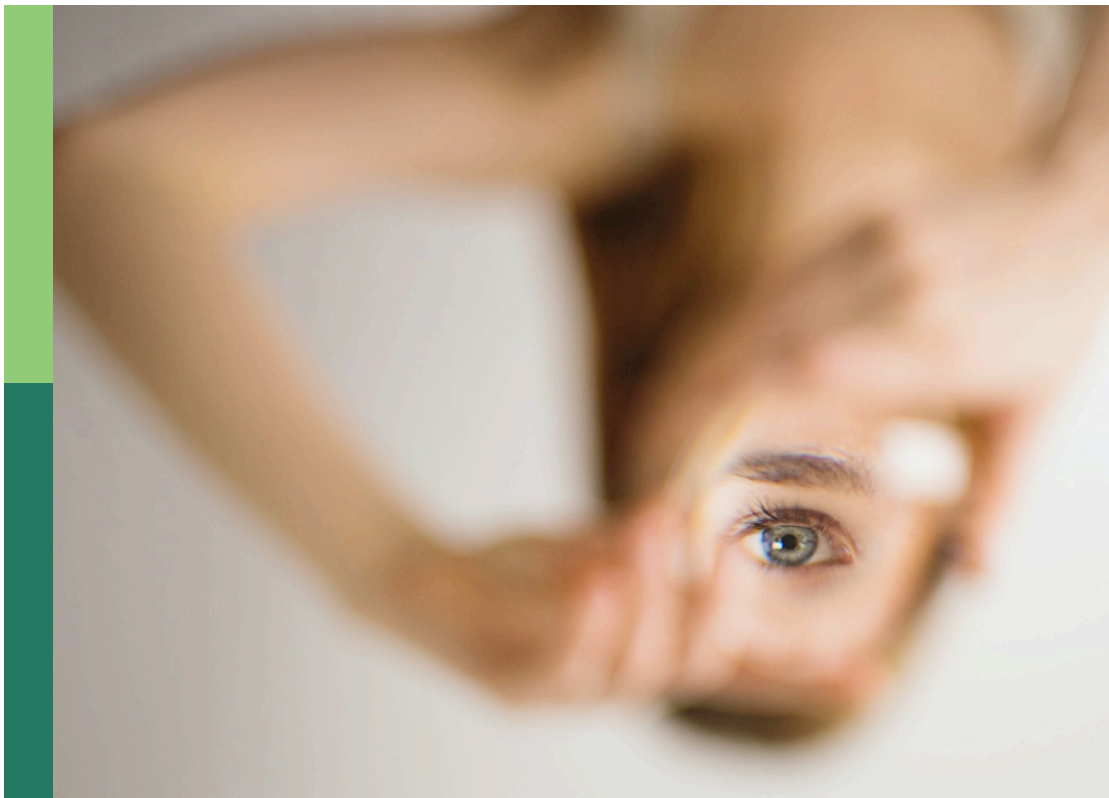

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New developments in the intention-behavior gap for physical activity – recent trends, controversies, and a critical outlook

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Editorial: New developments in the intention-behavior gap for physical activity – recent trends, controversies, and a critical outlook

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Editorial on the Research Topic
New developments in the intention-behavior gap for physical activity – recent trends, controversies, and a critical outlook

Physical activity (PA) plays a predominant role in health promotion and disease prevention. Despite strong intentions, individuals often refrain from acting on intended behaviors due to various barriers (e.g., high stress, other priorities, and waning motivation), which is a phenomenon labeled as intention-behavior gap (e.g., Sheeran and Webb, 2016). Self-regulatory processes are particularly important to explain and bridge the intention-behavior gap as self-regulation enables us to modify our thoughts, feelings, moods, and impulses as well as other dominant response tendencies and to bring them in line with specific goals, aims, or norms (e.g., Rhodes and Yao, 2015; Finne et al., 2019; Pfeffer and Strobach, 2021; for a recent systematic review, see also Rhodes et al., 2022). Recent research has highlighted the importance of integrating explicit (e.g., motivational and self-regulatory processes) and implicit processes (e.g., habitual processes) to explain human behavior (e.g., Strobach et al., 2020; Rhodes, 2021). However, it is still unclear how explicit and implicit processes work together and, for example, if they operate in parallel (additive pattern) or may also interact (synergistically) in predicting PA behavior.

Therefore, the main aims of the current Research Topic were to expand our understanding of PA regulation, to identify the relevant processes affecting and bridging the intention-behavior gap, and to develop and evaluate treatments to promote and maintain PA behavior. In this context, dual-process theories (Hofmann et al., 2009; Brand and Ekkekakis, 2018; Strobach et al., 2020), action control theories (Rhodes and Yao, 2015), and integrated models of health behavior (Hagger and Hamilton, 2020) provide promising frameworks to examine and get new insights in the adoption and maintenance of PA behavior.

The review by Conner and Norman provides a theoretical discussion of the intention-behavior gap and the role of intention strength in the context of physical activity behavior. The authors provide insights in relevant intention-behavior moderators and they discuss features as well as predictors of intention strength. They conclude that stronger intentions predict more physical activity behavior and may be more stable over time, even though they are more difficult to change. As Conner and Norman explain, future research on the intention-behavior gap would benefit from a more systematic consideration of moderators of this relationship and an exploration of how these moderating effects might be explained.

The intensity of an exercise regime plays an important role for the subsequent health benefits as well as for future behavior. The study of Teixeira et al. examined how far the intensity of a training was in accordance with the preference and tolerance of participants and if this agreement/disagreement was associated with relevant predictors of future behavior (i.e., intention, habit) as well as behavior itself (i.e., exercise frequency). It was also hypothesized that agreement/disagreement interacted with physical activity enjoyment in predicting the dependent variables. Based on the results it seems to be important to tailor the intensity of exercise programs to the preference and tolerance of participants in order to foster future behavior.

To test the role of affective states for future physical activity behavior is a highly relevant (Rhodes and Gray, 2018). The study of Finne et al. aimed to examine the effect of affective states perceived directly after a training session on the intention to attend the next training as well as the attendance in the following week. In addition, the interaction effect between affective states and the intention to re-attend the course the following week was tested. In this longitudinal study over 13 weeks, affective states were positively related to intention, and intention mediated the effect of affective states on class attendance. In contrast to the assumption, affective states did not moderate the intention-class attendance relationship. Nevertheless, affective states during and after exercising should be further examined in relation to future behavior in the context of dual-process theories.

The study of Zhang et al. investigated the applicability of the planned behavior theory model (TPB-5) and TPB-6 model of enhanced physical exercise in college students, and explored the role of exercise commitment in the relationship between exercise intention and behavior. The results indicate that exercise commitment seems to be an important variable which might help to reduce the intention-behavior-gap.

More and Phillips in their study compared the utility of the Integrated Behavior Change Model (IBCM; Hagger and Chatzisarantis, 2014) — a social cognitive model that includes automatic factors involved in behavioral engagement and a moderator of the intention-behavior gap — to its theoretical predecessor, the Theory of Planned Behavior (TPB; Ajzen, 1991). While the IBCM was well-suited to explain intention formation, it did not predict significantly more variance than the TPB.

Text messages might be a cost-effective strategy for changing physical activity behavior in physically inactive individuals. The study of Tessier et al. examined the effects of goal-framing manipulation on physical activity attitude, perceived behavioral control, intention, goal content, as well as physical activity behavior. Low-active adolescents received messages targeting their salient beliefs with intrinsic vs. extrinsic-framing (compared to a control group). The results revealed that intrinsic goal framing compared to the extrinsic goal framing was not superior with regard to the behavior change process. Combining the message with a planning intervention was an effective strategy to promote physical activity behavior in low-active adolescents. However, the mechanisms by which these changes occurred could not be uncovered by the expected mediators. Further potential mechanisms should be examined in future studies.

Most efforts to change physical activity ideally translate from intentional to habitual regulation for long-term behavior change maintenance (Rhodes and Sui, 2021). Phillips and More aimed to identify the relevant factors which contribute to habit formation over a 4-week period, assuming that task complexity would play an important role. As postulated, intrinsic motivation, self-identity, and habit strength contributed to behavioral maintenance; however, only habit strength significantly predicted behavioral frequency over the 4-week period, independent of the respective task complexity. This is in line with theory that habit can underly long-term behavior change; but more is still needed to understand how initial intentions can translate into long-term physical activity.

Regular physical activity and the intention-behavior gap also plays an important role in the therapy of chronic diseases. The brief research report of Reicherzer et al. provides insights into perceived facilitators and barriers for physical activity of stroke patients with severe functional limitations. Based on semi-structured guided interviews, this qualitative study provided new insights into the intention-behavior gap in this specific population. The results might help to design tailored physical activity interventions. However, the small sample size of this study prevents the generalization of the results at this point in time as mobility impairments are a very heterogeneous within those with stroke diagnosis.

In recent years, dual process theories have become increasingly relevant for the examination of physical activity adoption and maintenance. The study of Zhu et al. examined the interplay of reflective (i.e., intention and action planning) and automatic processes (i.e., habit strength) in the prediction of exercise behavior in the volitional phase. Action planning is thought to make behavior more automatic by mentally pairing a situation with a specific exercise behavior (Gollwitzer, 1999). The authors take a closer look at the role of habit strength as a moderator of the planning-behavior relationship. As expected, action planning mediated the association between intention and behavior. Even though action planning might facilitate behavior because the plan is activated and executed automatically as soon as the anticipated situation arises, higher habit strength (i.e., automaticity) of exercise behavior seems to further strengthen this association. Therefore, action planning together with higher habit strength synergistically supported higher physical activity levels and diminished the intention-behavior gap rather than acting in a counterproductive manner.

Author contributions

CE and IP wrote the first draft of the present manuscript. AR and RR contributed to its critical revision. 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.

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Enjoyment as a Predictor of Exercise Habit, Intention to Continue Exercising, and Exercise Frequency: The Intensity Traits Discrepancy Moderation Role

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Given the need to explore the factors that can account for a better understanding of the intention-behavior gap in exercise practice in health club settings, and considering the emergence of hedonic assumptions related to exercise adherence, this cross-sectional study aimed to test the moderation effect of the intensity traits agreement/disagreement in three relevant outcomes of exercise enjoyment: exercise habit, intention to continue exercising, and exercise frequency. A sample consisted of 273 exercisers (male = 127; M_{age} = 36.21; *SD* = 11.29) enrolled in nine health clubs who voluntarily fulfilled a battery of questionnaires. All analyses were performed using SPSS v. 23.0/PROCESS v. 3.5. The results of the study presented a moderation effect of exercise intensity traits agreement on three relevant enjoyment outcomes: exercise habit, intention to continue exercising, and exercise frequency. No relevant results emerged from intensity traits disagreement. The results suggest that assessing and tailoring exercise prescription and supervision in order to customize exercise intensity may influence future exercise participation.

Keywords: exercise, intensity, enjoyment, intention, habit, moderation

INTRODUCTION

Decades of reports have shown that health clubs register high dropout rates, particularly in the first 3 to 6 months of practice (Edmunds et al., 2007; Buckworth et al., 2013; Sperandei et al., 2016). Given that globally, these are one of the most relevant contexts of exercise practice (International Health Racquet and Sportsclub Association, 2020; EC, 2018) promoting sustainable and long-term exercise adherence is paramount.

As a means to understand exercise adherence and dropout, several theoretical approaches have been used to measure and test motivational and cognitive determinants of individuals' behavior. One aspect that has been consistently reported as relevant for exercise participation is enjoyment (Rhodes and Kates, 2015; Chen et al., 2020; Klos et al., 2020), understood as a subjective experience that depicts generalized feelings of pleasure and satisfaction (Moore et al., 2009; Nielsen et al., 2014). Enjoyment can, in turn, substantially affect individual perceptions of the activity, thus reinforcing it (when perceived as interesting or pleasant) or avoiding it (when perceived as unpleasant, uninteresting, or boring), influencing exercise commitment and engagement (Jekauc and Brand, 2017; Teixeira et al., 2021a).

A few recent approaches have brought new insights and considerations that highlight pleasure and enjoyment as relevant factors that can explain and support exercise behavior. For example, the Affect and Health Behavior Framework (AHBF; Williams and Evans, 2014; Stevens et al., 2020) divides affective correlates and determinants (e.g., enjoyment) into four categories which, eventually, can help explain variables related to health behavior. Another approach is the Affective-Reflective Theory (ART; Brand and Ekkekakis, 2018) that postulates that physical inactivity and exercise can be explained through dual-process theory perspectives that underline automatic associations to pleasurable states. One more recent paradigm, also grounded in dual-process theories, is called the Physical Activity Adoption and Maintenance model (PAAM; Strobach et al., 2020). It presents and identifies predictors of physical activity structured by explicit (i.e., reflective, deliberate) and implicit (i.e., affective, automatic) processes. Particularly, in the PAAM model, these processes are postulated to have direct, moderated, and interaction effects on physical activity. All in all, theoretical approaches grounded in hedonic assumptions have considerably reinforced the need for further development of research in various physical activity settings.

In health clubs, enjoyment seems to be a relevant predictor of the intention to continue exercising, exercise habit, and adherence, which are relevant outcomes capable of promoting behavior sustainability (Raedeke, 2007; Calder et al., 2020; Rodrigues et al., 2020). Intention, for example, has been proposed to be a proximal determinant of behavior enactment (Ajzen, 1991; Armitage, 2005). Although it has been proposed to not fully explain individual behavior as a separate variable, in literature it still does emerge as a relevant construct related to exercise practice (Norman et al., 2000; Jekauc et al., 2015; Gomes et al., 2018). It has been suggested that higher levels of enjoyment can manifest some effect on intentions, which could be related to exercise commitment and persistence (Rodrigues et al., 2020), being a relevant factor for understanding variables related to the intention-behavior gap. The AHBF and the PAAM model, for example, present behavioral intention as a result of reflective processes, which can receive influences (generally indirect) from affective processing (e.g., enjoyment) (Stevens et al., 2020; Strobach et al., 2020).

As for habit, it has been defined as a learning sequence of acts that can result in automatic responses linked to specific cues, and has been associated with exercise behavior in health clubs (Kaushal and Rhodes, 2015; Weyland et al., 2020; Feil et al., 2021). In the PAAM model, for instance, it is suggested that the repetition of a behavior in the same context can shift the behavior gradually from explicit to implicit control processes (thus aiding habit formation), and that this shift can be supported by positive affective reactions to physical activity. Therefore, affect and enjoyment can help habit formation and may be particularly relevant for exercise maintenance, thus reinforcing the need to understand possible factors and mechanisms that may account for the enjoyment effect.

Another relevant aspect that has been proven to influence pleasurable experiences is exercise intensity. As reported in several studies, increases in exercise intensity are usually related to more pleasurable experiences, up until the point where intensity tends to present reduced pleasure and increase displeasure (Ekkekakis et al., 2011; Evmenenko and Teixeira, 2020). Moreover, the point where exercise intensity tends to negatively influence the pleasure/displeasure ratio appears to have some inter-individual variability (Ekkekakis et al., 2011; Ladwig et al., 2017), highlighting the urge to better understand how this turning point can influence pleasurable experiences, enjoyment development, as well as promote adherence.

On the same topic related to the promotion of pleasurable experiences during exercise, some studies have tested the role of preference (i.e., predisposition to select a particular intensity level) and tolerance (i.e., individual ability to continue exercising at a defined level of intensity) as intensity traits relevant to the individual understanding of how intensity is related to exercise pleasurable responses (Ekkekakis et al., 2005; Box and Petruzzello, 2020; Teixeira et al., 2021a). In health club settings, some preliminary evidence suggests that the intensity traits may have a relevant role in the comprehension of several cognitive, behavioral and emotional outcomes. Particularly, Teixeira et al. (2021b) and Faria et al. (2021) have found positive associations between both traits and exercise frequency, habit, subjective vitality and well-being; Box and Petruzzello (2020) and Teixeira et al. (2021a) have demonstrated positive associations between the intensity traits and enjoyment. Moreover, it has been suggested that the intensity traits can modulate individual affective responses to an exercise regimen or a particular activity (Box and Petruzzello, 2020; Andrade et al., 2021) which, all in all, reveals the impact of intensity adjustments on exercise adherence.

Considering the diversity of exercise modes and dynamics in health clubs, it seems plausible to hypothesize that individual preference and tolerance might not always be contemplated in exercise prescription or supervision (Teixeira et al., 2021b). On one hand, gym dropout issues in the first months of practice have been suggested to be related to poor professional follow-up and supervision, which may also account for inadequate management of pleasure/displeasure in the first weeks or months of exercise (Rand et al., 2020; Faria et al., 2021). On the other hand, even in regular exercisers, interpersonal dynamics have been reported as a relevant factor for exercise adherence, and the steps taken by

the professionals to make individual adjustments to the training characteristics are proposed to modulate the exercise behavior (Rodrigues et al., 2018, 2019). Hence, all exercisers can be at some point more or less prone to have their pleasure/displeasure ratio affected. In a setting where exercise professionals are able to monitor and adjust training variables, the understanding of the potential role of the intensity traits in exercise practice may be relevant for the intended promotion of exercise adherence.

Several authors have highlighted the importance of targeting enjoyment development as a proxy for exercise adherence and maintenance (Rhodes et al., 2019; Calder et al., 2020; Chen et al., 2020). However, less attention has been given to the very factors and mechanisms that may influence enjoyment effect on related outcomes. For instance, a professional may suggest a group class that suits the exerciser's needs and that is aligned with his perception of a pleasant and enjoyable activity, but that is not congruent with the intensity preference/tolerance (e.g., an advanced high intensity training class); or, in personal training, the progression to a new mesocycle that presents significant changes to previously enjoyable exercise intensity, may alter this perception and cause different outcomes. Therefore, an enjoyable activity may present distinct effects on adherence related factors due to the level of the intensity traits agreement/disagreement perceived by the exerciser. This may modulate an individual's future practice through an avoidance-approach effect grounded in hedonic assumptions, which may reinforce or reduce exercise behavior and intentions (Watson et al., 1999; Stevens et al., 2020; Chen et al., 2021).

These contextual considerations align with two relevant lines of thought: (a) the suggestion regarding the role and relevance of potential moderators that explain the intention-behavior relationship and related variables (Rhodes and Smith, 2006; Faries, 2016; Rhodes et al., 2021), and (b) recent evidence, as well as recent implications, of the potential importance of the intensity traits agreement/disagreement with current training on relevant outcomes (Teixeira et al., 2021a,b). Particularly, regarding traits agreement/disagreement, the first studies to address this hypothesis showed that in a large sample of health club exercisers, preference, tolerance, or both, in agreement with current exercise intensity, depict higher exercise frequency, subjective vitality, and habit, and generally more positive associations with well-being variables (Marques et al., 2021; Teixeira et al., 2021b). These results, among other previous suggestions, tend to reflect the moderation role of the intensity traits agreement/disagreement in affective associated variables. With this in mind, the main aim of this cross-sectional exploratory study was to test the moderation effect of the intensity traits agreement/disagreement in three relevant outcomes of exercise enjoyment: exercise habit, intention to continue exercising, and exercise frequency. It was hypothesized that the intensity traits agreement with current training intensity should positively moderate the relation between enjoyment and proposed outcomes variables, and that traits disagreement would present negative or non-significant effects (Teixeira et al., 2021a). Considering previous suggestions of the possible relevance of these traits as moderators in exercise adherence variables, the present study adds new insights on how to approach the intention-behavior gap from an intensity perspective and provides health club professionals with new lines of reasoning in their exercise prescription and counseling.

MATERIALS AND METHODS

Participants and Procedures

In the present study 273 exercisers (male = 127; M_{age} = 36.21; *SD* = 11.29) enrolled in nine health clubs voluntarily completed a battery of questionnaires (general sociodemographic questions and psychometric scales; see instruments section).

Participants had a mean of 12.45 (*SD* = 11.73) years of practice in health clubs and were enrolled in individual activities (44%), group classes (31%), aquatic activities (11%), or a combination of these activities (14%). In order to be able to participate, exercisers had to be $\geq$ 18 years, be enrolled in Portuguese health clubs, and had to have had a minimum of 60 min of weekly practice in the last 3 months. Due to some technical issues, some data on exercise habit were lost, and the analysis for this variable was conducted with 215 participants.

The present work is part of an ongoing research project on the quality of the subjective exercise experience in health clubs. For the development of this study, approval from the Ethics Committee of the Faculty of Physical Education and Sport of Lusófona University was obtained. Later, health club managers were contacted and written approval for study development was requested. The sample of health clubs was chosen by convenience and represented Portuguese middle market and premium market segments (Pedragosa and Cardadeiro, 2020). After approval, questionnaires were made available at the club's reception desk in two forms: through a QR-code with a link to a Google forms questionnaire, or in a physical format. Answers were obtain equitably in both formats (QR-code = 133; physical format = 140). Written consent was requested before data collection in both formats to ensure that participants understood study purposes and expected participation. For that matter, an explanation letter was provided, emphasizing that the participation would be voluntary, the data would be treated with confidentiality, and that the participant could cease to participate at any moment without any repercussions. A contact of one of the researchers was also made available to allow for additional clarifications. All the procedures were developed according to the Helsinki Declaration and its later amendments.

Measures

Preference for and Tolerance of Exercise Intensity (Original: PRETIE-Q; Ekkekakis et al., 2005; Portuguese Version: PRETIE-Q-PT; Teixeira et al., 2021b)

For the intensity traits level of agreement, two questions developed to complement the 10-item (five items for each factor) instrument version of PRETIE-Q-PT were used. The questions, "The intensity of my training is in accordance with my preference" and "The intensity of my training is in accordance with my tolerance", were answered and coded with 0 (not

in agreement/disagreement) or 1 (in agreement) as in the work of Teixeira et al. (2021a).

The Physical Activity Enjoyment Scale (Original: PACES; Kendzierski and DeCarlo, 1991; PACES Portuguese Version: Teques et al., 2017; Rodrigues et al., 2021b)

The PACES is an 8-item scale that assesses the level of exercise enjoyment (e.g., *"It is fun"*) using a 7-point bipolar Likert scale ranging from 1 (Totally disagree) to 7 (Totally agree). The question used was *"How do you feel at the moment about the exercise you are doing?"* The scores for enjoyment were obtained through the sum of the eight items.

Self-Report Behavioral Automaticity Index (Original: SRBAI; Gardner et al., 2012; SRBAI Portuguese Version: Rodrigues et al., 2021a)

The SRBAI is a 4-item scale that measures behavioral habits related to exercise. The statement "*Exercise is something*" preceded the four items (e.g., *"I start doing before I realize I am doing it"*). Participants rated how true each statement was for them on a 7-point bipolar Likert scale, ranging from 1 ("Totally disagree") to 7 ("Totally agree"). The exercise habit score was obtained through the sum of all the items.

Intention to Continue Exercising

Three items were used to assess intention to continue exercising after 6 months, which followed Ajzen (2006) and previous related studies recommendations and applications (e.g., Rodrigues et al., 2020). The items had been previously translated using methodological recommendations (Brislin, 1970, 1980). The items *"I will continue to exercise in the next 6 months as I currently do or in a very similar way (same type, frequency, duration, and intensity)," "I will continue to practice physical exercise in the next 6 months as I currently practice or in a very similar way (same type, frequency, duration, and intensity),"* and *"I plan to continue practicing physical exercise in the next 6 months as I do today or in a very similar way (same type, frequency, duration, and intensity),"* were answered in a 7-point bipolar Likert scale ranging from 1—"Absolutely not" to 7—"Absolutely yes." The behavioral intention score was obtained through the sum of all the items.

Exercise Frequency

Exercise frequency was self-reported by answering to *"On average, how many workouts do you do per week in the club?"*

Statistical Analysis

Descriptive analysis and bivariate correlation were calculated for all variables. In cases with more than 5% of absent data (2.2%), participants were removed prior to statistical analysis (except for habit in the 58 participants where these responses were not obtained). No imputation procedures were developed. Calculations were performed using SPSS Statistics v. 23.0 for Windows (IBM Co., United States), setting statistical significance at $p < 0.05$.

For moderation purposes the SPSS PROCESS V. 3.5. macro was used and Hayes' (2018) recommendations were followed. To analyze the different moderation models hypothesized, the model 1 specification (i.e., single moderator testing between the independent and dependent variable) was chosen. This feature allows for conducting the analysis and interpretation if the estimation of the effect of the independent variable (enjoyment) on a dependent variable (e.g., intention) presents changes in size, sign, or strength of the effect (i.e., moderated; intensity-trait agreement/disagreement). Additionally, mean center for construction of products was used for all variables that define products. This procedure allows for the simplification of path analysis and significance interpretations without changing the moderation and interaction scores and effects. Finally, a bootstrap with 5,000 samples was used for CI95% intervals estimation, and significant effects were considered if CI did not encompass zero.

RESULTS

Data were initially screened for analysis assumptions and no issues were detected. Descriptive, reliability, and correlation analyses results are depicted in **Table 1**. All tested variables presented positive associations (all $p < 0.01$), ranging from weak to moderate strength of associations. For enjoyment, habit, and intention, results depicted scores above the constructs mid-point. Preference or tolerance agreement were present in 85.5 and 88.7% of exercisers, respectively. Reliability through Cronbach's alpha indicated excellent scores.

TABLE 1 | Descriptive, reliability, and correlation analysis of studied variables.

	α	Score range	M	SD	1	2	3	4
1. Enjoyment	0.94	8–56	46.28	8.16	1			
2. Habit	0.91	4–28	17.53	6.65	0.519***	1		
3. Intention	0.94	3–21	18.89	3.29	0.383***	0.176**	1	
4. Exercise frequency	–	1–7	2.99	1.26	0.563***	0.320***	0.298***	1
		0 (Disagreement)			**1 (Agreement)**			
Preference	–	14,50%			85,50%			
Tolerance	–	11,30%			88,70%			

α, *Cronbach's alpha; M, mean; SD, standard deviation; **p < 0.01; ***p < 0.001.*

TABLE 2 | Moderation and interaction analysis of preference and tolerance agreement/disagreement.

Habit Model											
	Coeff.	***t***	***p***	**LLCI**	**ULCI**		**Coeff.**	***t***	***p***	**LLCI**	**ULCI**
Enjoyment	0.47	0.05	< 0.001	0.364	0.578	Enjoyment	0.47	8.85	< 0.001	0.364	0.573
Preference	2.48	1.40	0.078	−0.287	5.250	Tolerance	1.61	1.13	0.262	−1.206	4.418
Interaction	0.64	0.16	< 0.001	0.334	0.954	Interaction	0.57	3.36	< 0.001	0.234	0.899
R^2 = 0.32; MSE = 30.80						R^2 = 0.30; MSE = 31.58					
	R^2-change	***F***	**df1**	**df2**	***p***		**R^2-change**	***F***	**df1**	**df2**	***p***
IV × Moderator	0.05	16.719	1	211	< 0.001	IV × Moderator	0.04	11,316	1	211	< 0.001
Conditional effects	**Effect**	***t***	***p***	**LLCI**	**ULCI**	**Conditional effects**	**Effect**	***t***	***p***	**LLCI**	**ULCI**
Preference = 0	−0.08	−0.546	0.586	−0.368	0.209	Tolerance = 0	−0.035	−0.222	0.825	−0.349	0.278
Preference = 1	0.56	9.670	< 0.001	0.449	0.679	Tolerance = 1	0.532	9.474	< 0.001	0.421	0.643
Intention Model											
	Coeff.	***t***	***p***	**LLCI**	**ULCI**		**Coeff.**	***t***	***p***	**LLCI**	**ULCI**
Enjoyment	0.10	4.52	< 0.001	0.057	0.145	Enjoyment	0.13	5.88	< 0.001	0.089	0.178
Preference	4.18	6.89	< 0.001	2.987	5.38	Tolerance	2.01	2.99	< 0.001	0.688	3.33
Interaction	0.14	2.45	0.015	0.028	0.256	Interaction	0.02	0.29	0.769	-0.130	0.176
R^2 = 0.27; MSE = 7.75						R^2 = 0.17; MSE = 8.83					
	R^2-change	***F***	**df1**	**df2**	***p***		**R^2-change**	***F***	**df1**	**df2**	***p***
IV × Moderator	0.02	5.99	1	269	0.015	IV × Moderator	< 0.001	0.086	1	269	0.769
Conditional effects	**Effect**	***t***	***p***	**LLCI**	**ULCI**	**Conditional effects**	**Effect**	***t***	***p***	**LLCI**	**ULCI**
Preference = 0	−0.02	−0.385	0.701	−0.124	0.083	Tolerance = 0	–	–	–	–	–
Preference = 1	0.12	4.962	< 0.001	0.073	0.170	Tolerance = 1	–	–	–	–	–
Frequency Model											
	Coeff.	***t***	***p***	**LLCI**	**ULCI**		**Coeff.**	***t***	***p***	**LLCI**	**ULCI**
Enjoyment	0.07	9.399	< 0.001	0.058	0.089	Enjoyment	0.08	10.14	< 0.001	0.062	0.092
Preference	1.43	6.739	< 0.001	1.012	1.845	Tolerance	1.27	5.68	< 0.001	0.832	1.716
Interaction	0.08	3.829	< 0.001	0.038	0.117	Interaction	0.07	2.83	0.005	0.023	0.125
R^2 = 0.41; MSE = 0.945						R^2 = 0.39; MSE = 0.98					
	R^2-change	***F***	**df1**	**df2**	***p***		**R^2-change**	***F***	**df1**	**df2**	***p***
IV × Moderator	0.03	14.661	1	269	< 0.001	IV × Moderator	0.02	8.020	1	269	0.005
Conditional effects	**Effect**	***t***	***p***	**LLCI**	**ULCI**	**Conditional effects**	**Effect**	***t***	***p***	**LLCI**	**ULCI**
Preference = 0	0.01	0.384	0.699	−0.029	0.043	Tolerance = 0	0.01	0.462	0.645	−0.037	0.060
Preference = 1	−0.08	9.873	< 0.001	0.068	0.101	Tolerance = 1	0.09	10.736	< 0.001	0.070	0.101

p, significance value; LLCI, lower level confidence interval; ULCI, upper level confidence interval; MSE, mean square error.

Regarding moderation analysis (**Table 2**), preference acted as a moderator in the three models tested (all independent variables × Moderator $p < 0.05$) (**Figure 1a**, **2a**, and **3a**). Tolerance moderated the habit and frequency models (Habit × Moderator $p < 0.001$ **Figure 1b**; Frequency × Moderator $p = 0.005$) (**Figure 3b**). Test for conditional effects (i.e., probing interactions) (**Table 2**) supported previous moderation results for preference agreement in all models (all $p < 0.001$) and tolerance agreement in the two previous models (habit and frequency; both $p < 0.001$). No significant effect emerged from preference or tolerance disagreement in all the tested models.

DISCUSSION

Given the need to explore the factors that can account for a better understanding of the intention-behavior gap in health clubs settings, and considering the emergence of hedonic assumptions related to exercise adherence, this cross-sectional

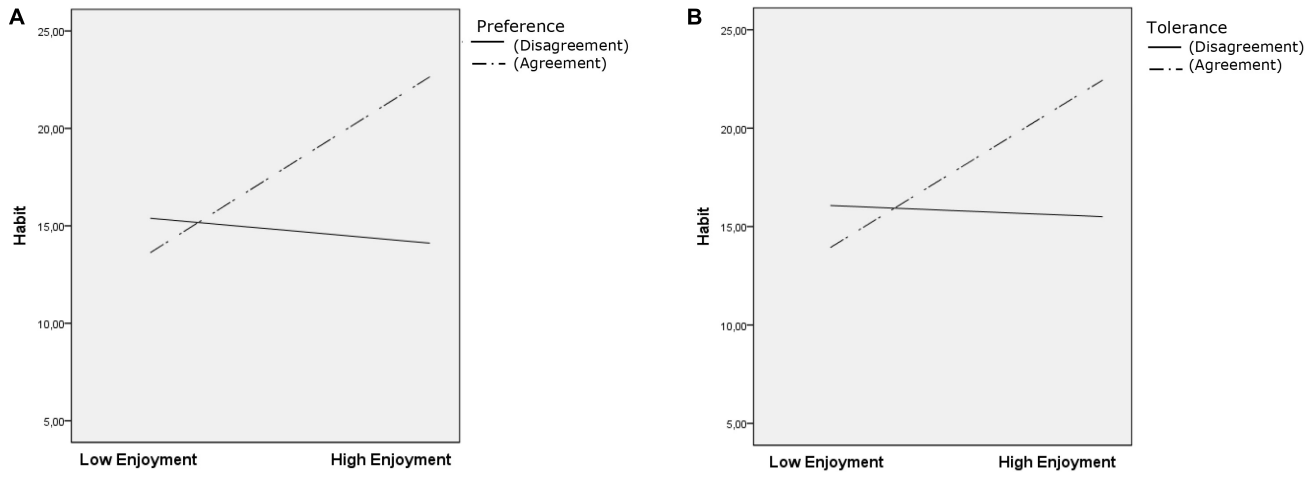

FIGURE 1 | Conditional effects analysis for the preference and tolerance levels of agreement/disagreement on exercise habit.

study aimed to test the moderation effect of the intensity traits agreement/disagreement in three relevant outcomes of exercise enjoyment: exercise habit, intention to continue exercising, and exercise frequency. Descriptive results indicate above mid-point scores for all psychological variables and an average weekly exercise frequency of 2.99 (SD = 1.26). Enjoyment presented positive associations with all variables (all $p < 0.001$). Moderation tests results indicate that enjoyment positively predicted all studied outcomes (all $p < 0.001$), and that the intensity traits agreement (except tolerance agreement > intention) positively moderated all the associations. No significant moderation role emerged from the intensity traits disagreement. The present results are aligned with the previous hypothesis suggesting that the intensity traits agreement with current training intensity might positively moderate the relation between enjoyment and proposed outcomes variables, and that traits disagreement would present negative or non-significant effects.

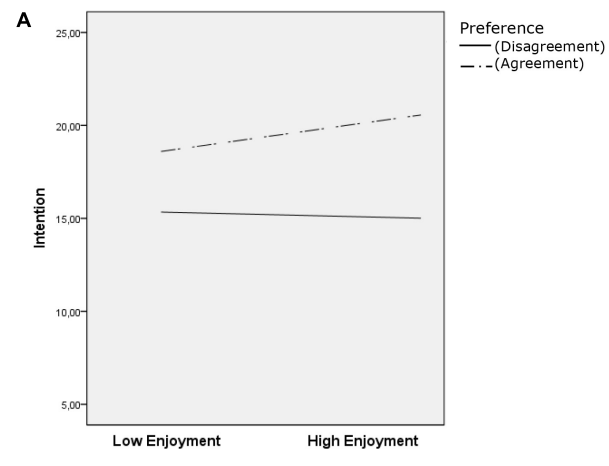

FIGURE 2 | Conditional effects analysis for the preference level of agreement/disagreement on intention to continue exercising.

Health clubs and other related settings have struggled to keep exercisers enrolled in their activities. Given the myriad of possible factors that can emerge that justify this problem, literature tends to suggest that interpersonal behaviors (particularly professional-exerciser relationships) have an important role that can account for some of the dropouts and lack of engagement (Rodrigues et al., 2018, 2019; Rand et al., 2020). Although dropout and lack of commitment can occur in all exercisers and at any point of their exercise experience, this tends to happen primarily in the first months of practice (Sperandei et al., 2016; International Health Racquet and Sportsclub Association, 2020; Rand et al., 2020). Thus, a better understanding of professional behaviors that can help reduce these issues can prove to have a relevant role in adherence and, ultimately, on the general population's health.

It can be assumed that in supervised activities the professional should develop his intervention aiming to address not only individual's needs, *but also* individual's preferences. Like that, this may help beginner exercisers develop a more adequate relation between exercise and bodily feelings, thus aiming to improve affect processing (automatic and reflective precursors), which may have consequences on enjoyment development, habit, and intentions to continue exercising (Williams and Evans, 2014; Stevens et al., 2020; Strobach et al., 2020; Cheval and Boisgontier, 2021). This also applies to more experienced exercisers, for instance, as results of immediate affective response, but particularly, post-behavior affective response, may influence reflective affect processing with consequences in exercise enjoyment (Stevens et al., 2020). Being enjoyment a self-determined factor commonly associated with exercise adherence (Nielsen et al., 2014; Calder et al., 2020; Chen et al., 2020), exercise supervision and prescription characteristics that may be aligned with the promotion of the pleasurable component of enjoyment should depict positive associations with exercise behavior (Rodrigues et al., 2020; Stevens et al., 2020).

Moreover, enjoyment perception of a given activity is not expected to be a static process. The characteristics of what is considered enjoyable may reflect a wide array of subjective

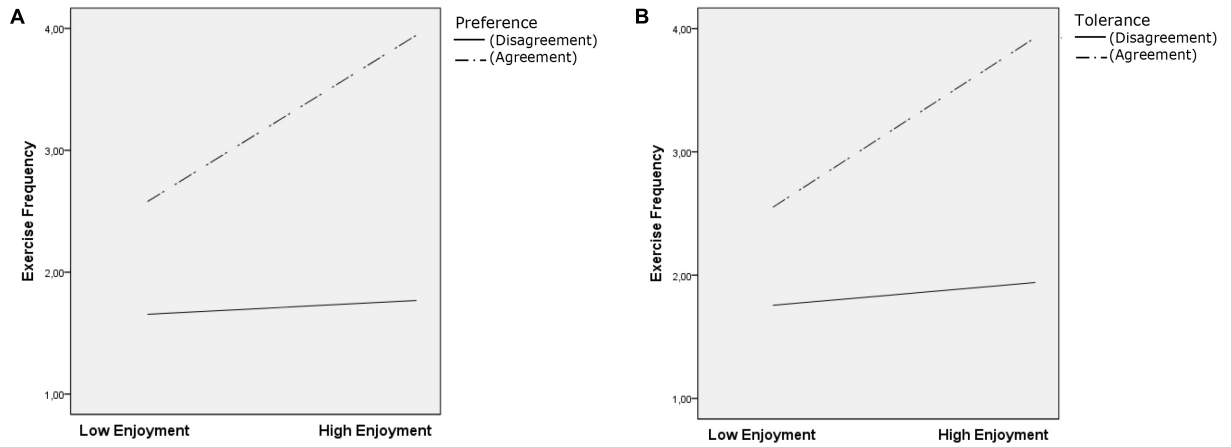

FIGURE 3 | Conditional effects analysis for the preference and tolerance levels of agreement/disagreement on exercise frequency.

aspects, and can be manifested in distinct ways (Rodrigues et al., 2021b). As seen in this study results, enjoyment positively predicted exercise habit, intention to continue exercising, and exercise frequency, aligning with previous empirical assumptions. More interestingly, the perception of agreement of each intensity-trait presented a moderation effect, albeit slightly favoring preference. As seen, interaction results showed a better model fit in frequency models (preference: $R^2 = 0.41$; tolerance: $R^2 = 0.39$), higher moderation effect in habit model (preference: independent variable × moderator $R^2_{change} = 0.05$; tolerance: independent × moderator $R^2_{change} = 0.04$), and results not so expressive or significant (tolerance > intention) in the intention models, which highlights a distinct role of enjoyment and traits agreement on the outcome variables. Additionally, results seem to be in line with the hypothesis presented previously; when exercisers perceived an alignment with their intensity traits, there is a suggestion that they will exercise more frequently, develop higher exercise habit, and sustain a higher intention to continue practicing. Regarding intention, it must be noted that the mean scores depicted in **Table 1** show a near-maximum value ($M = 18.89$; max = 21), thus suggesting a possible ceiling effect that can account for (and in case of tolerance, justify the absence of) the moderation effects. Moreover, considering the sample years of training experience ($M = 12.45$), it is somehow expected that several individuals have integrated the exercise practice in their life, thus reflecting higher means in the outcome variables which could affect moderation magnitude. Still, on the intention outcomes, the results may also coincide with some of the PAAM model assumptions. Given that intention tends to reflect explicit processes, and thus, less dependent on automatic affective processing and associations, changes promoted by the intensity traits agreement which are expected to influence the affective component of enjoyment, may express themselves with lower effects. All in all, these may justify the lower model fit and less relevant scores obtained with exercise intention.

The previous model's results and contextual interpretations may be reinforced when considering that no interaction emerged with the intensity traits disagreement. It is possible that long-term exercisers have found throughout the time the adequate activities and intensities that make them feel pleasure and consider enjoyable, or that the exercise professionals do account for individual preferences when developing the activities. Data from **Table 1** suggest that, considering that exercisers report that preference (85.50%) and tolerance (88.70%) are in agreement with the activities they engage in. This hypothesis may justify a future need for differentiating the intensity traits moderation role in distinct experience groups (e.g., novice vs. experienced) and with higher disagreement perceptions, thus shedding some light on the possible inferences in the exercisers more prone to dropout. To date, two studies have supported this premise, and showed that traits disagreement (individually or jointly) do have differentiated outcomes in several behavior outcomes (Marques et al., 2021; Teixeira et al., 2021b), but more research is needed to clarify this assumption.

Contextually, present study results suggest that assessing and tailoring exercise prescription and supervision aiming to contemplate intensity delivery and exposure may augment future exercise behavior. This may justify the need to reflect on exercise evaluation processes aiming to target preferences identification and intra- and post-session affective assessments, as for supervision techniques/methods that can account for better counseling and activities adjustments.

Limitations and Future Studies

The present exploratory study, despite its strengths, has some limitations that should be acknowledged for an adequate interpretation and future implications. Firstly, the study design (cross-sectional), as for the characteristics of the sample, could depict a survivor bias. When considering the high exercise experience in the study participants, it is expected that the sample size of the exercisers more prone to dropout (0 to 6 months) would be lower, justifying taking caution when interpreting the results, but also redirecting further research efforts on this topic. Moreover, the current sample had a higher percentage of preference or tolerance agreement, and high enjoyment scores, which may bias the results toward a specific subgroup of exercisers. Additional efforts should be made to test these assumptions with a longitudinal approach, and in a more

heterogeneous sample of exercisers, particularly considering exercise experience and distinct agreement/disagreement levels.

Secondly, it must be noticed that no moderation model was tested with both intensity traits simultaneously nor it was considered specific agreement/disagreement subgroups (e.g., preference and tolerance agreement subgroup; not preference but tolerance agreement subgroup). Individuals may present an agreement between preference and current training regimen, but also a disagreement with tolerance. These combinations should be of interest for future research focused on individual responses to exercise intensity and related subjective exercise experiences.

Thirdly, exercise frequency was obtained through self-report and with only one item. A relevant improvement in the understanding of this outcome may be achieved with additional questions (e.g., framed by time periods; duration), and particularly through objective measures (e.g., history of gym access; direct observation).

In conclusion, the results presented a moderation effect of exercise intensity traits agreement on three relevant enjoyment outcomes: exercise habit, intention to continue exercising, and exercise frequency. No relevant results emerged from intensity traits disagreement. Present study results suggest that assessing and tailoring exercise prescription and supervision aiming to contemplate intensity delivery and exposure may augment future exercise behavior.

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 human participants were reviewed and approved by Ethics committee of the Faculty of Physical Education and Sport, ULHT. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DT, FR, LC, and DM contributed to conception design of the study. DT performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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The Value-Added Contribution of Exercise Commitment to College Students' Exercise Behavior: Application of Extended Model of Theory of Planned Behavior

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The aim of this study was to investigate the applicability of the planned behavior theory model (TPB-5) and TPB-6 model of enhanced physical exercise in college students, and to explore the role of exercise commitment in the relationship between exercise intention and behavior, so as to provide theoretical and empirical support for college students to promotion exercise. The study participants were 581 college students (male = 243, female = 338, age = 19.27 ± 0.94) are investigated with Theory of Planned Behavior (TPB) Scale, Exercise Commitment Scale, and Physical Activity Rating Scale. Results showed that the explanatory power of the TPB to exercise intention and exercise behavior is 0.70 and 0.52, respectively, and exercise intention was the primary factor to predict exercise behavior of college students. The Model fit of TPB-6 model is acceptable, compared with TPB 5-factor model, the predictive power of TPB-6 (with the mediator: exercise commitment) on behavioral intention increases from 70.0 to 75.0%, and the predictive power towards behavior raises from 52.0 to 59.0%. Exercise commitment has a partial mediating effect between exercise intention and behavior, which accounts for 26.89% of the total effect, but it has no moderating effect. In conclusion, this research demonstrates the TPB-5 model has good applicability among the college students, with exercise commitment variables, exercise intention can better predict college students' exercise behavior, which can be used as the theoretical basis for the intervention on their exercise behavior.

Keywords: college students, exercise commitment, physical exercise behaviors, theory of planned behavior, exercise intention

INTRODUCTION

The proposition that participation in short- and long-term physical exercise has both physical and psychological benefits is widely known and supported by previous research. Currently, physical inactivity has become the highest risk factor for death from non-communicable diseases worldwide (Bull et al., 2020; Zhu et al., 2020). College students are reserve forces of the society, and the proportion of them who regularly participate in physical exercise are less than 30% (Dong and Zhang, 2016; Yang et al., 2020). Among these students, the obesity and myopia rates remain high, and their cardiopulmonary function does not reach the appropriate level at that age (Van Sluijs et al., 2021; Zhang et al., 2021). Moreover, self-inflicted injuries caused by mental and psychological disorders are frequent, and the health condition of college students is of great concern (Qiu et al., 2011; Yu et al., 2021). Therefore, it has been a common concern of universities and society to promote college students to actively participate in physical exercise, avoid being sedentary and build a healthy body. And it has also become an issue of scientific research to explore the psychological mechanism for the promotion of exercise behavior of college students and construct a predictive intervention model suitable for this group, so as to enable them to keep exercising regularly (Rosenkranz et al., 2021; Liao et al., 2022).

In the area of physical exercise intervention, researchers have constructed multiple theoretical models to provide a strong theoretical basis for physical exercise intervention, among which the most widely-used and mature one is Theory of Planned Behavior (TPB) proposed by Ajzen (1991). the core proposition of TPB is that behavioral intention and perceived behavioral control are the strongest predictors for behavior, while individuals' attitudes towards behavior, subjective norms and perceived behavioral control, in turn, can predict their behavioral intentions (Plotnikoff et al., 2012; Qiu and Yang, 2017). TPB has contributed to the prediction and intervention of physical exercise, but it also has some shortcomings, that is, the predictive power of the model for behavioral intentions is far higher than that for behavior itself. The "high intention and low behavior" structure indicates that there is a "gap" between intention and behavior (Sheeran, 2002; Gomes et al., 2018; Kang et al., 2020). In order to bridge this "gap" and improve the predictive power of the TPB model for physical exercise behavior, scholars have further improved the TPB model by introducing new variables, integrating the models and adjusting the structural relationships, which has achieved positive effect (Zhang and Mao, 2016; Yang et al., 2020; Rhodes et al., 2021; Arigo et al., 2022; Liao et al., 2022).

The main purpose of bridging the "gap" between intention and behavior is to improve the predictive power of the original TPB model. In the case of college students, exercise commitment plays an important role in the process from behavioral intention to behavioral execution (Dong, 2013). Exercise commitment refers to a kind of positive psychological state that exercisers desire and resolve to continue the physical exercise (Chen and Li, 2007), which is also a driving force to keep exercising adherence. Studies have found that the exercise commitment made by college students before physical exercise can predict their execution of the actual behavior, reflecting the individuals' determination and loyalty to physical exercise (He, 2011; Sun et al., 2011; Williams, 2013; Weiss, 2021; Hong and Li, 2022). The research made by Dong Wenbo has showed that exercise commitment acts as a partial mediator in the transformation from consciousness to behavior among middle school students, and exercise consciousness can be better transformed into exercise behavior by enhancing the level of exercise commitment (Dong, 2013). The above studies on bridging the gap between intention and behavior are mainly based on the discussion that takes exercise commitment as a mediator, and it acting as a partial mediator between intention and behavior.

Some studies reported that both exercise commitment and intrinsic motivation are incentives for behavior, and also the rational factors that individuals maintain on the basis of cognitive strategies, which makes individuals more inclined to participate in physical exercise (Wu et al., 2010; Qiu et al., 2012; Zhu and Dong, 2016; Jeng et al., 2020). People with strong exercise commitment usually have clear and explicit exercise intentions and goals. On the contrary, if individuals lack exercise commitment (i.e., having weak exercise intentions and determination), some inappropriate behaviors may appear in the face of physical exercise, such as procrastinating and giving up (Dong and Mao, 2020). In the experiment of health behavior intervention, Brinthaupt found that improving exercise commitment had a significant effect on healthy habits and regular exercise (Brinthaupt et al., 2013). Rhodes concluded that there was a higher correlation between exercise intention and actual exercise behavior for individuals with higher exercise commitment and perceived behavioral control (Rhodes and Matheson, 2005). Many studies have shown that exercise commitment is an important factor in the process of exercise behavior that prompts the transformation from behavioral intention to behavior (Wilson et al., 2004; Gabriele et al., 2011; Dong and Zhang, 2016; Frayeh and Lewis, 2016; Wu, 2016; Robbins et al., 2017). These studies suggest that the level of exercise commitment regulates the relationship between intention and behavior, which acts as a moderator between intention and behavior.

The shortcomings of TPB model lies in the gap between intention and behavior, caused by the failure to consider the potential influence of individual personality factors on their behavior, such as motivation, interests, hobbies, and emotions. From the perspective of psychological attitude, commitment is integrated and formed by individual cognitive, affective, volitional and behavioral factors (Xie, 2016; Bum, 2018) so that it is the psychological variable that bridges the gap between intention and behavior. However, current studies on exercise commitment mainly focus on the validation and restructuring of this theoretical model, and few studies incorporate this variable into a complete theoretical framework of exercise behavior for analysis. Given that, this study implants exercise commitment into TPB model (the 5-factor model of physical exercise) to form the 6-factor model of enhanced physical exercise, aiming to examine the application of exercise

commitment to the social cognitive theory framework (TPB) and probe into the mechanism of exercise commitment in the transformation from intention to behavior, thus providing a theoretical guidance for the promotion of exercise participation of college students. Therefore, exercise commitment is a psychological link between exercise intention and behavior, and also a psychological contract to enhance individuals' exercise behavior, which has an influence on students' overt exercise behavior. For this reason, much attention should be paid to improve the physical exercise commitment of college students, with the purpose of explaining and predicting their exercise behavior, and then providing a theoretical basis for promoting the exercise behavior intervention.

In conclusion, this study puts forward the following hypotheses: (1) The TPB can significantly predicts exercise behavior and has good practicability in college student population. (2) Exercise commitment plays a mediating or moderating role between exercise intention and behavior. (3) The 6-factor model of enhanced physical exercise with exercise commitment can better predict exercise behavior of college students (**Figure 1**). This study aims to clarify the practicability of the theoretical model of planned behavior in college student groups, and to investigate in-depth the role of exercise commitment in the exercise intention–behavior relationship, and then to provide theoretical guidance for promoting college students' physical exercise participation.

METHOD AND PARTICIPANTS

Participants and Procedures

The participants were 610 general undergraduate students in their first and second years from three different types of universities in China (including: Normal education, science and technology, and medicine). After removing those with invalid responses, 581 (95.24%) valid samples were collected. There were 243 males, 338 females, and the mean age was 19.27 (SD = 0.94).

This study obtained the support of university administrative leaders and physical education teachers, after they were introduced to the purpose of this study and filled out anonymously, participants signed an informed consent form, the questionnaire took approximately 15 min to complete, and participants were given a small gift, and this study was carried out in accordance with the ethical guidelines of the American Psychological Association (APA).

Research Method

Assessment Tools

The TPB scale, exercise commitment scale, physical activity level scale-3, and demographic information such as gender, grade, and birthday were included. The details are as follows.

Ajzen's planned behavior theory includes the subscales of attitudes, subjective norms, perceived behavioral controls, and intentions (Ajzen, 1991). Hu (2008) revised and compiled the TPB scale in China in 2008. This study consists of 14 items rated on a 6-point Likert scale. Ranging from 1 (strongly disagree) to 6 (strongly agree). Example items include: intention "e.g., In the next 4 weeks, I plan to engage in physical exercise at least three times a week for more than 20 min each time," etc. The internal consistency reliability of the scale ranges from Cronbach's $a = 0.754$ to 0.893, and its subscales were reported to have decent internal reliability. For each subscale, item scores were averaged to create the composite scores.

The exercise commitment of college students adopts the revised Exercise Commitment Scale by Chen and Li (2007), which consists of 23 items rated on a 5-point Likert scale from 1 ("strongly disagree") to 5 ("strongly agree"). It includes the subscales of exercise enjoyment, personal investments, social constraints, valuable opportunities, and other priorities. Example items include: "I desire to have enough time and opportunities to participate in physical activity" and "I get a special sense of satisfaction from physical exercise and sport," etc. The scale has a reliability of Cronbach's $a = 0.936$. Item scores were averaged to create the composite scores for commitment.

Physical exercise behavior was measured using the physical activity level scale-3 revised by Liang Deqing, which had a retest reliability of 0.82, and an internal consistency coefficient of 0.75 (Liang, 1994). The scale contains three questions on exercise intensity, time and frequency, and uses a 5-level Likert

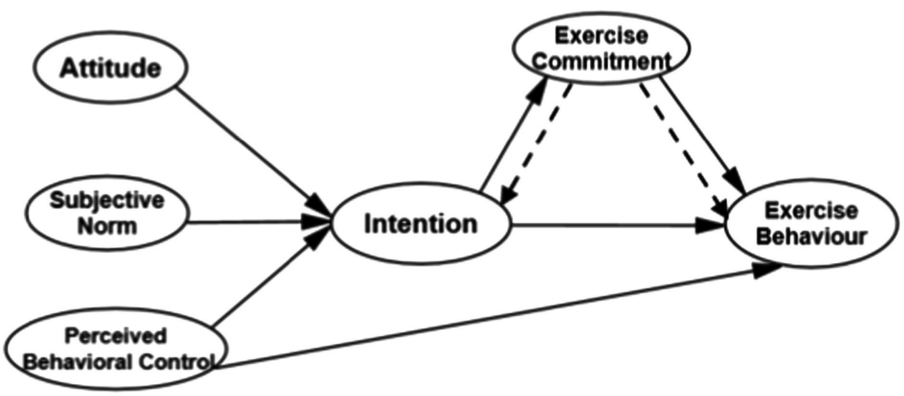

FIGURE 1 | Path coefficient diagram of structural equation model for TPB-6.

scale. Example items include: "What is the intensity of your physical exercise?" etc. The scale is well-validated by the previous research and is a relatively mature measurement tool, so its reliability is not tested in our study.

Statistical Methods

Descriptive statistics of means and standard deviations (SDs) were used to summarize the study variables. Pearson correlation test was used to display the associations among the variables. The software of SPSS 23.0 was used for the data management and correlation test. The potential mediation and moderation effect of exercise commitment (1 model for each) were tested using PROCESS macro. The 5-factor and the extended TPB model were fitted using AMOS 21.0.

RESULTS

Descriptive Statistics and Pearson Correlation Among the Variables in the Extended TPB Model

As shown in **Table 1**, participants had higher mean scores on intentions, attitude, and perceived behavioral control than on exercise behavior and exercise commitment. The correlation test showed that the six variables involved in the extended-TPB model were positively and significantly correlated. The moderate associations among the variables suggested that they were both independent and interconnected, and were well-suited for the SEM analyses.

The 5-Factor TPB Model

The SEM parameter estimates are shown in **Figure 2**. The 5-factor TPB model had satisfactory model fit, $\chi^2/df = 3.853$ ($p < 0.05$), TLI = 0.930, CFI = 0.944, IFI = 0.944, GFI = 0.920, and RMSEA = 0.070. the path coefficients were significant and in the right direction for Attidude–Intention (standardized coefficient $\beta = 0.49$), Subjective norm–Intention ($\beta = 0.20$), and the Perceived behavioral control–Intention relationship ($\beta = 0.30$), Perceived behavioral control–Exercise behavior ($\beta = 0.41$), Intention–Exercise behavior ($\beta = 0.37$), all path coefficients are significant ($p < 0.001$). The SEM model explained 70% of the variance in intentions ($R^2 = 0.70$) and 52% of the variance in exercise behavior ($R^2 = 0.52$). The results suggested that the 5-factor TPB model is appropriate for predicting college students' exercise behavior.

Mediation and Moderation Effect of Exercise Commitment

We then tested the mediation and moderation effect of exercise commitment in the relationship between intentions and exercise behavior. We adopted the bias-correction bootstrap method (Hayes, 2013) with 5,000 re-samplings and 95% confidence interval (95% CI) using PROCESS macro to test both mediation and moderation effects. If the 95% CI do not include zero, it indicates significant effects.

Regression Models for Mediation Effect

Table 2 shows the regression model results for mediation effect testing purpose. After controlling for other variables in the TPB model, intentions positively and significantly predicted exercise behavior ($\beta = 0.351$, $p < 0.001$) and exercise commitment ($\beta = 0.331$, $p < 0.001$) in separate regression models. Intentions ($\beta = 0.286$, $p < 0.001$) and exercise commitment ($\beta = 0.257$, $p < 0.001$) jointly predicted exercise behavior.

As shown in **Table 3**, the indirect effect had bootstrapped 95% CI of [0.061, 0.130], which does not include zero, indicating significant mediation effect of exercise commitment in the relationship between intentions and exercise behavior. Further, the direct effect from intentions to exercise behavior was also significant [bootstrapped 95% CI was (0.203, 0.312)], suggesting that exercise commitment played a partial mediation role. The indirect effect accounted for 26.89% of the total effect from intentions to exercise behavior. Therefore, the results supported our research hypothesis.

Moderation Effect Testing Using Bootstrap Method

The moderation effect of exercise commitment in the relation between intentions and exercise behavior was tested using bias-corrected Bootstrap method with 5,000 re-samplings and 95% CI. PROCESS macro was used. Results showed that the moderation effect was not significant ($\beta = -0.022$, $t = -0.714$, $p > 0.05$; 95% CI = −0.080, 0.038), therefore, exercise commitment did not play a moderation role in the relation between intentions and exercise behavior.

The regression models showed that the inclusion of exercise commitment enhanced the prediction power of intentions to exercise behavior, and exercise commitment played a role of partial mediator in the relationship. We next tested the mediation effect using SEM technique to reveal a more comprehensive picture of the relationship among the variables.

TABLE 1 | Descriptive statistics and Pearson correlation between the variables in the extended TPB model ($n = 581$).

	Variables	1	2	3	4	5	6	*M*	SD
1.	IN	1						4.17	1.21
2.	AT	0.690**	1					4.55	1.06
3.	SN	0.473**	0.599**	1				4.59	1.13
4.	PBC	0.550**	0.495**	0.368**	1			4.15	1.31
5.	EB	0.526**	0.455**	0.330**	0.468**	1		3.11	0.81
6.	EC	0.529**	0.565**	0.406**	0.383**	0.470**	1	3.01	0.75

IN, intentions; AT, attitude; SN, subjective norms; PBC, perceived behavioral control; EB, exercise behavior; EC, exercise commitment.
***P < 0.01.*

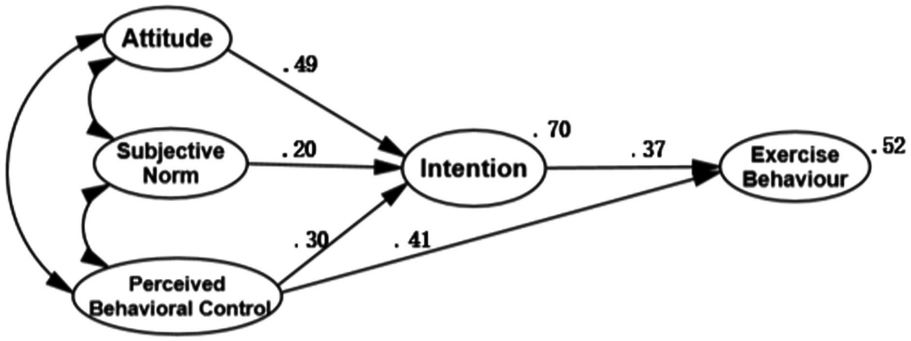

FIGURE 2 | Path coefficient diagram of structural equation model for TPB-5.

TABLE 2 | Regression analyses for testing the mediation effect of exercise commitment.

Regression models		Fit index			Regression parameters	
Outcome	**Predictor**	***R***	***R²***	**F**	***β***	***t***
Exercise behavior	Intentions	0.526	0.276	220.917	0.351	14.863***
Exercise commitment	Intentions	0.529	0.28	225.185	0.331	15.006***
Exercise behavior	Exercise commitment	0.572	0.328	140.742	0.286	6.642***
	Intentions				0.257	9.5582***

****p < 0.001.*

TABLE 3 | Results of bootstrapped 95% CI for mediation effect.

	Effect	Boot	95% CI		Variance explained (%)
		SE	Lower	Upper	
Direct effect	0.257	0.028	0.203	0.312	73.11
Indirect effect	0.095	0.018	0.061	0.13	26.89
Total effect	0.351	0.023	0.307	0.396	

Prediction of Exercise Behavior Using the Extended TPB

Figure 3 shows the SEM model of the extended-TPB model predicting exercise behavior. The model had satisfactory fit, $\chi 2/df = 3.948$ ($p < 0.05$), TLI = 0.906, CFI = 0.918, IFI = 0.919, and RMSEA = 0.071. The SEM model explained 75% variance in intentions ($R^2 = 0.75$), and 59% variance in exercise behavior ($R^2 = 0.59$). Compared to the 5-factor TPB model, the 6-factor TPB model explained 7% more variance in exercise behavior.

As shown in **Figure 3**, attitude, subjective norms, and perceived behavioral control significantly predicted exercise intentions, and exercise intentions significantly predicted exercise commitment and behavior. Moreover, exercise intentions, commitment, and perceived behavioral control significantly predicted exercise behavior. With the inclusion of exercise commitment, the prediction power towards exercise behavior increased 7%.

Our results showed that exercise commitment played the role of a partial mediator in the relation between exercise intentions and behavior, and significantly enhanced the prediction power of TPB model to exercise behavior. Therefore, the extended 6-factor TPB model can be used to predict exercise behavior among college students. These results supported our research hypothesis.

DISCUSSION

Analysis of Applicability of the 5-Factor Model of Physical Exercise

The conclusion of this study supports the notion of TPB that exercise intention is the strongest predictive variable of exercise behavior (Rivis and Sheeran, 2003; Ajzen and Fishbein, 2005; Beville et al., 2013; Zhang and Mao, 2016; Yang et al., 2020). The results revealed that the college students' exercise intention mainly depends on their attitude towards exercise, subjective norms and perceived behavioral control, among which attitude and perceived behavioral control account for the largest proportion of variance. Therefore, when promoting college students' participation in physical activity and implementing interventions, it is important to enhance their positive cognitive level and self-control of physical activity. When college students have positive attitudes toward exercise and perceive more favorable factors and fewer hindering factors in the process of implementing exercise behaviors, this will lead to stronger exercise intentions and behaviors. Indicating that college students' positive attitude towards physical exercise and their sense of behavioral control and efficacy in exercise execution are more important for the formation of behavioral intention and the execution of final behavior, the results are consistent with that of Xu et al. (2018)

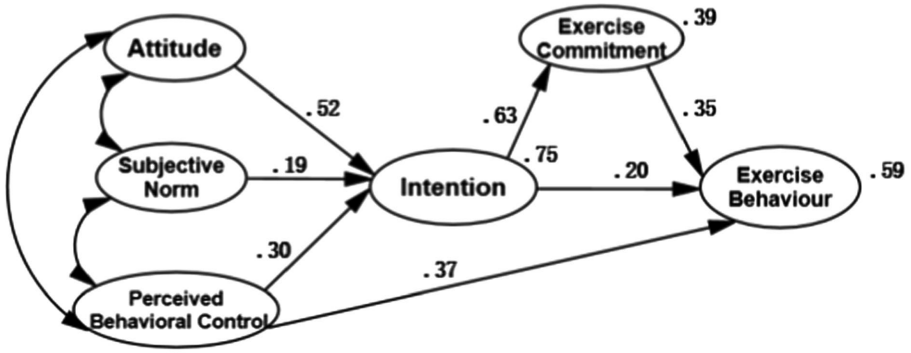

FIGURE 3 | Path coefficient diagram of structural equation model for TPB-6.

and Wu (2020) study. The subjective norms of college students are injunctive norms, and they have a high-level self-determination and autonomy, so the pressure of injunctive norms from significant others has less effect on college students' intention to exercise. As a result, their perceived subjective norms are lower. The results also show that behavioral intention and perceived behavioral control are both effective predictors of exercise behavior, and both have remarkable explanatory power for exercise behavior, among which behavioral intention is more helpful to exercise behavior. The results of the study support the hypothesis 1.

Mechanism of Exercise Commitment on the Transformation From Exercise Intention to Behavior

Mediation and moderation effect of exercise commitment was tested with the bootstrapped confidence interval. Results showed that exercise commitment has a partial mediating effect between exercise intention and behavior, which accounts for 26.89% of the total effect, and the moderating effect is less significant; the results are consistent with that of Dong (2013) and Kang et al. (2020) study. The results suggest that exercise intention may be transformed into behavior through exercise commitment, and it is meaningful for the prediction of exercise behavior to incorporate exercise commitment, in the promotion of exercise behavior, it is necessary to enhance college students' attachment and loyalty to physical exercise and raise the level of exercise commitment. The results of the study support hypothesis 2.

The results verified that the 5-factor model of physical exercise can better predict exercise behavior of college students, and further verify that the model can improve the predictive power of exercise behavior after the introduction of exercise commitment. The results of the 5-factor model suggest that the total explained variance in intention is 70% and the explained variance in exercise behavior is 52%. In contrast, the explained variance in intention of 6-factor model with exercise commitment reaches 75%, which is 5% higher than the original model, and explained variance in exercise behavior is 59%, with an increase of 7%. The hypothesized 6-factor model has sound model fit and greater prediction power, and serves as a suitable predictive intervention model for college students; the results prove that in addition to higher exercise intention, college students should also have positive exercise perceptions and experiences, so as to enrich their exercise consciousness and cognitive system, equip the individuals who originally have higher exercise intentions with stronger exercise desire and determination, and then establish a continuously stable, regular and orderly exercise behavior, the results of the study support the hypothesis 3.

According to Beatty's commitment model theory, commitment, internalized by emotional dependence, behavioral engagement and effect expectations, is the bridge between individuals' cognition and behavior (Beatty et al., 1988). On the basis of this theory, the study confirms the significant mediating effect of exercise commitment between exercise intention and behavior. Exercise intention is the motivational basis for college students to participate in physical exercise, and exercise commitment is a high-level intrinsic motivation and contractual attitude to achieve the exercise motivation intensity and produce exercise behavior. It also reflects the loyalty of actual participation in exercise behavior, reflecting the motivation intensity and persistence of the process from individual exercise intention to behavior, thereby ensuring the transformation from behavioral intention to behavior, indeed, exercise commitment plays a mediating role between exercise intention and behavior. In conclusion, college students' intention to participate in physical exercise can directly predict their behavior, and it can also act on behavior through the mediating effect of exercise commitment, but the direct effect of intention on behavior is stronger than the mediating effect of exercise commitment. The results imply that behavior execution is not only determined by individuals' intention, but also influenced by other factors. The new variables added previously are single-sided and uncomprehensive explanatory behavior (e.g., social support, emotion, persistence, etc.), whereas exercise commitment includes such aspects as exercise enjoyment, personal investment, social constraint, participation opportunity and choice, which promotes exercise behavior more comprehensively and improves the explanatory power of behavior. Exercise commitment, as a rational psychological decision, stimulates individuals' desire and determination to participate in physical exercise and provides strong motivation and behavioral volition for college students to engage in exercise activities. It is a bridge between individuals' cognitive intention and behavior, and also a strong evidence for the formation of

stable, active, regular, and orderly exercise. Individuals with strong exercise commitment usually have clear exercise goals and intentions, positive exercise experiences, as well as strong desire and determination to participate in physical exercise, who are more willing to devote themselves to physical exercise.

Social psychologists generally believe that behavioral commitment reflects the persistence, stability or continuity of individuals' behavioral process (Qiu and Xu, 2018). Studies prove that exercise commitment is a comprehensive manifestation of individuals' cognitive evaluation, emotional experiences and behavioral tendencies of exercise behavior, and internal efficacy of college students' persistence in physical exercise, individuals' desire and determination to participate in physical exercise will increase the possibility of actual participation. The results of this study also shows that the higher the commitment level of participation in physical exercise is, the better the exercise behavior will be, college students can devote themselves to physical exercise and be self-disciplined, and they have a sense of exercise efficacy and experience the joy of exercise. Providing opportunities and options for participation and strengthening social supports will have a positive impact on promoting physical exercise, that is, individuals with a high-level commitment to exercise behavior will participate in and maintain physical exercise more actively. Therefore, increasing the level of behavioral commitment and enhancing the attachment and inclination to exercise behavior is a positive and effective way to promote college students to participate in physical exercise.

By organizing various and appropriate forms of physical exercise, universities could provide more opportunities for students to participate in physical exercises, enrich the mode of exercises, stimulating college students' enthusiasm and participation in exercises. The more positive emotional experience obtained through physical exercises, the more likely that college students would engage in physical exercises. At the same time, it would give students more space and opportunities to pursue autonomy, and reduce social and external constraints and pressure. Making physical exercise mandatory will cause college students to be more resistant to physical exercise. The high-quality environmental support from schools, sufficient sports exercise facilities, and appropriate layout of activity space help to enhance college students' perceived sports value, motivation in sports participation, and hence promoting physical exercise behavior. College students who form positive and stable exercise intention and exercise commitment would autonomously engage in exercise activities under various conditions. The autonomy and enjoyment they obtain from doing physical exercises would facilitate their self-growth and the sustainable participation in physical exercises. Therefore, college students should participate in physical exercise with a positive attitude, integrate into sports activities, stimulate individual subjective initiative, actively participate in peer interaction, and reduce psychological stress reactions. Boycott of online games and reducing sedentary behavior, making exercise plans and publicly committing to complete them, setting up reward and punishment mechanisms, punching reminders through sports bracelets or sports fitness APPs, and reminding to exercise by ringing when they are sedentary, and sports fitness APPs help users record sports fitness indices, guide sports learning, and lead healthy lifestyles and social elements, which help overcome exercise laziness and strengthen exercise Experience. Find exercise partners to motivate and support each other together, play the positive role of peer leadership, enhance the fun of exercise, experience the sense of joy of exercise, mold physique, show personality, promote the interpersonal skills of college students, integrate physical exercise into life, constantly enrich their spiritual world, and achieve more effective and lasting exercise behavior promotion through different boosting strategies.

An important way to promote physical exercise among college students is to raise their level of exercise commitment through certain educational methods. For example, we create diversified physical education platforms such as sports clubs, sports teams, sports festivals, sports APPs, digital sports smart devices, etc. We regularly send information on health knowledge and physical exercise skills through the school's WeChat public number to facilitate students' reading and learning at any time, and provide online support for students' physical exercise. Record running clock and fitness through the WeChat sports APP and Keep APP, students are regularly selected as "exercise star" and the campus marathon and fitness exercise star game to stimulate positive imitation behavior and exercise motivation through the role model effect and group motivation. Strengthen the intelligent management and resource utilization rate of sports venues to fully meet the space needs of college students for physical exercise. Strengthen the construction of campus sports culture, build a social model of students' sports exercise through the social collaboration function of sports clubs and sports festivals, expand the attractiveness and cohesiveness of "campus sports circle," and motivate students to participate in leisure sports exercise after class. It is also required that students in grades 1–2 elective physical education courses to master sports skills and cultivate sports interests, while combining digital sports punch cards with sports exams, conducting regular physical health tests for college students, providing intervention programs through accurate analysis of physical health data, and establishing scientific and reasonable sports practice methods with the core of improving college students' physical quality. Therefore, school physical education should focus on stimulating students' motivation for physical exercise, creating an atmosphere to promote physical exercise and positive effect perception of exercise, helping students to realize and experience the benefits of physical exercise, such as and, entertainment, social networking, and skill development. By promoting students' psychological inclination and attachment to participate in physical exercise and their attachment to exercise itself, college students are likely to consciously and actively participate in physical exercise, develop good exercise habits and then achieve the goal of lifelong physical exercise.

In response to the high intention–low behavior in the exercise model, the stronger the individual's commitment and determination to participate in physical exercise, the more likely they are to make sustained effort to achieve the exercise goal, and the more positive, conscious, and enthusiastic their performance will be in physical exercise. Therefore, to promote college students' physical exercise behaviors, the formation, maintenance and enhancement of

exercise commitment should be promoted in certain ways to bring into play the positive effects of exercise commitment. In this regard, future research should focus on the interventions of exercise commitment and provide a set of effective intervention methods to promote physical exercise behavior of college students.

CONCLUSION AND RECOMMENDATIONS

Conclusion

(1) The 5-factor model of physical exercise can better predict exercise intention and behavior of college students. (2) The 6-factor model of enhanced physical exercise is better than the 5-factor model in the prediction of intention and behavior, which is an applicable model for predictive interventions on college students' physical exercise behavior. (3) Exercise commitment plays a partial mediating role between exercise intention and behavior, and it has no moderating effect.

Recommendations

This study is cross-sectional, and the data are collected through self-reported surveys, making it difficult to grasp the dynamic characteristics of exercise commitment. It is recommended that future studies should conduct longitudinal experimental intervention studies, so as to explain the causal effect more effectively. In order to reduce the common method bias, more objective measuring tools (e.g., pedometer, accelerometer, and heart rate monitor) should be used to measure the actual exercise behavior of college students. TPB is not an exhaustive model, and there is plenty of room left for other mediators, moderators and predictors beyond the basic model. Future studies need to further integrate other social cognitive variables to enhance the predictive power of the model, and provide theoretical guidance and promotion strategies for the overall development of physical exercise and fitness of college students.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of Qufu Normal University. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

W-JZ and Z-XM conceived and designed the study. W-JZ and Y-JF drafted the manuscript. Z-YY and T-FF collected the data and controlled the quality. Z-XM and MX revised the manuscript. W-JZ conducted the data analyses. All authors contributed to the article and approved the submitted version.

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Understanding the intention-behavior gap: The role of intention strength

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This manuscript overviews recent research on the intention-behavior gap, focusing on moderators of the intention-behavior relationship. The manuscript draws on the concept of intention strength to make two important points. First, strong intentions provide better predictions of behavior, thereby reducing the intention-behavior gap. However, strong intentions have the additional features of being more stable over time, less pliable in the face of interventions to change them, and more likely to bias information processing about engaging in the behavior. These four features of intention strength are not independent. For example, stable intentions are likely to provide better predictions of behavior. Second, various predictors of strength (e.g., importance, certainty, extremity) may also constitute important, but little studied, moderators of the intention-behavior relationship. Moreover, the effects of these moderators of the intention-behavior relationship may be mediated through intention stability (and perhaps other features of intention strength). Future research on the intention-behavior gap would benefit from a more systematic consideration of a broad range of moderators of the intention-behavior relationship both individually and in combination. In addition, future research could usefully explore how these moderating effects might be explained. Such a systematic approach may further our understanding of the intention-behavior gap in relation to physical activity and other behaviors.

KEYWORDS

intention, intention strength, intention-behavior gap, attitude strength, intention stability, physical activity, health behavior

Introduction

Definitions of intentions often focus on the idea of them being self-instructions (Triandis, 1980; Sheeran and Webb, 2016) that capture the underlying motivation (Rogers, 1983) or commitment (Sheeran and Webb, 2016) to act. It is common to distinguish goal (e.g., "I intend to get fit") and behavioral (e.g., "I intend to engage in physical activity at least five times per week") intentions, with the former focusing achieving desired goals and the latter focusing on engaging in a behavior or action (perhaps in the service of reaching a goal). It is the latter that are the main focus here. Behavioral intentions are central to a range of theories about the determinants

of behavior/action. Indeed they are the proximal and sole determinant of action in the reasoned action approach (Fishbein and Ajzen, 2010) and in protection motivation theory (Rogers, 1983), and one of several proximal determinants of behavior in social cognitive theory (Bandura, 1997) and the health action process approach (Schwarzer and Luszczynska, 2015). Nevertheless, intentions rarely if ever explain *all* the variance in behavior. This has become known as the intention-behavior gap and is the focus of the current manuscript.

The current manuscript is divided into six main sections (see **Figure 1** for a route map and summary). The first briefly reviews the intention-behavior gap for physical activity and other behaviors. The second reviews work on various factors that reduce the intention-behavior relationship (i.e., moderate the intention-behavior relationship) for physical activity and other behaviors. The third introduces the concept of intention strength as a means to improve our understanding of the intention-behavior relationship. The fourth and fifth consider features and then predictors of intention strength. In particular, these sections consider the intention-behavior gap as one of four key features of intention strength and reviews various predictors of intention strength as potential moderators of the intention-behavior relationship. The sixth and final section discusses a number of directions for future research on the intention-behavior gap.

Intention-behavior gap

Measures of behavioral intentions (e.g., "I intend to engage in physical activity at least five times per week," strongly disagree – strongly agree) commonly include both a valence (i.e., intenders versus non-intenders and sometimes a neutral category) and an extremity component (i.e., slightly agree versus strongly agree) component. Such measures of intention to engage in a behavior rarely predict all or even the majority of the variance in behavior. For example, reviews of the theory of planned behavior and the reasoned action approach indicate that intentions explain between 18 and 23% of the variance in behavior across a broad range of behaviors (Armitage and Conner, 2001) or health behaviors in particular (McEachan et al., 2011, 2016). Reviews suggest values at the lower end of this range for studies focusing on physical activity (18% variance in Hagger et al., 2002; 20% in McEachan et al., 2011). It is notable that the (mostly prospective) correlational studies included in these reviews almost exclusively focus on behavioral intentions rather than goal intentions. Experimental studies that manipulate intentions and observe effects on subsequent behavior similarly indicate less than perfect relationships. For example, studies of a range of behaviors indicate that medium-to-large sized changes in intentions are associated with only small-to-medium sized changes in behavior (Webb and Sheeran, 2006; Sheeran et al., 2016). Similar sized effects are reported in studies focusing just on physical activity (Rhodes and Dickau, 2012). It is notable that the effect sizes reported in reviews of these experimental studies (r_+ = 0.08–0.18) are considerably smaller than those reported in reviews of correlational studies (r_+ = 0.40–0.48). The disjunction between intentions and behavior observed in both correlational and experimental studies has been termed the intention-behavior gap (Sheeran, 2002; see also Godin and Conner, 2008; Rhodes and de Bruijn, 2013).

A range of methodological factors will be associated with either a narrowing or widening of this gap; more reliable measures of intention and behavior or a focus on relationships disattenuated for measurement error may be associated with a narrowing of the gap, while a focus on objective measures of behavior and failure to ensure that measures of intention and action/behavior are matched on the principle of correspondence (Ajzen, 1991) may widen the gap. Unfortunately the former effects may be more modest than the latter effects. For example, McEachan et al. (2011) estimated the intention-behavior correlation increased from 0.40 to 0.43 when disattentuated for measurement error. In contrast, McEachan et al. (2011) reported that intention and perceived behavioral control explained 26% of the variance in self-reported measures of physical activity, but only 12% of the variance in objective measures. Across a broader set of behaviors, Armitage and Conner (2001) reported that intention and perceived behavioral control explained 31% of the variance in self-reported behaviors, but only 20% of the variance in objective behaviors. Matching of intention (plus other measures) and behavior measures on action and target elements is central to the theory of planned behavior (Ajzen, 1991). However, some behaviors such as physical activity often employ frequency measures of behavior that commonly fail to follow this principle. For example, some physical activity studies measure behavior based on frequency measures such as the International Physical Activity Questionnaire (sometimes converting this into METs) but predict this from intention items focusing on meeting recommended guidelines for physical activity (e.g., five sessions per week of at least 20 mins). The problem here is that the intention measure should be matched to a behavior item that taps whether the recommended activity had been completed or not rather than number of METs. The linearity of the relationship between such an intention measure and a measure of METs is unclear and could under- or over-estimate the size of the true intention-behavior relationship (see Morwitz and Munz, 2020 on other methodological issues in relation to the intention-behavior relationship).

An important focus in furthering our understanding of the intention-behavior gap has been exploring the role of conceptual moderators. This research focuses mainly on features of the

Intention-behavior gap

A brief review of the nature of the intention-behavior gap.

Intention-behavior moderators

A review of seven key sets of moderators of the intention-behavior relationship:

- Goal dimensions (goal difficulty, goal desire, goal priority, goal conflict)
- Basis of intention (affective attitude, moral norms, anticipated regret, self-identity)
- Structure of intention (degree of reasoned action, motivational coherence, realism of intention)
- Past behavior / habit (frequency of past behavior, habit)
- Personality (openness, conscientiousness, extraversion, agreeableness, neuroticism)
- Socio-demographic factors (age, gender, socio-economic status)
- Temporal stability of intentions (similarity of intentions over time)

What is strength?

A consideration of construct strength from the attitude domain that could be applied to intentions.

Features of strength

Four features of strength distinguished:

- Durability (temporal stability, pliability)

- Impact (impact on behavior, impact on processing of relevant information)

Predictors of strength

Consideration of 11 predictors of strength (under four categories) derived from the attitude domain and their potential application to intentions:

- Aspects of the cognition (Extremity)

- Aspects of the cognition structure (Knowledge, Accessibility, Moralization, Ambivalence, Cognitive-Affective Consistency, Intensity)

- Processes (Elaboration)

- Subjective beliefs about the cognition (Certainty, Importance, Vested Interest)

Future directions

An integration of presented work and consideration of future directions:

- Need for systematic study of individual moderators (consider effects on different features of intention strength)

- Need for systematic study of multiple moderators (consider effects on different features of intention strength; identify dominant moderators)

- Exploration of mechanisms (consider stability and other features of strength as mechanisms explaining the mechanisms of action for identified moderators).

FIGURE 1
Route map and summary of main sections of the manuscript.

intention and other constructs that influence the intention-behavior gap and is briefly reviewed in the next section.

Intention-behavior moderators

In the existing research literature, a key approach to understanding the intention-behavior gap in relation to physical activity and other behaviors has been to focus on potential moderators of the relationship, i.e., factors associated with changes in the magnitude of the intention-behavior relationship. Moderators help identify the limits of the relationship between intention and behavior and also the conditions under which strong versus weak relationships might be expected. A range of such moderators have been identified in various studies and discussed in several reviews (e.g., Sheeran, 2002; Sheeran and Webb, 2016). In addition, a recent, broad review of intention-physical activity moderators (Rhodes et al., 2022) provides a number of insights. The moderators that have received the most attention can be broadly split into goal dimensions, basis of intention, structure of intention, past behavior/habit, personality and socio-demographic factors, and temporal stability.

Goal dimensions

The goal dimensions explored as moderators of the intention-behavior relationship include goal difficulty, goal desire and commitment, plus goal priority and conflict. As the difficulty of a goal increases, the power of intentions to predict behavior decreases (e.g., Sheeran et al., 2003). Goal difficulty is a function of the goal itself and the skills, resources, and effort an individual can bring to achieving the goal. Measures typically tackle how easy or difficult the individual perceives it to be to achieve the goal. Easy-difficult judgments are a key component of perceived behavioral control. Lower perceived behavioral control (i.e., high goal difficulty) should be associated with larger intention-behavior gaps. This is the prediction in the theory of planned behavior and reasoned action approach (Fishbein and Ajzen, 2010). However, the empirical findings are mixed. Armitage and Conner (2001) reported that approximately 50% (9/19 studies) of the studies in their meta-analysis testing the interaction between perceived behavioral control and intentions reported a significant effect (i.e., intentions being stronger predictors when perceived behavioral control was higher). More recently, Hagger et al. (2022) reported that across 36 tests, the intention-behavior relationship was stronger when perceived behavioral control was high (M + 1SD: b = 0.555, 95%CI [0.452, 0.658]) compared to moderate (M: b = 0.489, 95%CI [0.384, 0.594]) or low (M-1SD: b = 0.423, 95%CI [0.301, 0.545]). Rhodes et al. (2022) in their review reported that perceived behavioral control significantly moderated the intention-behavior relationship for physical activity in approximately 60% (13/21 tests) of studies reporting this effect. Sheeran and Webb (2016) argue that some of the mixed findings for perceptions of goal difficulty as a moderator may be attributable to people under-estimating actual difficulty of performing these more difficult behaviors.

Goal desire and commitment have received much less attention. The more a goal is desired (Prestwich et al., 2008) and the more an individual is committed to the goal (Rhodes et al., 2018) then the stronger should be the intention-behavior relationship. Prestwich et al. (2008) reported stronger intention-behavior relationships at higher compared to lower levels of goal desire across four studies. Greater commitment to a goal might also be expected to increase the intention-behavior relationship (Cooke and Sheeran, 2013). Rhodes et al. (2022) reported that commitment significantly moderated the intention-behavior relationship for physical activity in approximately 70% (2/3 tests) of studies.

Goal conflict and goal priority have also received attention as moderators of the intention-behavior relationship. The less a focal goal conflicts with other goals might be expected to be associated with greater effort to achieve the focal goal and so stronger intention-behavior relationships. Rhodes et al. (2022) reported that goal conflicts significantly moderated the intention-behavior relationship for physical activity in approximately 70% (6/9 tests) of studies reviewed. Goal priority is an important concept in understanding the pursuit of multiple goals and refers to the temporary increase in the importance attached to, and resources directed toward, one or more goals compared to other goals – that serve to benefit the performance of the prioritized behavior (Unsworth et al., 2014). Although conceptually important, goal priority has not received widespread attention as an intention-behavior moderator (Geers et al., 2009; Conner et al., 2016a). Conner et al. (2016a) showed that goal priority moderated the intention-behavior relationship for physical activity (Study 1) and a range of health behaviors (Study 4) and that a manipulation of goal priority increased the intention-physical activity relationship when physical activity was self-reported (Study 2) or objectively measured (Study 3). More recently, Conner et al. (2022c) showed that prioritizing one or two behaviors (including physical activity) that individuals intended to engage in resulted in greater performance of the prioritized behaviors with no decrement to the non-prioritized behaviors.

Basis of intention

Studies that have explored the basis of intention as a moderator of the intention-behavior relationship have primarily considered the extent to which intentions are based on affect or identity. Several studies indicate that intentions based more on personal or affective compared to other factors are more

predictive of behavior, consistent with the predictions of self-determination theory (Deci and Ryan, 1985). This includes work on attitudes versus norms (Sheeran et al., 1999) and affective versus instrumental attitudes (Keer et al., 2014). Similarly, high levels of moral norms (Godin et al., 2005), anticipated regret (Sheeran and Abraham, 2003), and self-identity (Sheeran and Orbell, 2000; Carfora et al., 2017) have also been found to be associated with stronger intention-behavior relationships. Rhodes et al. (2022) reported that affective attitudes (4/6 tests), anticipated regret (4/5 tests), and physical activity personal/self-identity (5/7 tests) each significantly moderated the intention-physical activity relationship in their review. Across a group of health behaviors including physical activity, Conner et al. (2016b) showed that out of instrumental attitude, affective attitude, injunctive norm, descriptive norm, and anticipated regret, it was intentions based on anticipated regret that most strongly predicted behavior. Other studies have shown that drawing attention to anticipated regret via measuring it (drawing on the Question-Behavior Effect; Wood et al., 2016) is sufficient to increase the power of intentions to predict behavior. For example, Sandberg and Conner (2011) showed that measuring anticipated regret increased the power of intentions to predict objectively measured sports center use. Sandberg and Conner (2009) showed similar effects for objective measured attendance for cervical screening. Importantly this effect was only present when anticipated regret was assessed before rather than after intention, suggesting that the anticipation of regret had to inform the intention for the moderation effect to occur.

Structure of intention

A number of recent studies have explored various aspects of the structure of intention as moderators of the intention-behavior relationship. This includes work on the degree of reasoned action (Sheeran and Conner, 2019), motivational coherence (Sheeran and Conner, 2017) and the realism of the intention (Avisha et al., 2019). Degree of reasoned action refers to the extent to which a person's determination to act is based on relevant expectancies, or how well behavior-relevant cognitions predict intentions. Across two studies, Sheeran and Conner (2019) showed that well-reasoned intentions better predicted behavior. Motivational coherence is the extent to which predictors of intentions (e.g., attitudes, norms, perceived control from the theory of planned behavior) cohere or point in the same direction. Across three studies (including one on physical activity), Sheeran and Conner (2017) showed that greater motivational coherence was associated with a stronger relationship between intentions and behavior. Finally, Avisha et al. (2019) examined how realistic intentions (i.e., those based on considerations of the expectations that the behavior could be performed) might moderate the intention-behavior relationship. Across three studies (including one on physical activity), it was shown that more realistic intentions were stronger predictors of behavior.

Past behavior/habit

The frequency of past performance of a behavior (or habit based on self-report measures) has also been found to moderate the intention-behavior relationship, although the direction of this moderation effect is inconsistent. For example, Rhodes et al. (2022) reported that past behavior/habit was associated with a significantly stronger intention-physical activity relationship in approximately 30% (4/14 tests) of studies, but a significantly weaker relationship in approximately 50% (7/14 tests) of studies (see also Gardner et al., 2011). Sheeran et al. (2017) showed that this apparent inconsistency can be explained by the fact that the impact of past behavior/habit on the relationship between intentions and behavior follows an inverted U-shaped relationship. At low levels of past behavior, increasing experience initially enhances the power of intention to predict behavior, while at higher levels of past behavior increasing experience attenuates the power of intention to predict behavior. The former effect may be attributable to experience strengthening the intention (similar arguments have been made in relation to experience on the attitude-behavior relationship; Fazio and Zanna, 1978), while the latter effect may be attributable to the behavior becoming more automatized or habitual (Ouellette and Wood, 1998).

Personality

The personality factors explored as moderators of the intention-behavior relationship have included all of the big five personality dimensions (openness, conscientiousness, extraversion, agreeableness, and neuroticism) with generally no significant effects (see Rhodes et al., 2022). The exception to this trend is conscientiousness, with Rhodes et al. (2022) reporting that 80% (4/5 tests) of studies reported that higher levels of conscientiousness were associated with stronger intention-physical activity relationships. Conscientiousness refers to the ability to control one's behavior and to complete tasks, with individuals high in conscientiousness being more organized, careful, dependable, self-disciplined and achievement-oriented than those low in conscientiousness (McCrae and Costa, 1987). In addition, conscientiousness is associated with greater impulse control (Bogg and Roberts, 2004, 2013). A number of these factors might help explain why those high in conscientiousness show stronger relationships between their intentions and behavior with perhaps different factors operating in relation to risk (e.g., impulse control) versus protection (e.g., self-discipline) behaviors like physical activity. These explanations remain to be tested.

Socio-demographic factors

A number of socio-demographic factors have been explored as moderators of the intention-behavior relationship with mostly null effects. For example, Rhodes et al. (2022) reviewed a range of such demographic factors including age and gender although no clear evidence emerged of consistent effects across the various physical activity studies examined. One exception to these generally null effects has been socio-economic status. A number of studies on physical activity (Schüz et al., 2017) and other behaviors (e.g., Conner et al., 2013; Schüz et al., 2020, 2021) indicate that socio-economic status moderates the intention-behavior relationship (i.e., weaker intention-behavior relationships in lower SES groups). However, Rhodes et al. (2022) reported mixed effects for different measures of socio-economic status on intention-physical activity relationships: 1/2 significant effects for material deprivation, 1/5 significant effects for income, 0/1 for social deprivation, and 2/4 for education. The observed effects may be attributable to the same goal being of greater difficulty in lower socio-economic status groups due to variations in the opportunities, resources, ability, skills and time and effort required to realize the goal (Sheeran and Webb, 2016; Schüz, 2017).

Temporal stability of intentions

Research in the goal/behavioral intention domain has also focused on the whether the temporal stability of intentions is associated with stronger effects on behavior. Temporal stability here refers to the lack of change in an intention measure over time. In most studies this is typically operationalized as a lack of absolute change in an intention measure within an individual over time (see Conner et al., 2000 for consideration of different measures of stability). For intensive longitudinal designs, where intention is measured multiple times, stability might be better captured by some form of within-person variability measure (with low variability equating to greater stability). The important moderating role of temporal stability has been highlighted as one of the limiting conditions of the Theory of Planned Behavior/Reasoned Action and Reasoned Action Approach (Fishbein and Ajzen, 2010) which states that intentions will only predict behavior to the extent that they remain unchanged between when they are measured and the time point at which they may influence the decision to act. A number of studies show that more stable intentions better predict behavior. Cooke and Sheeran's (2004) meta-analysis showed temporal stability to significantly moderate intention-behavior (10 studies) relationships. More specifically in relation to physical activity, Conner and Godin (2007), across seven studies, showed the intention-behavior relationship to be a substantial $r_+ = 0.60$ when intentions were stable, but only $r_+ = 0.27$ when intentions were unstable. Similarly, the review of Rhodes et al. (2022) showed intention stability to be a significant moderator of intention-physical activity relationships in nearly 80% (10/13 tests) of studies and noted intention stability as one of the more consistent moderators. Beyond the physical activity domain, Conner et al. (2002) reported intentions were stronger predictors of healthy eating over a period of 6 years when these intentions were stable over a 6-month time period. More recently, Norman et al. (2022) showed that the temporal stability of intentions moderated intention-behavior relationships across a number of COVID-19 protection behaviors. As discussed in subsequent sections, the temporal stability of intentions may also be considered a key feature of a strong intention and also represent a key mechanism to explain the effects of other moderators of the intention-behavior relationship.

What is strength?

The moderators reviewed in the previous section provide a number of insights into the factors that may account for the intention-behavior gap. However, in general they fail to provide a strong framework for understanding the magnitude of the impact of intentions on behavior. The subsequent sections of this manuscript consider the concept of *intention strength*, what it can add to our understanding of the intention-behavior relationship, and how it might provide the basis for such a framework.

The concept of "strength" in relation to social/health cognitions has received the most attention in relation to attitudes. Attitude strength has been defined as "the extent to which attitudes manifest the qualities of durability and impactfulness" (Petty and Krosnick, 1995, p. 3). Thus, strong attitudes are stable and resistant to efforts to change them (i.e., they are durable) and they bias information processing and guide behavior (i.e., they are impactful). In the attitude literature, a distinction is made between predictors versus the defining features of attitude strength (Luttrell and Sawicki, 2020). Predictors of attitude strength include the importance, accessibility and extremity of an attitude, while defining features include the attitude's temporal stability and impact on behavior.

The idea that goal or behavioral intentions also possess a dimension of strength has received comparatively less attention, although the idea does appear sporadically in the literature. For example, Hall (2013), in the *Encyclopedia of Behavioral Medicine*, offers this definition:

> "Intention strength can be defined as the quantity of personal resources that an individual is prepared to invest in executing a behavior. Intention strength is closely akin to the concept of "motivation," with high levels of intention strength understood to represent strong motivation to perform a behavior."

Similarly, Fuchs et al. (2017) suggest that "intention strength refers to the degree of firmness a person expresses toward

an intended action" and Rebar et al. (2019) define intention strength as "the degree of commitment a person has to enact their intention." The distinction here is between the focus of the intention and the strength of the commitment to pursue that intention. Rebar et al. (2019) label these decisional intentions versus intention strength. Decisional intentions can be tapped by items such as "I intend to engage in __ minutes of physical activity next week," yes/no. In contrast, strength of commitment can be tapped by items such as "How strong is your intention to resume your fitness training within the next weeks and months?," I do not have this intention at all – I do have a very strong intention (Fuchs et al., 2017), or "To what degree do you intend to engage in physical activity next week?," Very little – Very much (Rebar et al., 2019).

These definitions of strength identify some of the different predictors of strength but say little about the consequences of having a strong intention. It is argued here that work on intention strength would benefit from employing a similar definition to that used for attitude strength. That is, intention strength should be broadly defined in terms of the extent to which intentions manifest the qualities of durability and impactfulness. These are discussed in the next section under the features of intention strength. A subsequent section examines a number of predictors of strength that might be expected to impact on the features of strength.

Features of strength

There are interesting parallels between work on the intention-behavior gap and work on the attitude-behavior relationship. In the attitude domain, strong attitudes are defined as having the consequences of being durable and having impact (Petty and Krosnick, 1995). Luttrell and Sawicki (2020) refer to these as the *defining features* of attitude strength. Durability can be further split into temporal stability and pliability (or persistence and resistance), while impact can be further split into effects of the attitude on behavior and the processing of attitude-relevant information. Temporal stability and impact on behavior (i.e., the attitude-behavior gap) are the defining features of attitude strength that have received the most attention (Petty and Krosnick, 1995). It is worth noting that these two features of strong attitudes are not unrelated, with attitude temporal stability being one important mechanism through which strong attitudes better predict behavior (the prediction explanation; Fabrigar et al., 2005). As Schwartz (1978) noted, attitudes will not be likely to predict subsequent behavior unless they persist over the intervening time interval between when the two are measured. A number of previous studies support this prediction explanation (Schwartz, 1978; Davidson and Jaccard, 1979; see also Glasman and Albarracín, 2006). More recently, Conner et al. (2022a) showed across three studies that more stable attitudes were more predictive of subsequent behavior. Indeed, temporally stable attitudes may predict behavior over periods as long as 10 years (Conner and Norman, 2021). Research has also looked at the resistance of strong attitudes to persuasive attempts and the impacts of strong attitudes on information processing. In general, this research shows that stronger attitudes are more resistant to efforts to change them (Eagly and Chaiken, 1995) and have greater impact on the processing of attitude-relevant information (Petty and Krosnick, 1995) leading to more biased processing (i.e., enhancement of information consistent with current attitude and denigration of information inconsistent with current attitude).

As with strong attitudes, strong intentions might usefully be defined as having the consequences of being durable and having impact. Durability can be split into the temporal stability of intentions and the pliability of intentions. Impact can be split into effects of the intention on behavior and on the processing of intention-relevant information. In the intentions domain it is the intention-behavior relationship that has received the most attention. From an intention strength perspective, strong intentions are more predictive of behavior and therefore reduce the gap between intentions and behavior. However, strong intentions are also likely to have the features of being stable over time, less pliable when challenged, and having greater impacts on the processing of intention relevant information. The need for these features of intention strength to be given more attention alongside examination of impacts on the intention-behavior relationship is noted in the future directions section below. Importantly stability, pliability and information processing effects may each represent important mechanisms by which moderators of the intention-behavior relationship have their effects.

Predictors of strength

A number of factors may be associated with having strong cognitions. In the attitude domain, Luttrell and Sawicki (2020) refer to these as *predictors* of attitude strength. In relation to predictors of attitude strength, Howe and Krosnick (2017) identified 11 predictors: certainty, importance, ambivalence, accessibility, knowledge volume, extremity, cognitive-affective consistency, intensity, moral conviction, elaboration, and vested interest. Similarly, Luttrell and Sawicki (2020) identified seven such predictors: accessibility, ambivalence, certainty, importance, elaboration, knowledge, and moralization.

Many of these predictors of attitude strength may also have direct or indirect utility in relation to understanding intention strength. Each of the eleven predictors of strength identified in previous reviews (Howe and Krosnick, 2017; Luttrell and Sawicki, 2020) are discussed in detail below: extremity, knowledge, accessibility, moralization, ambivalence, cognitive-affective consistency, intensity, elaboration, certainty, importance, and vested interest. Evidence from the attitude

strength literature is reviewed alongside any work in the intention domain.

These different predictors of strength fall into one of four basic categories (Petty and Krosnick, 1995; Eaton and Visser, 2008). The first category comprises *aspects of the cognition*. Extremity is the key predictor in this category. The second category comprises *aspects of the cognition structure*. This includes aspects of the structure of the thoughts associated with the cognition in memory such as the amount of knowledge linked to the cognition in memory (i.e., knowledge) and the strength of the association between the cognition and the object (i.e., accessibility), but also the extent to which the cognition is based on something being right or wrong or moral or immoral (i.e., moralization), the extent to which positive and negative evaluations are incongruent (i.e., ambivalence), the extent to which cognitive and affective evaluations are incongruent (i.e., cognitive-affective inconsistency), and the extent to which strong emotions are elicited (i.e., intensity). The third category comprises *processes* by which the cognition is formed. This includes the degree of thinking done (i.e., elaboration) about the merits and shortcomings of target. The fourth and final category comprises the *subjective beliefs about the cognition*. This includes the degree of certainty about the object, the importance given to the cognition or the object, and vested interest in the cognition.

Aspects of the construct

In relation to *extremity*, attitude measures are typically operationalized using bipolar scales with a neutral mid-point (e.g., "For me, engaging in the recommended levels of physical activity each week over the next month is. . .bad – good;" scored 1–7). Such measures simultaneously tap the valence of the attitude (i.e., negative for scores 1–3; neutral for a score of 4; positive for scores 5–7) and the extremity of the attitude (i.e., scored as the distance from the neutral point; scores of 5 and 7 both indicate a positive attitude but the latter score indicates a more extreme positive score than the former). More extreme attitudes are assumed to be stronger and considerable literature shows more extreme attitudes to be more predictive of behavior, stable over time, resistant to change and impactful on information processing (see Abelson, 1995 for a review). The majority of tests of the strength of the attitude-behavior relationship employ bipolar measures of attitude that confound the valence and extremity of the attitude. For example, McEachan et al. (2011) meta-analysis of the theory of planned behavior reports an attitude-behavior relationship of $r_+ = 0.30$ for physical activity based mainly on such bipolar attitude measures. Such analyses assume the attitude-behavior relationship is linear, although an attitude strength perspective might suggest a cubic relationship with the greatest change in behavior apparent at the extremes. Some recent research has supported a cubic relationship between attitude extremity and behavior (Bechler et al., 2021), although here the greatest change in behavior was apparent around the neutral point (these tests mainly focused on the attitude-intention relationship). Bassili (1996) makes the useful distinction between operative and meta-judgmental measures of strength. Operative measures link to processes and may be less open to bias in self-report (e.g., accessibility based on reaction times), while meta-judgmental measures are based on self-perceptions and may be more open to bias in self-report (e.g., perceived importance of a cognition). Extremity measures can be considered to be both operative and meta-judgmental measures of strength.

Similarly in relation to intentions, although few studies explicitly examine extremity, typically measures are bipolar and include elements tapping both direction (equivalent to valence in attitude measures) and extremity which is assumed to tap strength. For example, behavioral intentions toward physical activity might be measured by an item such as, "I intend to engage in the recommended levels of physical activity each week over the next month, strongly disagree – strongly agree" (scored 1–7). Such a measure taps the direction of the intention (i.e., negative/disinclined for scores 1–3; neutral for a score of 4; positive/inclined for scores 5–7) and the extremity of the intention (i.e., scored as the distance from the neutral point; scores of 5 and 7 both indicate a positive intention but the latter score indicates a more extreme [and stronger] positive intention than the former). Although unipolar measures of intention (e.g., "I intend to engage in the recommended levels of physical activity each week over the next month, not at all – definitely;" scored 1–7) are possible, they are relatively little used. For example, the intention-behavior relationship of $r_+ = 0.45$ for physical activity reported by McEachan et al. (2011) was largely based on bipolar intention measures that include both direction (or valence) and extremity elements. Such analyses assume the intention-behavior relationship is linear, although research points to this being unlikely to be the case (e.g., Rebar et al., 2019). For example, Sheeran (2002) makes the important point that the intention-behavior gap is mainly attributable to those who are inclined to act (i.e., positive intention in the distinction above) failing to subsequently act (i.e., inclined abstainers in his matrix; see also Orbell and Sheeran, 1998). Sheeran (2002) noted that in relation to physical activity, 54% of intenders (i.e., those inclined or with positive intentions) failed to act (and 46% did act), while only 3% of non-intenders (i.e., those disinclined to act/with negative intentions) acted (and 97% failed to act). Rhodes and de Bruijn (2013), in their meta-analysis, reported the overall intention-physical activity gap to be 46% (only 2% of non-intenders acted; while 42% of intenders acted).

Reanalysis of data from Conner et al. (2021; Study 1) on engagement with physical activity examined the effects for both valence/direction and extremity for intention. This study was conducted in a sample of almost 1,000 adults over a 1-month time period using the above bipolar intention measure and a self-report measure of engaging with the recommended

level of physical activity ("Over the past month, how many weeks did you engage in the recommended levels of physical activity"? 0–4 weeks; coded into 0–3 weeks non-compliance, 4 weeks compliance). The results indicate that the discordant percentages were 65% for intenders, but only 4% for non-intenders. **Table 1** reports the percentage engaging with the behavior for each point on the intention scale. This indicates several interesting findings. First, that the relationship between intention and behavior is not linear (with the pattern either side of the neutral point looking very different). Second, that the relationship between extremity and likelihood of behavior is not linear (even for the positive intender end of the scale). Third, the rate of change in the likelihood of behavior is greater between more extreme positive responses. More detailed examination of how extremity impacts on intention-behavior relationships is warranted, particularly as tests of other moderators of the intention-behavior relationship may be mainly based on measures of intention that include both direction/valence and extremity components. As Bechler et al. (2021) note in relation to the attitude-behavior relationship, different patterns of relationships between extremity and behavior have different implications (e.g., a strength perspective would be expected to lead to an accelerating effect at more extreme levels).

Aspects of the construct structure

Attitude *knowledge* or knowledge volume refers to the amount of information the person has about the attitude object. This is usually tapped by knowledge listing tasks or quizzes (i.e., operative indexes), although meta-judgmental measures have also been used. For example, Davidson et al. (1985) asked respondents about how well-informed they were about the attitude object (completely uninformed - completely informed). Davidson et al. (1985) showed greater knowledge to be associated with stronger attitude-behavior relationships and studies have also shown it to be linked to greater attitude stability (Bartle, 2000). Similarly, Conner et al. (2022b) reported that more self-reported knowledge about the behavior was associated with attitudes that were more predictive of behavior.

Knowledge measures typically focus on the attitude object (i.e., behavior) and therefore could also predict the strength of an intention, including its impact on behavior. However, to date there are no studies using operative or meta-judgmental measures of knowledge on the intention-behavior relationship. It might be expected that knowing more about a behavior would be associated with intentions that are more predictive of engaging in the behavior.

TABLE 1 Percentages of respondents reporting engaging in recommended levels of physical activity at different levels of intention (reanalysis of data from Conner et al., 2021, Study 1).

	Scale point						
	1	2	3	4	5	6	7
Behavior	0%	0%	9%	17%	28%	33%	51%

Higher scores indicate more positive intentions (4 is the neutral point).

In relation to attitudes, *accessibility* is the likelihood that the attitude will come to mind automatically in relevant situations. It is an operative measure (i.e., response latency) and assessed in relation to the evaluation of the attitude object (Fazio, 1995). More accessible attitudes have been found to be more stable over time (Bassili, 1996) and more predictive of behavior (Fazio et al., 1982); they are also more resistant to persuasion (Pfau et al., 2003) and more likely to bias information processing (Houston and Fazio, 1989).

In relation to intentions, accessibility would be the likelihood that the intention comes to mind automatically in relevant situations. It is an operative measure (i.e., response latency) and assessed in relation to the intention. Bassili (1993, 1995) reported more accessible voting intentions for a candidate to better predict voting for that candidate. In contrast, Doll and Ajzen (1992) failed to observe a significant moderating effect for accessibility on intention-behavior relationships in relation to playing with a video game. A meta-analysis by Cooke and Sheeran (2004) reported that across five studies for the intention-behavior relationship that accessibility was a significant moderator. Those with highly accessible intentions (r_+ = 0.75) compared to those with less accessible intentions (r_+ = 0.62) showed stronger intention-behavior relationships. There is a lack of studies testing intention accessibility in relation to engaging in physical activity.

In relation to attitudes, *moralization* or moral conviction is the degree to which an attitude is a strong and absolute belief that something is right versus wrong, moral versus immoral, or that it reflects core moral values and convictions (Skitka, 2014). It is measured by meta-judgmental measures and usually, but not always, measured in relation to the attitude/evaluation (e.g., Skitka, 2014) rather than the object (e.g., Conner et al., 2022b). Various studies have shown such attitudes to be more stable (Luttrell and Togans, 2021) and to better predict behavior (Skitka and Bauman, 2008; Judge et al., 2012). For example, Conner et al. (2022b) showed a measure of moral conviction taken in relation to the object (e.g., "Morally, wearing a face covering in public places is the right thing to do? Strongly disagree-Strongly agree") in a multi-behavior study significantly moderated the attitude-behavior relationship (i.e., higher moral conviction associated were better predictors of behavior).

To date there is a lack of studies assessing the impact of moralization or moral conviction in relation to the intention or in relation to the behavior on the intention-behavior relationship. As noted earlier, some studies do show that intentions based on moral norms were more predictive of behavior, consistent with this hypothesis. For example, Godin et al. (2005) showed, across six datasets for various

behaviors (including physical activity), that intentions more closely aligned with moral norms (compared to attitudes) were more predictive of subsequent behavior. Further tests of moral conviction as a predictor of intention strength, are warranted, although moralization might not be expected to be a key predictor of intention strength in relation to physical activity as physical activity is not typically considered to be a moral behavior.

In the attitude domain, *ambivalence* is the degree to which an individual has both positive and negative reactions to an attitude object (Conner and Sparks, 2002). Greater ambivalence is generally associated with less stable attitudes and weaker attitude-behavior relationships. Cooke and Sheeran (2004) reported a significant effect of ambivalence on the attitude-behavior relationship across six studies, although the average effect size was small. Both meta-judgmental and operative measures of ambivalence are widely used (Conner and Sparks, 2002), although the correlation between the two is modest. A limited number of studies have examined ambivalence as a moderator of the intention-behavior relationship (see Armitage and Conner, 2004), although the effects do not appear to be consistent.

Cognitive-affective inconsistency is the absolute difference between the cognitive and affective evaluations of an attitude object (irrespective of whether these evaluations are oppositely valenced or not as would be required for a measure of *cognitive-affective ambivalence*). Conner et al. (2021) found that a measure of cognitive-affective inconsistency, derived from bipolar measures of cognitive and affective attitudes, moderated the attitude-behavior relationship, as did a measure of cognitive-affective ambivalence. Higher levels of cognitive-affective inconsistency and ambivalence were both associated with weaker attitude-behavior relationships, although cognitive-affective inconsistency was the stronger moderator of attitude-behavior relations (Conner et al., 2021). There are few tests of cognitive-affective inconsistency as a predictor of attitude stability (see Chaiken et al., 1995). In addition, to date, there have been no tests of cognitive-affective inconsistency (taken in relation to the behavior) as a moderator of the intention-behavior relationship. It might be expected that when cognitive-affective inconsistency is low intentions to perform the behavior will be more predictive of behavior.

In the attitude domain, *intensity* is the degree to which a person's evaluation of the attitude object activates powerful emotions (Howe and Krosnick, 2017). Intensity is measured by simple, meta-judgmental measures about how strong the participant's feelings are about an issue or attitude object (Krosnick and Schuman, 1988). Again, there are no tests to date of intensity taken in relation to the behavior as a moderator of the intention-behavior relationship. It might be expected that when the behavior activates powerful positive emotions then intentions toward to perform the behavior will be more predictive of behavior. For example, if the thought of physical activity elicits powerful positive or negative emotions then intentions might be expected to be more predictive of engaging in physical activity than if no emotions are elicited. This may be related to intentions being better predictors of behavior when based on affective attitudes or anticipated regret. Future research could usefully explore intensity as an intention-behavior moderator in the physical activity domain.

Cognitive processes

Attitude *elaboration* is the degree of thought or careful consideration one has given to the attitude object's merits and shortcomings (Barden and Tormala, 2014). The classic measure is based on thought listing where participants list all their thoughts about an attitude object (i.e., operative measures; Petty and Cacioppo, 1977), although meta-judgmental measures of elaboration could be tapped by simple self-report. Studies have shown more elaborated attitudes based on thought-listing to be more stable (Haugtvedt and Petty, 1992) and to better predict behavior (Barden and Petty, 2008). In contrast, Conner et al. (2022b) did not find a meta-judgmental measure of attitude elaboration about the attitude object to moderate the attitude-behavior relationship.

There are no published tests of elaboration (operative or meta-judgmental) taken in relation to the behavior as a moderator of the intention-behavior relationship. It might be expected that greater elaboration about a behavior might lead to intentions that are more predictive of engaging in the behavior.

Subjective beliefs about the construct

Attitude *certainty* refers to the degree of confidence an individual has that his or her evaluation of the attitude object is correct/clear to him or her. The conviction with which an attitude is held is included as part of other definitions of certainty (Tormala and Rucker, 2018). Simple single-item, meta-judgmental measures are often used to tap certainty (e.g., Fazio and Zanna, 1978) and studies have shown greater certainty to be linked to both greater stability of attitudes (Bassili, 1996) and stronger attitude-behavior relationships (Warland and Sample, 1973; Fazio and Zanna, 1978). Cooke and Sheeran (2004) found significant effects of certainty on attitude-behavior relationships across four studies with small-medium average effect sizes. Conner et al. (2022b) showed that a measure of certainty taken in relation to general thoughts and feelings about the behavior (e.g., How certain are you about what you think about wearing a face covering in public places? Not at all certain-Extremely certain') in a multi-behavior study significantly moderated the attitude-behavior relationship (i.e., higher certainty associated with attitudes that were better predictors of behavior).

A limited number of studies have reported that intentions held with greater certainty better predict behavior (Bagozzi and Yi, 1989; Bassili, 1993; Pieters and Verplanken, 1995; Chandrashekaran et al., 2000; Sheeran, 2002; Sheeran and Abraham, 2003). A meta-analysis by Cooke and Sheeran (2004) reported that that certainty was a significant moderator of the intention-behavior relationship across two studies, with those with more certain intentions (r = 0.64) compared to those with less certain intentions (r = 0.41) showing stronger intention-behavior relationships. Sheeran and Abraham (2003) reported that intention certainty significantly moderated the intention-physical activity relationship.

Attitude *importance* is the degree to which an individual attaches significance to the attitude. This is a predictor of attitude strength that has received considerable attention (e.g., it is the focus of the first *Annual Review of Psychology* article focusing on attitude strength; Howe and Krosnick, 2017). Howe and Krosnick (2017) argue that attitude importance is a key predictor of attitude strength and reflects the degree of priority a person attaches to an attitude and distinguish it from concepts that link an attitude to one's values or self-image (e.g., centrality, involvement, ego-involvement, salience, personal relevance). The most frequently used measures of this construct tap how important the attitude or object is to the individual, how concerned they are about it, or how deeply they care about it (i.e., meta-judgmental measures; Krosnick, 1989; Gopinath and Nyer, 2009). Studies show greater attitude importance to be associated with stronger attitude-behavior relationships in relation to product choices (Kokkinaki and Lunt, 1997), work behavior (Ziegler and Schlett, 2016), and environmental behaviors (Bolsen, 2013). There are fewer tests of the impact of attitude importance on attitude stability with mixed findings (Krosnick, 1988).

Eaton and Visser (2008) note that although typical definitions of attitude importance focus on the significance that people attach to their attitude toward a given object, measures of attitude importance (Boninger et al., 1995) tend to focus on how important the attitude object is to them. However, studies show that measures of these two aspects of attitude importance are extremely highly correlated (Boninger et al., 1995). Conner et al. (2022b) showed a measure of importance taken in relation to the attitude object or behavior (e.g., "How important is wearing a face covering in public places to you? Not at all – Extremely important") in a multi-behavior study significantly moderated the attitude-behavior relationship (i.e., higher importance associated with better predictions of behavior).

Given the attention in the attitude domain it is perhaps surprising that importance has not received any attention in relation to intention strength. It might be expected that intentions toward behaviors judged to be important (or indeed behaviors judged to be important) might be stronger (i.e., durable and impactful) than those toward behaviors not judged to be important. Tests in the intention domain are warranted given the large amount of attention devoted to this variable in relation to attitude strength and the conclusion that it is a key predictor that may account for the role of other predictors (Conner et al., 2022b).

In the attitude domain, *vested interest* is the degree to which the attitude object is perceived to be of significant personal consequence (Crano, 1995; Howe and Krosnick, 2017). Crano (1995) notes the strong overlap between vested interest and personal relevance (and also attitude importance). Personal relevance is measured by simple, meta-judgmental measures about the attitude object anchored with "not personally relevant" to "personally relevant" (Haugtvedt and Wegener, 1994). To date there are no tests of vested interest or personal relevance taken in relation to the behavior as a moderator of the intention-behavior relationship. It might be expected that greater vested interest/personal relevance of a behavior would be associated with intentions that are more predictive of engaging in the behavior.

Future directions

In this section two related directions for future research on the intention-behavior gap are set out based on the above review of the existing literature (see **Figure 1** for a summary). These are the systematic study of individual and multiple moderators of the intention-behavior relationship and exploration of mechanisms by which moderators influence the intention-behavior relationship.

Systematic study of individual and multiple moderators

The literature reviewed above has highlighted a wide range of moderators of the intention-behavior relationship which together could provide a better understanding of the intention-behavior gap in relation to physical activity and other behaviors. The moderators reviewed prominently included goal dimensions, intention strength predictors and intention stability but also those linked to the basis of intention, structure of intention, and the personality dimension of conscientiousness. The concept of intention strength might provide a useful way to conceptualize these various different moderators. In this view, the different individual moderators would be considered as predictors of intention strength. As such, it would be useful to explore their effects on the intention-behavior relationship as well as on other features of intention strength such as intention stability, pliability and impacts on information processing (for an example see Cooke and Sheeran, 2013). For example, in addition to the predictors of strength reviewed above (i.e., extremity, knowledge, accessibility, certainty, and importance), goal dimensions such as goal desire, goal commitment, goal priority and goal conflict and measures of the structure of intentions (e.g., motivational coherence) might all be expected

to influence the intention-behavior relationship as well as other features of intention strength (i.e., intention stability, intention pliability and impact on information processing). As noted below, studies assessing the impact of moderators on both the intention-behavior relationship and other features of intention strength opens up the possibility of testing these other features as mechanisms to explain their effects on the intention-behavior relationship. In particular, research on intention stability as a mechanism to explain the effects of various intention-behavior moderators is reviewed below.

Studies examining multiple moderators of the intention-behavior relationship open up additional avenues for analysis. Relatively few studies have assessed more than one of these moderators, making comparisons of effects difficult due to differences in samples and behaviors. More studies could usefully assess multiple moderators to allow more direct comparisons of effects without the potential confounding factors that limit between study comparisons (e.g., sample, behavior or measure differences). Such studies could also allow exploration of the inter-relationships between moderators. In the attitude domain, a number of studies have examined the inter-relationships of different predictors of attitude strength. The general conclusion is that these predictors of attitude strength are both conceptually and empirically distinct (Luttrell and Sawicki, 2020). Correlations (e.g., Conner et al., 2022b) and confirmatory factor analyses (Krosnick et al., 1993; Lavine et al., 1998) support the idea that each constitutes its own latent factor), although they are intercorrelated. This may also be the case for moderators of the intention-behavior relationship although this remains to be determined. Studies that assess multiple intention-behavior moderators could employ exploratory and confirmatory factor analyses to test for underlying dimensions among moderators.

A limited number of studies have examined the effects of more than one predictor of attitude strength at a time on more than one feature of attitude strength (Bassili, 1996; Prislin, 1996; Luttrell and Togans, 2021; Conner et al., 2022b; see also Philipp-Muller et al., 2020 on predicting intentions). Such studies also allow exploration of the simultaneous effects of different predictors of attitude strength in order to assess if, for example, particular predictors dominate in their impact on the stability of attitudes and the attitude-behavior relationship. Conner et al. (2022b) showed that attitude certainty, importance, subjective knowledge, moral basis of attitude, cognitive-affective felt and potential ambivalence plus cognitive-affective inconsistency, but not attitude elaboration, individually and in combination (excluding potential ambivalence) predicted attitude stability. It was also found that attitude certainty, importance, subjective knowledge, moral basis of attitude, cognitive-affective felt ambivalence, cognitive-affective inconsistency plus attitude stability, but not cognitive-affective potential ambivalence or attitude elaboration, each individually moderated the attitude-behavior relationship. But when considered simultaneously only attitude importance and cognitive-affective inconsistency moderated the attitude-behavior relationship and only the former remained significant when controlling for attitude stability. This supports the idea that attitude importance is a key predictor of attitude strength (see Howe and Krosnick, 2017). Similar studies in relation to the various moderators of the intention-behavior relationship would be valuable to identify key moderators. This might indicate that moderators found to be dominant in relation to attitude strength such as importance are also key in relation to intention strength or whether different patterns exist (e.g., a different moderator such as certainty or several moderators are important).

Exploration of mechanisms

A further useful direction for research on the intention-behavior gap would be exploration of the mechanisms by which moderators of this relationship have their effect. In statistical terms this would be a test of whether measures of a proposed mechanism fully or partially mediate the effect of a moderator of the intention-behavior relationship. As noted above, intention stability, intention pliability and impacts on information processing might each be features of intention strength that could explain the effects of various moderators of the intention-behavior relationship. For example, a moderator like conscientiousness might be associated with stronger intention-behavior relationships because conscientious individuals hold intentions that are more stable and less pliable in the face of persuasive attempts and also because they are more likely to denigrate information that conflicts with their existing intentions (or bolster information that is consistent with their existing intentions).

The stability of attitudes has particularly received attention as a mechanism to explain the effects of other moderators of the attitude-behavior relationship. The idea that attitude temporal stability is one important mechanism through which strong attitudes better predict behavior is known as the prediction explanation (Fabrigar et al., 2005). As Schwartz (1978) noted, attitudes are unlikely to predict subsequent behavior unless they remain stable over the intervening time interval between when the two are measured. For example, Conner et al. (2022b) showed that the moderating effects of certainty, importance, knowledge, moral basis of attitude, ambivalence and inconsistency on the attitude-behavior relationship were fully or partially explained by their effects on attitude stability. Other mechanisms relate to other features of attitude strength (e.g., changing/biased perceptions of the attitude object; Fabrigar et al., 2005).

Similarly, intention stability rather than being just another moderator of the intention-behavior relationship, may represent an important mechanism through which other moderators of the intention-behavior relationship have their effect. That is, a moderator like high goal commitment may strengthen the intention-behavior relationship *because* it is

associated with more stable intentions. The extent to which intention stability effects fully mediate the effects of other moderators of the intention-behavior relationship would point to stability being a key mechanism by which they have this effect. Research has shown intention stability to fully or partially explain the effect of various other moderators of the intention-behavior relationship. For example, Sheeran and Abraham (2003) reported that intention stability moderated the intention–behavior relationship for exercising (intention-behavior correlation for low stability, r_+ = 0.49, for high stability, r_+ = 0.76). More importantly, Sheeran and Abraham (2003) found that intention stability fully mediated the effect of other moderators (i.e., intention certainty, past behavior, self-schema, anticipated regret and attitudinal control) of the intention–behavior relationship. This suggests that the mechanism by which these other moderators have their effect on intention–behavior relationships is through changing the temporal stability of intentions. Hence, factors that might be expected to make individual intentions more stable over time would be expected to increase the impact that these intentions have on behavior and so reduce the intention–behavior gap.

Further studies that consider intention stability and other mechanisms as mediators of the effects of moderators of the intention-behavior relationship would be valuable. This is the case both for the examination of the effects of individual (e.g., motivational coherence, Sheeran and Conner, 2017) and multiple (e.g., Sheeran and Abraham, 2003) moderators. In relation to other mechanisms, it was noted earlier that in the attitude strength domain, attitude stability was assumed not to be the only mechanism that might explain the effects of moderators of the attitude-behavior relationship. Similarly, in the intention domain, intention stability may not be the only mechanism to explain the effects of moderators of the intention-behavior relationship. For example, such moderators may have their effects on the intention-behavior relationship through their effects on various aspects of goal pursuit. Sheeran and Webb (2016) provide a useful review of the processes leading to goal realization. Self-regulatory challenges such as getting started, keeping goal pursuit on track, and bringing goal pursuit to a successful close are highlighted. Aspects of these processes could also form mechanisms explaining how moderators of the intention-behavior relationship have their effect (see also Johnson et al., 2006 for relevant suggestions from control theory). Relatedly, increased effort during goal pursuit and greater persistence in the face of obstacles could constitute additional mechanisms by which moderators have their effect on the intention-behavior relationship (see Bogg and Roberts, 2004, 2013 on conscientiousness). Studies that compare various different mechanisms through which individual and multiple moderators of the intention-behavior relationship have their effects could make an important contribution to understanding in this area. Further, experimental studies that attempt to manipulate moderators or mechanisms could aid our understanding of causal relationships in relation to intentions and behavior.

Conclusion

This manuscript has reviewed the work on various moderators of the intention-behavior relationship in order to provide insights into the factors that might explain the gap between the two. The focus was on the concept of intention strength and how this might add to understanding in this area. In particular, the idea that strong intentions may not only better predict behavior but also be more stable over time was advanced and it was noted that stability may be an important mechanism by which moderators of the intention-behavior relationship have their effects. In addition, a number of potential moderators drawn from the concept of intention strength and its parallels to predictors of attitude strength were reviewed. Future research in this area could benefit from a systematic examination of multiple moderators of the intention-behavior relationship and the extent to which intention stability or other mechanisms might explain their moderating effects. Relatedly, future research should also consider other key features of intention strength such as the pliability of intentions and their impact on the processing of intention-relevant information. Although strong intentions may be stable over time and more predictive of engaging in behaviors such as physical activity, they may also be more difficult to change through intervention and may lead to the biased processing of messages designed to change them (see Johnson et al., 2006; Cooke and Sheeran, 2013).

Author contributions

MC and PN developed the idea, contributed to and wrote the manuscript, 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.

Publisher's note

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The utility of the integrated behavior change model as an extension of the theory of planned behavior

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Introduction: There are several widely used theories of health behavior change, which mostly utilize the social cognitive approach. These theories tend to posit that intention is a direct predictor of behavior, do not include automatic influences on behavior, and propose a one-size-fits-all theory for both initiators and maintainers. However, the intention-behavior gap is a well-observed phenomenon, researchers have highlighted that both automatic and reflective factors promote behavioral engagement, and predictors of behavior have been shown to differ between initiators and maintainers—three issues that necessitate theory advancement. To that end, the present research compares the utility of the Integrated Behavior Change Model (IBCM) – a social cognitive model that includes automatic factors involved in behavioral engagement and a moderator of the intention-behavior gap – to its theoretical predecessor, the Theory of Planned Behavior (TPB). Further, the relevance of the IBCM factors for predicting exercise behavior is compared in initiators versus maintainers.

Method: Participants were 494 US undergraduates. Participants reported on variables from the IBCM (and TPB) at baseline and reported on their exercise behavior in two surveys at seven- and 14-days post-baseline.

Results: Findings supported the first hypothesis that the IBCM would be more relevant for initiators in comparison with maintainers, using structural equation modeling. Specifically, only the paths between intrinsic motivation and affective attitude, affective attitude and intention, and intention and behavior were reliably found for maintainers. For initiators, the aforementioned paths were also reliably supported and the additional following paths were also supported: intrinsic motivation and perceived behavioral control, perceived behavioral control and intention, and intention and action planning. However, results did not support the second hypothesis that the IBCM would predict significantly more variance in behavior than its theoretical predecessor, the TPB. Specifically, the addition of action planning, implicit attitude, implicit motivation, and the interaction between intention and action planning only predicted an additional 0.3% ($p < 0.05$) of the variance in exercise behavior above and beyond intention.

Conclusion: Results highlight the continued need for theoretical refinement in terms of delineating mechanisms of initiation and maintenance and the need for further development in terms of improving upon current predictions of behavior engagement and change.

KEYWORDS

theory of planned behavior, integrated behavior change model, physical activity, stage of change, dual process cognition

Introduction

The World Health Organization reports that worldwide 1.4 billion adults do not engage in sufficient levels of physical activity (WHO, 2020). This is problematic given that sufficient levels of physical activity engagement can decrease the risk of all-cause mortality as well as the onset of certain chronic illnesses such as hypertension, type 2 diabetes, and some site-specific cancers (e.g., colon). The fields of health psychology and behavioral medicine utilize many theoretical models to understand health behavior and health behavior change (Smedslund, 2000). Most of these theories take the social cognitive approach, which hypothesizes that intention is a direct proximal predictor of behavioral action, neglect to include the influence of automatic constructs on behavior, and generally do not differentiate between mechanisms of initiation and maintenance – specifying an invariant theory of behavior. However, the intention-behavior gap is a well-observed phenomenon (Sheeran and Webb, 2016), both automatic and reflective constructs have been shown to influence behavioral engagement (Rebar et al., 2016), and predictors of behavior have been shown to differ between initiators and maintainers (Phillips et al., 2016) – three issues that require theory advancement to promote more well-rounded, theoretically-based interventions. Using an exploratory approach, the focus of the present research is to compare, conceptually and statistically, two theories of health behavior change – for exercise initiators and maintainers – which are rooted in the link between intentions and behavior: The Integrated Behavior Change Model (IBCM; Hagger and Chatzisarantis, 2014b) and its theoretical predecessor, the Theory of Planned Behavior (TPB; Fishbein and Ajzen, 2011). Moreover, this research will compare the utility of the IBCM for predicting behavior against the TPB for initiators.

The theory of planned behavior

The TPB (Fishbein and Ajzen, 2011) specifies that behavior is proximally predicted by intentions and that intention is proximately predicted by attitudes, subjective norms, and perceived behavioral control (**Table 1** and **Figure 1**). Within the TPB, all constructs are reflective in nature. Moreover, the TPB includes three mediational hypotheses whereby attitudes, subjective norms, and perceived behavioral control predict behavior through intentions (**Table 1**). In general, *attitudes* refer to an individual's beliefs about whether a behavior is favorable or unfavorable (Ajzen, 1991). Attitudes can be delineated into affective and instrumental types – a distinction that is not explicitly made in the TPB. *Affective attitudes* are emotion-based, whereas *instrumental attitudes* are based on thoughts about the costs and benefits associated with a behavior (Hamilton and Johnson, 2020). Generally, *subjective norms* refer to an individual's perception of the social pressure surrounding behavioral performance (Ajzen, 1991). Subjective norms can be further delineated into descriptive and instrumental norms – similar to attitude types this distinction is not explicitly made by the TPB. *Descriptive norms* are an individual's perception of the behavior of others, whereas *injunctive norms* are an individual's perception of perceived pressure to engage in a behavior (Okun et al., 2002). *Perceived behavioral control* refers to an individual's assessment of how easy or difficult it would be to engage in a behavior (Ajzen, 1991). Finally, *intentions* reflect an individual's motivation to engage in a behavior (Ajzen, 1991). Intentions can vary in quality with higher quality intentions (e.g., intentions that are based on goals that are promotion versus prevention focused, autonomy versus control focused, and mastery versus performance focused) being more likely to lead to behavioral performance (Sheeran and Webb, 2016).

The TPB (Fishbein and Ajzen, 2011) has been criticized in part for not addressing the robustly observed intention-behavior gap (e.g., Sniehotta et al., 2014). Specifically, approximately 50% of intentions do not get translated into behavioral action (Sheeran and Webb, 2016). Perhaps unsurprisingly, meta-analyses of experimental studies have found that a medium-to-large change in manipulated intentions only leads to a small-to-medium change in behavior (Webb and Sheeran, 2006; Rhodes and Dickau, 2012). The intention-behavior gap is largely due to *inclined abstainers*, those who intend to change their behavior but fail to do so (Godin and Conner, 2008). Not acting on intentions can be due to barriers such as forgetting intentions, failing to engage in preparatory

TABLE 1 Theory of Planned Behavior predictions for positive health behaviors.

		Independent variable	Dependent variable	Mediator	Prediction
Direct effects					
	1	Attitude	Intention	–	Effect (+)
	2	Subjective norm	Intention	–	Effect (+)
	3	Perceived behavioral control	Intention	–	Effect (+)
	4	Intention	Behavior	–	Effect (+)
Mediated effects					
	1	Attitude	Behavior	Intention	Effect (+)
	2	Subjective norm	Behavior	Intention	Effect (+)
	3	Perceived behavioral control	Behavior	Intention	Effect (+)

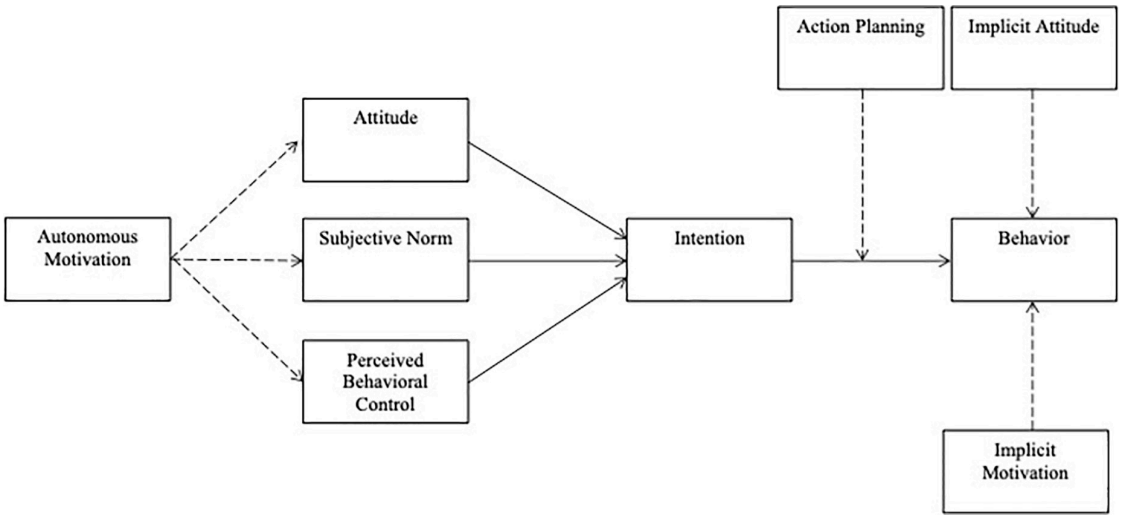

FIGURE 1
The theory of planned behavior and the integrated behavior change model. The Theory of Planned Behavior is represented by the solid lines only. The Integrated Behavior Change model is an extension of the Theory of Planned Behavior and encompasses the entirety of the figure.

behaviors, or missing behavioral opportunities (Sheeran and Webb, 2016). Considering this, forming if-then plans (i.e., action planning/implementation intentions) has been suggested as an effective means of reducing the intention-behavior gap. Specifically, a meta-analysis (Gollwitzer and Sheeran, 2006) found that action planning is strongly related to actual behavior (d = 0.65), and that this effect did not significantly differ based on study design (observational: d = 0.70; experimental: d = 0.65) or on the type of outcome measure (self-report: d = 0.63; objective: d = 0.67). Specifically, action plan formation predicted greater detection (d = 0.72) and attention (d = 0.72) to specified cues as well as behavioral opportunities for action.

The integrated behavior change model

The IBCM (Hagger and Chatzisarantis, 2014b) expands upon the TPB by including action planning as a moderator of the intention-behavior gap, by including automatic processes alongside reflective processes, and by introducing a humanistic approach with the inclusion of autonomous motivation derived from Self-Determination Theory. Specifically, the IBCM adds (1) autonomous motivation as a predictor of attitudes, subjective norms, and perceived behavioral control, (2) implicit attitudes and implicit motivation (automatic factors) as direct predictors of behavior, and (3) action planning as a moderator of the intention-behavior gap (**Figure 1**; Hagger and Chatzisarantis, 2014b). Preliminary support for this theory has been given with regard to both simple behaviors such as sunscreen use as well as more complex behaviors such as fruit and vegetable consumption (Hagger et al., 2017; Hamilton et al., 2017; Brown et al., 2018; Caudwell et al., 2019; Shannon et al., 2019). To date, the full IBCM has yet to be tested with physical activity or exercise as an outcome (although this extension was theoretically proposed in 2014 by Hagger and Chatzisarantis, 2014a). Preliminary observational studies using the IBCM have *not* supported the moderating effect of action planning on the relationship between intention and behavior. This is the

case for research examining sugar consumption, sun safety behaviors, and fruit and vegetable consumption (Hagger et al., 2017; Hamilton et al., 2017; Brown et al., 2018). That is, the intention-behavior gap has not been reduced by the inclusion of action planning in observational research using the IBCM as a guiding theory.

Preliminary findings have supported the direct relationships between autonomous motivation and attitudes, subjective norms, and perceived behavioral control regarding sugar consumption, fruit and vegetable consumption, pre-drinking behavior, sun safety behavior, and self-management of mental health (Hagger et al., 2017; Hamilton et al., 2017; Brown et al., 2018; Caudwell et al., 2019; Shannon et al., 2019). The mediated relationship between autonomous motivation and intentions through attitudes, subjective norms, and perceived behavioral control were also supported for sugar consumption, fruit and vegetable consumption, and sun safety behaviors (Hagger et al., 2017; Hamilton et al., 2017; Brown et al., 2018; Shannon et al., 2019). However, the relationship between autonomous motivation and pre-drinking intention was only mediated by attitudes (Caudwell et al., 2019). In addition, there were no significant indirect effects regarding self-management of mental health (Shannon et al., 2019).

Finally, findings on the utility of the addition of implicit attitudes and implicit motivation as direct predictors of behavior within the IBCM are sparse. First, a literature search revealed only one empirical test of implicit attitudes within the framework, which supports the direct relationship between implicit attitudes about sugar and actual sugar consumption (Hagger et al., 2017). Second, implicit motivation as a direct predictor of behavior – as suggested by Hagger and Chatzisarantis (2014b) – has not been included in any test of the IBCM to date.

Stage of change

The absence of a significant moderating effect of action planning in tests of the IBCM does not negate the important role of action planning in intention fulfillment with regard to both the observational and experimental literature (Gollwitzer and Sheeran, 2006). The mechanisms of behavioral engagement have been theorized to differ between individuals who are just starting a behavior (i.e., initiators) versus those who have been engaging in a behavior for some time (i.e., maintainers; Rothman, 2000; Rothman et al., 2009; Rhodes et al., 2021). Specifically, behavioral intention is thought to be a mechanism of initiation, and action planning is a means of action control to translate behavioral intention into behavior, which may be less relevant for maintainers (Rhodes et al., 2021). Previous tests of the IBCM for health outcomes do not recruit participants based on their stage of behavior change (Hagger et al., 2017; Hamilton et al., 2017; Brown et al., 2018; Caudwell et al., 2019; Shannon et al., 2019). Including participants from both the initiation and maintenance phase is a limitation and likely skews the direct linear effect of intentions on behavior as well as the moderating effect of action planning due to the shift to automatization of behavior when an individual has repeated behavioral experiences (Sheeran and Webb, 2016; Sheeran et al., 2017). Indeed, intentions have been shown to predict exercise behavior in initiators but not maintainers (Phillips et al., 2016). Additionally, other social cognitive models of health engagement have started to delineate the mechanisms of behavior for initiators versus maintainers (e.g., Health Action Process Approach, Schwarzer and Luszczynska, 2008; the Commonsense Model of Self-Regulation, Phillips et al., 2013).

Purpose of the present research

The purpose of the present research is twofold. First, the utility of the predictions made by the IBCM (**Figure 1**) – including automatic factors and moderation of the relationship between intention and behavior by action planning – will be compared between initiators and maintainers of physical activity. It was predicted that this model would fit better for initiators in comparison with maintainers. Second, prediction of physical activity behavior by the IBCM will be compared to prediction by its theoretical predecessor, the TPB, for initiators. This hypothesis was tested for initiators only as neither the TPB, nor the IBCM, includes constructs that have been proposed to be critical for maintenance (Rhodes et al., 2021).

Materials and methods

Participants and procedures

Participants were recruited from a Midwestern university in the United States and were eligible to participate if they were 18 years of age or older and participated in physical activity, at least sometimes. Non-exercisers were not eligible to participate in the present study, because they were not in the initiation or maintenance phase of behavior change. In addition to this, National Collegiate Athletic Association (NCAA) athletes were ineligible for participation because they have at least some of their exercise sessions scheduled by an external source. Participants reported their age, exercise stage of change, and NCAA status at pre-screen. A total of 21 participants were excluded at the pre-screen for not meeting the eligibility criteria. Eligible participants were directed to baseline and were asked to complete two weekly assessments of their exercise behavior at seven- and 14-days post-baseline. Participants were compensated with course credit. All procedures were approved by the institutional review board prior to data collection, and informed consent was collected from all participants via a

checkbox in the online baseline survey. Hypotheses and analyses were pre-registered on the Open Science Framework (https://osf.io/78fuh), study termination because of the announcement of the COVID-19 pandemic was also registered on the Open Science Framework (https://osf.io/4b7gf). It should be noted that the analysis type for the second hypothesis was updated after data collection to reflect a more appropriate methodology. Thus, the analysis of the second hypothesis should be considered exploratory in nature.

Measures

Pre-screen

Participants reported their age, gender, race, ethnicity, and NCAA membership. Additionally, participants reported their *stage of change* regarding exercise (Prochaska and Velicer, 1997). Participants were asked to 'Please tell us which option most closely fits you currently' (Note: 'Regular exercise' = 3 or more times per week for at least 30 min at moderate or greater intensity each time). Response options were: (1) 'I currently do not exercise and I do not intend to start', (2) 'I currently do not exercise, but I am thinking about starting', (3) 'I currently exercise some, but not regularly (regularly is 3x per week or more)', (4) 'I currently exercise regularly, but have only begun doing so within the past 6 months', and (5) 'I currently exercise regularly, and I have been doing so for longer than 6 months'. These options correspond to pre-contemplation, contemplation, preparation, action, and maintenance, respectively. Participants who were in the pre-contemplation or contemplation stages were not eligible for participation because they did not engage in exercise. Participants in the preparation or action stages of behavior change were classified as 'initiators', and participants in the maintenance phase were classified as 'maintainers'.

Baseline

Autonomous motivation was assessed using the Behavioral Regulation in Exercise Questionnaire – 3 (Markland and Tobin, 2004; Wilson et al., 2007). Three types of autonomous motivation were measured with four items each: (1) integrated (e.g., 'I exercise because it is consistent with my life goals'), (2) identified (e.g., 'It's important to me to exercise regularly'), and (3) intrinsic (e.g., 'I enjoy my exercise sessions').

Explicit attitudes were measured in terms of both instrumental and affective attitudes (Rhodes and Courneya, 2010). All items were preceded by the following stem: 'Over the next 2 weeks, engaging in physical activity on a regular basis would be. . .'. Affective attitudes were assessed using three items ranging from: (1) 'boring' to 'interesting', (2) 'unenjoyable' to 'enjoyable', and (3) 'stressful' to 'relaxing'. Instrumental attitudes were assessed using three items ranging from: (1) 'harmful' to 'beneficial', (2) 'useless' to 'useful', and (3) 'foolish' to 'wise'.

Subjective norms were measured in terms of both injunctive and descriptive norms (Rhodes and Courneya, 2010). Injunctive norms were measured using the following two items: (1) 'Most people in my social network want me to exercise regularly in the next 2 weeks', and (2) 'Most people in my social network would approve if I exercised regularly in the next 2 weeks'. Descriptive norms were measured using the following three items: (1) 'Most of my friends exercise regularly', (2) 'Most of my family members exercise regularly', and (3) 'Most of my college peers exercise regularly'. The third item was adapted from the original measure, which specified co-workers in lieu of college peers.

Perceived behavioral control was assessed using three items from Rhodes and Courneya (2010): (1) 'How confident are you that you will be able to exercise regularly in the next 2 weeks', (2) 'How confident are you over the next 2 weeks that you could overcome obstacles that prevent you from exercising regularly', and (3) 'I believe that I have the ability to regularly exercise in the next 2 weeks'.

Intention was measured using one item from Rhodes and Courneya (2010): 'Over the next 2 weeks, I intend to exercise _____times per week'.

Action planning was measured using four items from Sniehotta et al. (2005). Four items followed the stem: 'I have made a detailed plan regarding. . .'. Items were: (1) 'when to exercise', (2) 'where to exercise', (3) 'how to exercise', and (4) 'how often to exercise'.

Implicit attitudes and motivation were assessed using two Implicit Association Tests (IATs) created in the iatgen program (Carpenter et al., 2019). For the attitude IAT, stimuli from the categories 'good' (i.e., pleasure, enjoy, happy), 'bad' (i.e., pain, horrible, sadness), 'exercise' (i.e., active, fitness, workout), and 'sedentary' (i.e., inactive, seated, sitting) were used. Terminology used for the exercise and sedentary stimuli were adapted from Banting et al. (2009) to reflect neutral sedentary words – in lieu of words with negative connotations. This was done as even the most active individuals engage in sedentary behaviors, such as sitting down in lieu of standing, at least some of the time and over-engagement in sedentary behaviors poses risk even to individuals who exercise (e.g., Keadle et al., 2014). Thus, words like 'lazy' and 'sluggish' are likely not reflective of all sedentary behavior engagement. For the motivation IAT, stimuli were adapted from Keatley et al. (2014): self (i.e., me, myself), not self (i.e., it, that), autonomous motivation (i.e., choice, free, spontaneous, willing, authentic), and controlled motivation (i.e., pressured, restricted, forced, should, controlled). IAT order was randomized using a random number generator. Additionally, within IAT, left or right starting position was also randomized within each IAT. This is standard practice and implemented automatically by the iatgen program (Carpenter et al., 2019).

Two *random response checks* were administered at baseline to detect careless responding as this response pattern has been

shown to drastically alter effect sizes (Credé, 2010). Participants who failed either of these checks were excluded from all analyses ($n = 17$).

Weekly surveys

Physical activity behavior was measured at baseline and at each of the two weekly surveys using the International Physical Activity Questionnaire (Booth, 2000). Participants self-reported the number of minutes that they engaged in moderate and vigorous physical activity over the previous seven days. A composite score of moderate and vigorous physical activity was created for each timepoint. Weekly assessments were utilized if they were completed within 48 hours of administration and were emailed to participants at nine o'clock in the morning, with a follow-up email being administered 24 hours prior to the 48-hour deadline.

Statistical analyses

Power analysis for the proposed paths within the IBCM was conducted *a priori* using Monte Carlo simulations in Mplus, using $\alpha = 0.05$ and 1,000 bootstrapped samples (Muthén and Muthén, 2012).

Participants' implicit attitudes and motivation IATs were scored using the Greenwald et al. (2003) scoring algorithm through the iatgen shiny app program (Carpenter et al., 2019). This scoring resulted in a D-score, with higher scores indicating more positive implicit attitudes and more autonomous motivation and lower scores indicating less positive implicit attitudes and more controlled motivation.

Data were examined for multivariate outliers on all models, separately for initiators and maintainers using Mahalanobis distances ($p < 0.001$). Multivariate outliers were removed and the analysis reconducted until there were no outliers remaining. A multiverse approach (Steegen et al., 2016) was taken where the baseline data, week one data, and week two data were all analyzed with and without multivariate outliers. Main results are reported with the inclusion of multivariate outliers and baseline data. Deviations in results according to the multiverse approach are also reported.

Self-Determination Theory hypothesizes that motivation can vary in terms of autonomy. Therefore, a maximum likelihood exploratory factor analysis with an oblique rotation was used to determine whether all types of autonomous orientation (i.e., intrinsic, identified, and integrated) should be combined into one scale. Parallel analysis was used to determine the appropriate number of factors for extraction (Zwick and Velicer, 1986).

The first analysis, which compares the utility of the IBCM between initiators and maintainers, was conducted using multi-group recursive structural equation modeling in Mplus to test the relationships between both observed and latent variables (Muthén and Muthén, 2012). The second analysis, which compares the IBCM to its theoretical predecessor, the TPB, was analyzed using hierarchical linear regression to determine whether implicit motivation, implicit attitudes, action planning, and the interaction between action planning and intention add to the prediction of behavior above and beyond intention. This contrasts with the pre-registered analysis, which specified comparing the two theories using structural equation modeling. This pre-registered plan was deviated from because Mplus does not allow for comparing models with different observed variables (Mplus Discussion, 2008).

Results

Preliminary results

For the power analysis, as suggested by Muthén and Muthén (2002), path parameter estimates were obtained from a previous meta-analysis conducted by Hagger and Chatzisarantis (2014a). However, implicit attitudes, implicit motivation, and action planning were not assessed in the meta-analytic study, and therefore β (standardized beta coefficients) values for the relationship between these variables and behavior were estimated using a sensitivity analysis from previous tests of the IBCM in terms of both weakest and strongest reported values (i.e., Hagger et al., 2017; Hamilton et al., 2017; Brown et al., 2018; Caudwell et al., 2019; Shannon et al., 2019). Parameter estimates were expressed as (β) to account for shared variance between a set of predictors with a given outcome variable with residual variance being calculated using the formula: $1 - \Sigma(\beta^2)$. The primary power analysis suggested that 300 initiators and 300 maintainers were needed to be sufficiently powered across paths, however, due to the COVID-19 pandemic, data collection was terminated early as lockdown resulted in many participants leaving the area and having their routines disrupted. Online data collection after this point was deemed not feasible as the measured variables and the relationships between them would almost certainly have been affected by the pandemic. An updated power analysis for the IBCM for 287 initiators and 207 maintainers was conducted. For initiators, the observed power was as follows: (1) autonomous motivation and attitude, 100%, (2) autonomous motivation and subjective norms, 65.1%, (3) autonomous motivation and perceived behavioral control, 100%, (4) attitude and intention, 100%, (5) subjective norm and intention, 22.3%, (6) perceived behavioral control and intention, 98.9%, (7) intention and behavior, 66.1–96.9%, (8) implicit attitudes and behavior 47.7–97.1%, (9) implicit motivation and behavior, 46.5–96.2%, (10) action planning and behavior, 12.3–99.6%, and (11) action planning*intention and behavior, 14.5–67.9%. For maintainers, the observed power was: (1) autonomous motivation and attitude, 100%, (2) autonomous motivation and subjective norms, 52.8%, (3) autonomous motivation and perceived behavioral control 99.9%, (4) attitude

and intention, 100%, (5) subjective norms and intention, 18.4%, (6) perceived behavioral control and intention, 96.1%, (7) intention and behavior, 52.2–93.8%, (8) implicit attitudes and behavior, 36.9–89.3%, (9) implicit motivation and behavior, 35.4 and 89.1%, (10) action planning and behavior, 10.9–97.4%, and (11) action planning*intention and behavior, 10.3–53.7%.

A total of 17 participants were excluded from data analysis because they failed at least one of two random response checks at baseline leaving a total of 494 participants (i.e., 287 initiators and 207 maintainers). Participants were 19.31 years of age on average ($SD = 1.77$), and most participants self-identified as female using she/her pronouns (54.7%). Most participants also self-identified as Caucasian (86%). For the weekly data, 339 participants completed the first survey and 323 completed the second survey. Maintainers engaged in more moderate and vigorous physical activity in comparison to initiators, at baseline [$t(473) = -3.70$, $p < 0.001$], week one [$t(353) = -4.08$, $p < 0.001$], and week two [$t(336) = -3.43$, $p = 0.001$]. Additionally, maintainers ($M_{months} = 28.79$, $SE = 0.58$) had been engaging in regular exercise significantly longer than initiators ($M_{months} = 5.67$, $SE = 2.05$; [$t(474) = -12.67$, $p = < 0.001$]).

Missing data was relatively sparse as the survey reminded (but did not force) participants to respond to unanswered questions. For predictor variables, there was only one missing item for injunctive subjective norms. For the outcome variable of exercise there were 19 cases of missing data at baseline, eight cases for week one, one case for week two. Missing data represented at least 50% of each scale. Therefore, multiple imputation was not conducted as the proportion of missing data was too large to impute (Garson, 2015).

A maximum likelihood exploratory factor analysis with an oblique rotation – allowing for factors to be correlated – was conducted to determine whether all autonomous motivation types should be combined into one factor. A parallel analysis (Zwick and Velicer, 1986) revealed that it was appropriate to extract two factors. Both factors also met the eigenvalue greater than one threshold (i.e., Factor 1 = 6.09; Factor 2 = 1.28). The first factor accounted for 50.73% of the total variance and was made up of the items from the integrated and identified subscales of the BREQ-3 (**Table 2**). The second factor explained 10.69% of the total variance and was made up of the items from the intrinsic motivation scale. Due to intrinsic motivation being the most prototypical form of autonomous motivation, and the fact that it loaded separately from both identified and integrated motivation types, it was used as the measure for motivation in hypothesis 1.

For hypothesis 1, multivariate outliers were removed separately for initiators and maintainers as these groups were analyzed separately and have been shown to differ on mechanisms of behavior in past research (Phillips et al., 2016). For the relationship between the predictor intrinsic motivation and the outcomes of perceived behavioral control, explicit attitudes, and descriptive subjective norms, there was one multivariate outlier for initiators and no multivariate outliers for maintainers exceeding the critical value of 18.47 ($p < 0.001$). For the relationship of intentions being predicted by perceived behavioral control, explicit attitudes, and descriptive subjective norms, there were six multivariate outliers for both initiators and maintainers exceeding the critical value of 18.47 ($p < 0.001$). For the relationship between intention and action planning, there were three multivariate outliers for initiators and no multivariate outliers for maintainers exceeding the critical value of 13.82 ($p < 0.001$). Finally, for the prediction of exercise behavior from intention, action planning, implicit attitudes, and implicit motivation, the multivariate analysis was as follows (critical value: 20.52, $p < 0.001$): (1) with baseline exercise as the outcome, there were eight initiators and two maintainers with outlying values, (2) with week one exercise as the outcome, there were three initiators and four maintainers with outlying values, and (3) with week two exercise as the outcome, there were three initiators and four maintainers with outlying values.

For hypothesis 2, multivariate outliers were assessed at the critical value of 20.52 ($p < 0.001$) for behavior, intention, action planning, implicit attitude, and implicit motivation. Unlike hypothesis 1, this was done without the removal of outliers for preceding relationships in the IBCM. Multivariate outliers were as follows: baseline had 13 outliers, week one had seven outliers, and week two had six outliers.

TABLE 2 Exploratory Factor Analysis (EFA) pattern matrix.

Item	Factor 1 loading	Factor 2 loading
Integrated: I consider exercise a fundamental part of who I am	1.04	
Integrated: I consider exercise part of my identity	0.991	
Integrated: I consider exercise consistent with my values	0.623	
Identified: It's important for me to exercise regularly	0.516	
Integrated: I exercise because it is consistent with my life goals	0.499	
Identified: I get restless if I don't exercise regularly	0.436	
Intrinsic: I enjoy my exercise sessions		0.906
Intrinsic: I find exercising a pleasurable activity		0.876
Intrinsic: I exercise because it's fun		0.717
Intrinsic: I get pleasure and satisfaction from participating in exercise		0.632

Items with cross loadings ≤ 0.2 were not included in the model.

Hypothesis 1

Measurement model

The first hypothesis, that the IBCM would more accurately reflect the antecedents of physical activity for initiators in comparison with maintainers was first assessed by examining the measurement model (i.e., CFA) and recursive structural equation modeling in initiators only. The measurement model was conducted between the latent variables and their indicators (i.e., all variables except for intention, implicit attitudes and motivation, and behavior; Kline, 2005; Hoyle, 2012). In this model, the latent factor of attitudes was composed of both affective and instrumental attitudes and the latent factor of subjective norms consisted of both injunctive and descriptive norm indicators (Rhodes and Courneya, 2010). This model was not a good fit for the data [RMSEA = 0.09, CFI = 0.83, TLI = 0.80, χ^2 (199) = 615.18, $p < 0.001$]. Although all factor indices significantly loaded onto their latent factor ($p < 0.001$), instrumental attitudes represented points of ill fit on the latent factor of attitudes (Hoyle, 2012). Specifically, all R^2 values were equal to or lower than 0.32 (i.e., 0.21 – 0.32). Additionally, injunctive norms represented points of ill fit with the latent factor of subjective norms with all R^2 values being equal to or below 0.20 (i.e., 0.09 – 0.20). Both instrumental attitudes and injunctive norm items explained less variance in their latent variables than either affective attitudes (R^2 = 0.34 – 0.62) or descriptive norms (R^2 = 0.08 – 0.84). Additionally, instrumental attitudes (R^2 = 0.68 – 0.79) and injunctive norms (R^2 = 0.80 – 0.91) had higher levels of residual item variance compared to affective attitudes (R^2 = 0.28 – 0.66) and descriptive norms (R^2 = 0.17 – 0.93), respectively. Thus, a second measurement model without the inclusion of instrumental attitude and injunctive norm items was conducted and fit the data well [RMSEA = 0.04, CFI = 0.99, TLI = 0.96, $\chi^2(109)$ = 169.49, $p < 0.001$]. It should be noted that within this model the first descriptive norm item was a poor indicator of the latent construct of subjective norms (factor loading: 0.27, residual variance: 0.93, R^2 = 0.07). However, this item was retained as it is part of a validated scale and the removal of the item did not improve the overall model fit [RMSEA = 0.05, CFI = 0.97, TLI = 0.96, $\chi^2(95)$ = 156.78, $p < 0.001$].

A structural model was computed to determine whether action planning significantly moderated the intention behavior gap, as the analysis type in Mplus that allows for specification of interactions between latent and observed variables does not provide indices of model fit, which are necessary to compare models (Muthén, 2009). Results indicated that action planning did not moderate the intention behavior gap (p = 0.28). Considering this, the interaction term was removed from the model and hypothesis 1 was conducted using the type 'general', which allows for indices of model fit. Thus, action planning was instead specified as a variable linking intention and behavior, which has been done in previous structural equation modeling assessments of the IBCM (e.g., Hagger et al., 2017).

Structural equation model in initiators

Prior to comparing the IBCM between initiators and maintainers, the utility of this model in initiators only was established. Data is presented with the inclusion of multivariate outliers and with baseline physical activity data (RMSEA = 0.04, CFI = 0.95, TLI = 0.94).

Intrinsic motivation predicted perceived behavioral control (β = 0.26, SE = 0.07, $p < 0.001$) and affective attitude (β = 0.72, SE = 0.04, $p < 0.001$), but did not predict descriptive subjective norms (β = 0.11, SE = 0.06, p = 0.093). Second, perceived behavioral control (β = 0.18, SE = 0.06, p = 0.004), affective attitude (β = 0.24, SE = 0.06, $p < 0.001$), and descriptive subjective norms (β = 0.17, SE = 0.06, p = 0.003) all predicted intention to engage in physical activity, with affective attitudes being the strongest predictor. Intention predicted both action planning (β = 0.32, SE = 0.06, $p < 0.001$) and behavior (β = 0.15, SE = 0.06, p = 0.019). Action planning (β = 0.11, SE = 0.08, p = 0.115), implicit attitudes (β = 0.04, SE = 0.07, p = 0.549), and implicit motivation (β = −0.07, SE = 0.07, p = 0.289) did not predict behavior. All significant findings were consistent with the hypothesized direction (**Table 3**).

The multiverse analyses revealed several deviations from the main results. First, the relationship between intentions and behavior was non-significant, concerning week one exercise, when outliers were included. When outliers were excluded, the relationship between intention and behavior was significant in all models, except for the week 2 data, in which the data was not interpretable due to poor model fit. Thus, the relationship between intention and behavior was significant in four of the five interpretable models. Additionally, in the data with the removal of multivariate outliers, the relationship between descriptive subjective norms and intentions was non-significant in all interpretable models (i.e., except for week 2, which had poor model fit). Thus, the relationship between descriptive subjective norms and intention was significant in three of the five interpretable models. No other paths varied across the multiverse analysis in terms of either significance or directionality of the effect.

Comparison between initiators and maintainers

Hypothesis 1, that the IBCM would more accurately reflect the antecedents of behavior for initiators in comparison with maintainers, was first assessed by comparing the equivalence of the measurement model with fixed factor loadings with the measurement model with free factor loadings to assess metric invariance, which is a pre-requisite of multi-group structural equation modeling. The measurement model with

TABLE 3 Integrated Behavior Change Model predictions for positive health behaviors.

		Independent variable	Dependent variable	Mediator	Moderator	Prediction
Direct effects						
	1	Autonomous motivation	Attitude			Effect (+)
	2	Autonomous motivation	Subjective norm			Effect (+)
	3	Autonomous motivation	Perceived behavioral control			Effect (+)
	4	Attitude	Intention			Effect (+)
	5	Subjective norm	Intention			Effect (+)
	6	Perceived behavioral control	Intention			Effect (+)
	7	Intention	Behavior			Effect (+)
	8	Implicit attitude	Behavior			Effect (+)
	9	Implicit motivation	Behavior			Effect (+)
Mediated effects						
	1	Autonomous motivation	Intention	Attitude		Effect (+)
	2	Autonomous motivation	Intention	Subjective norm		Effect (+)
	3	Autonomous motivation	Intention	Perceived behavioral control		Effect (+)
	4	Attitude	Behavior	Intention		Effect (+)
	5	Subjective norm	Behavior	Intention		Effect (+)
	6	Perceived behavioral control	Behavior	Intention		Effect (+)
Moderator effects						
	1	Intention	Behavior		Action planning	Effect (+)

fixed factor loadings for initiators and maintainers fit the data well [RMSEA = 0.05, CFI = 0.94, TLI = 0.94, $\chi^2(242) = 417.77$, $p < 0.001$]. The model that allowed free factor loadings for initiators and maintainers fit the data similarly well [RMSEA = 0.05, CFI = 0.95, TLI = 0.95, $\chi^2(230) = 3328.17$, $p < 0.001$]. The criteria of metric invariance were satisfied as the RMSEA values not differ substantially between models (Cheng and Rensvold, 2002). Specifically, The RMSEA values fit within each other's confidence intervals (Fixed: 95% CI [0.045,0.063], Free: 95% CI [0.042,0.061]).

The model fit was assessed by comparing the model where factor loadings were fixed between initiators and maintainers, but paths were able to vary (i.e., unconstrained model), and a model where both factor loadings and path and mean parameters were fixed (i.e., constrained model). Across the six multiverse iterations, the unconstrained model fit better than the constrained model in five of the iterations. The unconstrained model was not supported in terms of baseline exercise when multivariate outliers were included. The overarching robustness of these results supports the notion that model paths and mean parameters are significantly different between initiators and maintainers.

Overall, across the five iterations of the multiverse analysis results were as follows (**Figure 2**): (1) intrinsic motivation predicted perceived behavioral control in five models for initiators and none of the models for maintainers, (2) intrinsic motivation predicted affective attitudes in five models for initiators and five models for maintainers, (3) intrinsic motivation predicted descriptive subjective norms in none of the models for initiators or for maintainers, (4) perceived behavioral control predicted intention in five models for initiators and none of the models for maintainers, (5) affective attitudes predicted intention in five models for initiators and five models for maintainers, (6) descriptive subjective norms predicted intention in two models for initiators and none of the models for maintainers, (7) intention predicted action planning in five models for initiators and none of the models for maintainers, (8) action planning predicted behavior in none of the models for initiators or for maintainers, (9) intention predicted behavior in four models for initiators and three models for maintainers, (10) implicit motivation predicted behavior in none of the models for initiators or for maintainers, and (11) implicit attitudes predicted behavior in none of the models for initiators and one model for maintainers. All significant paths were in the expected direction for initiators and maintainers (**Table 3**), except for the significant relationship between implicit attitude and behavior for maintainers in which worse attitudes resulted in more behavioral engagement with the week two data with the inclusion of multivariate outliers. Overall, these results further highlight how the IBCM is supported more for initiators in comparison with maintainers. However, there were no unique proximal predictors of behavior for initiators in comparison with maintainers overall.

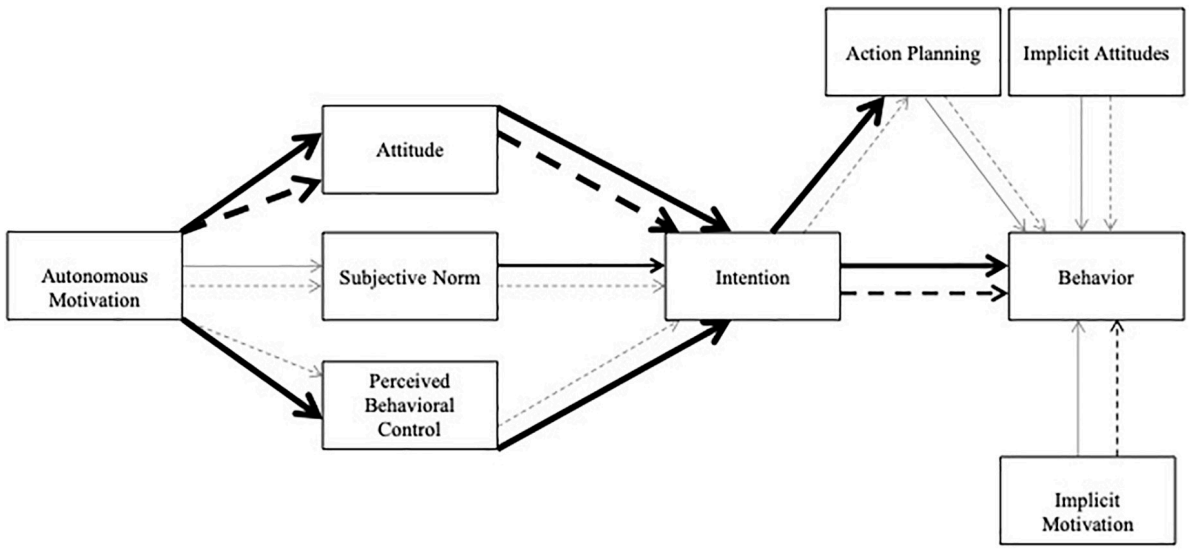

FIGURE 2
Supported paths across multiverse analysis for the Integrated Behavior Change Model weighted by level of support. Initiators are represented by the solid lines only. Maintainers are represented by dashed lines only. Thicker lines indicate support across more multiverse iterations than thinner lines.

Hypothesis 2

The second hypothesis, that the IBCM would add unique direct predictors of behavior above and beyond the TPB, was assessed using linear regression. In all models, moderate and vigorous exercise behavior was the outcome (i.e., baseline, week one, or week two). Intention was entered into the first block, action planning, implicit attitude, and implicit motivation were entered into the second block, and the interaction between intention and action planning was entered into the third block. Intention accounted for 3.1% (Adjusted $R^2 = 0.031$, $p = 0.003$) of the variance in behavior and was a significant predictor of behavior ($\beta = 0.19$, $SE = 14.59$, $t = 3.03$ $p = 0.003$). The addition of action planning, implicit attitudes, and implicit motivation accounted for an additional 0.3% (ΔR^2 change) of the variance in behavior above and beyond intention (Adjusted $R^2 = 0.034$, $p = 0.012$). Only intention significantly predicted behavior ($\beta = 0.16$, $SE = 15.17$, $t = 2.46$, $p = 0.015$). Action planning ($\beta = 0.11$, $SE = 32.56$, $t = 1.66$, $p = 0.097$), implicit attitudes ($\beta = 0.04$, $SE = 43.09$, $t = 0.61$, $p = 0.545$), and implicit motivation ($\beta = -0.07$, $SE = 62.81$, $t = -1.07$, $p = 0.285$) did not significantly predict behavior. The addition of the interaction between intention and action planning in step three accounted for no additional variance in exercise behavior (Adjusted $R^2 = 0.034$, $p = 0.017$). When the interaction term was included, none of the variables significantly predicted behavior: intention ($\beta = -0.22$, $SE = 89.42$, $t = -0.57$, $p = 0.567$), action planning ($\beta = -0.04$, $SE = 81.98$, $t = -0.26$, $p = 0.793$), implicit attitudes ($\beta = 0.04$, $SE = 71.29$, $t = 0.54$, $p = 0.588$), implicit motivation ($\beta = -0.07$, $SE = 62.81$, $t = -1.08$, $p = 0.280$), and the interaction between intention and action planning ($\beta = 0.45$, $SE = 22.11$, $t = 1.01$, $p = 0.316$). In the analysis utilizing the week 1 data with multivariate outliers included, intention was no longer significant at the second step. Otherwise, results were consistent across the entirety of the multiverse analysis in terms of significant predictors. Overall, these results highlight that the additional proximal predictors in the IBCM did not predict behavior better than intentions in the current data.

Discussion

Behavioral theories have largely taken a social cognitive approach specifying intention as a proximal predictor of behavior, including only reflective constructs, thereby neglecting to include the influence of automatic processes, and have specified an invariant theory of behavior across different stages of behavior change such as initiation and maintenance. This is problematic as the intention-behavior gap is a well-observed phenomenon (e.g., Sheeran and Webb, 2016), focusing only on reflective factors, such as attitudes, ignores the influence that automatic processes have on behavior (Rebar et al., 2016), and predictors of behavior are known to differ between initiators and maintainers (Phillips et al., 2016). The overarching purpose of this study was twofold. First, the present research compared, two theories of health behavior change – for exercise initiators and maintainers – which are rooted in the link between intentions and behavior: the IBCM (Hagger and Chatzisarantis, 2014b) and its theoretical predecessor, the TPB (Fishbein and Ajzen,

2011). Second, this research compared the utility of the IBCM for predicting behavior against the TPB for initiators.

In this first known test of the IBCM for physical activity (Hagger and Chatzisarantis, 2014b), the utility of the IBCM was supported for people who were just beginning their exercise journey (i.e., initiators), and was more highly supported for initiators in comparison with maintainers. However, the IBCM did not add any unique contribution to the direct prediction of behavior in comparison with the TPB for initiators. That is, action planning, the interaction between action planning and intention, implicit attitudes, and implicit motivation did not predict behavior. This is in line with previous tests of the IBCM for other health behaviors (i.e., action planning: Hagger et al., 2017; Hamilton et al., 2017; Brown et al., 2018). Action planning has been shown to be a viable target to elicit behavior change in past intervention studies and is one of the only known techniques that leads to continued activity engagement six months post-intervention (Gollwitzer and Sheeran, 2006; Howlett et al., 2019). The lack of significant results concerning action planning in present and past tests of the IBCM may be due to the variability in the quality of plans (e.g., I will exercise on Fridays, versus I will exercise after work on Fridays; de Vet et al., 2011). The quality of plans may be especially problematic when made without the guidance provided by an intervention.

Neither implicit attitudes nor implicit motivation predicted physical activity. To that end, it is possible that implicit attitudes and motivation are not powerful targets for an intervention due to their null or small influence on behavior. This is likely to be especially true for implicit motivation, which is a trait-like tendency underpinning why one performs behaviors that is likely resistant to change. It should be noted that past research has intervened upon implicit attitudes with success in changing health behaviors (i.e., alcohol consumption, healthy eating practices) over a short period of time (Houben et al., 2010; Hollands et al., 2011). More research will be needed to test the viability of targeting implicit attitudes for sustained behavioral changes.

In contrast to the TPB, the IBCM adds autonomous motivation as a new distal target of intention formation. In the present study, this was supported through the mechanisms of perceived behavioral control and affective attitudes. However, greater theoretical development and empirical evaluation is needed regarding the causal relationships between motivation and other antecedents of behavior; namely, for physically taxing behaviors, like physical activity engagement, it is unlikely that initial engagement is 'enjoyable' or 'fun', especially for individuals who do not already have good cardiorespiratory fitness (Rhodes, 2017). Indeed, previous research has found that physical fatigue both during and after physical activity sessions is one of the most frequently reported barriers to engagement (Ebben and Brudzynski, 2008). Moreover, reasons for starting activity engagement are vast and extend beyond enjoyment—for example improving one's physical appearance has been shown to be the most highly ranked reason across the lifespan (Gavin et al., 2014). Thus, the most autonomous form of motivation (i.e., intrinsic) in and of itself may not be a viable target in terms of changing intentions and subsequent behavior for most individuals as it likely does not reflect their pre-existing goals. Additionally, because feeling competent is a theoretical precursor of the development of fully autonomous or intrinsic motivation in Self-Determination Theory (Ryan and Deci, 2000), it is unlikely that fully autonomous motivation would precede perceived behavioral control as feeling competent requires behavioral practice. However, it should be noted that the causal link between autonomous motivation and attitudes, social norms, and perceived behavioral control as specified in the IBCM may be more theoretically appropriate when considering partially controlled motivations such as identified motivation (i.e., valuing the outcomes of a behavior).

Additionally, it is important to note that although the IBCM hypothesizes that action planning moderates the intention behavior gap, a recent systematic review has shown that many psychosocial variables are potentially important moderators of this relationship (Rhodes et al., 2022). These include demographic variables (e.g., employment), personality variables (e.g., conscientiousness), and automatic factors (e.g., identity). Moreover, another recent systematic review has shown that unpleasant experiences while engaging in physical activity may reduce participation for people with chronic illnesses that are related to increased pain and fatigue (Collado-Mateo et al., 2021). Thus, the TPB and IBCM likely need to be extended to include other moderators of the intention-behavior gap. These moderators may serve to not only identify who is at risk of not fulfilling their physical activity intentions (e.g., based on demographic factors, personality factors, and/or chronic illness status), but also propose mechanisms of maintenance – such as identity (Rhodes et al., 2016) – within traditional social cognitive frameworks.

The present study is not without limitations. First, the desired sample size was not collected due to the restrictions that were placed on data collection by the COVID-19 pandemic. Continuing data collection during the pandemic was deemed inappropriate given the contextual shifts that occurred, which had the capacity to undermine exercise behaviors. In support of this, 30% of individuals surveyed in the United States reported that they exercised less than usual during April of 2020 (Gough, 2020). Second, participants in the present study were college students who are unlikely to be representative of the general population (Peterson, 2001; Henrich et al., 2010). However, it is still important to understand the mechanisms of physical activity initiation and maintenance in students as approximately half of American college students are not sufficiently active (Keating et al., 2005). Third, the current study artificially dichotomized individuals based on their score on a stage of change measure and in accordance with the Transtheoretical Model, which may have resulted in range

restriction (Prochaska and DiClemente, 1982; Sackett et al., 2007). In the current study, 'maintainers' engaged in more physical activity per week and had been engaging in physical activity for more months than 'initiators', which provides at least some evidence that these groups were different with regard to their behavior. Fourth, the current research, similar to past studies using the IBCM as a guiding framework, was observational. Therefore, causal inferences cannot be made from the results based on the present data as it can only be concluded whether variables were related. Finally, IATs were used to measure implicit attitudes and motivation. Although IATs are commonly used to measure implicit constructs (e.g., Project Implicit hosted by Harvard University), including in previous tests of the IBCM, they are also known to have several limitations. Specifically, the use of difference scores is psychometrically problematic as they are subject to higher type 1 error rates than non-difference scoring procedures (Edwards, 2001; Cafri et al., 2010). Additionally, previous research has highlighted that IAT scores tend to be weak predictors of behavior, which could be due to the measurement procedure itself or the scoring procedure as outlined above (Oswald et al., 2013). Moreover, traditional IATs cannot provide the refinement of measuring types of attitudes or motivation toward an activity beyond a mere dichotomy. Previous research using a single category IAT has assessed instrumental and affective attitudes toward activity behaviors (Phipps et al., 2021) and has found that implicit affective attitudes significantly predict physical activity, whereas implicit instrumental attitudes do not. Thus, it is possible that the IAT used in the present study was not sensitive enough and that future research using the IBCM should delineate the implicit constructs further. However, other research has provided evidence that IAT scores are more reliable than other implicit measures in terms of both test-retest and split-half reliability (Nosek et al., 2007; Znanewitz et al., 2018). Additionally, IAT scores also have been shown to have both convergent and divergent validity using multi-trait, multi-method matrices (Nosek and Smyth, 2007; Nosek et al., 2007).

There is a need for researchers to continue to refine and develop theories of behavior change to specify viable intervention targets for initiators, including automatic targets, and for including a maintenance phase of behavior change where appropriate targets are specified (Sheeran and Webb, 2016; Rothman, 2000). The IBCM is an attempt to improve the toolbox of targets for behavior change to include automatic processes, action planning, and autonomous motivation (Hagger and Chatzisarantis, 2014b). However, in the present study it was found that the IBCM did not improve upon its theoretical predecessor – the TPB (Fishbein and Ajzen, 2011). That is, the IBCM does not add any unique proximal predictors of behavior. Additional theories, such as the Health Action Process Approach, which also includes action planning, will need to be assessed as it already delineates initiation from maintenance (Schwarzer, 2016). However, dual-phase theories, including the Health Action Process Approach, will need to be extended to include automatic mechanisms of maintenance (e.g., habit) in addition to the reflective determinants that are already included. Moreover, research should assess whether automatic determinants of initiation add a unique contribution to behavior. However, it should be noted that in the present study automatic determinants of initiation did not contribute to the variance predicted in behavior.

The purpose of the present study was twofold. First, the present research compared, two theories of health behavior change – for exercise initiators and maintainers – which are rooted in the link between intentions and behavior: the IBCM (Hagger and Chatzisarantis, 2014b) and its theoretical predecessor, the TPB (Fishbein and Ajzen, 2011). Second, this research compared the utility of the IBCM for predicting behavior against the TPB for initiators. Although there are important limitations that need to be considered when interpreting the results, the present study highlights some important considerations for the field of behavior change. First, the mechanisms of behavioral engagement differed between initiators and maintainers. This is not the first study to support this delineation (e.g., Phillips et al., 2016), nor is it likely to be the last. Theories such as the TPB and IBCM need to specify these differences using a dual-phase approach to allow for more precise behavioral prediction, but also to include appropriate intervention targets depending on stage of change. Second, the present study suggests that the TPB should be preferred over the IBCM, because it is more parsimonious. Although the IBCM adds action planning, a known technique to promote behavioral engagement, this is not a unique contribution in and of itself given that action planning has been added to the TPB by others as a method of reducing the intention-behavior gap (e.g., Norman and Conner, 2005). However, since interventions based on the TPB and other social cognitive frameworks – with the exclusion of the more recently added action planning – have been shown to be sub-optimal in terms of behavior change (e.g., Kinmonth et al., 2008; Sniehotta, 2009), it is of the utmost importance that theory refinement and development continues.

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 human participants were reviewed and approved by Iowa State University Office of Research Ethics.

The participants provided their written informed consent to participate in this study.

Author contributions

KM and LP contributed to the conceptualization, design of the study, and writing of the manuscript. KM organized the dataset and performed the analyses. Both authors contributed to manuscript revision and approved the current version.

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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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Examining the role of affective states in relation to exercise intentions and participation in extra-curricular exercise classes at university: A repeated measurement observational study

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Background: Previous research has shown evidence on the role of affective states for physical activity behavior. However, there is a lack of research investigating the interplay between affective states, intentions, and exercise behavior, especially with respect to maintaining regular exercise over time. The study aimed to investigate whether post-exercise affective states and changes in affect during exercise (i) are related to exercise intentions; (ii) moderate the relationship between intention and subsequent exercise behavior, and (iii) directly predict future exercise.

Methods: Participants from weekly voluntary sports and gym classes at two universities were recruited. For 13weeks, 268 individuals' (M_{age}=24.5years, SD=5.6, 90% students, 67.4% female) class attendance was documented on a weekly basis. Before and immediately after training, participants self-reported affective states, including affective valence (Feeling Scale) and perceived arousal (Felt Arousal Scale). Participants also reported their intention to re-attend the class the following week. Mixed-effect linear models and Cox proportional hazard models were used to examine the relationships between affective states, change in affective states, re-attendance intentions, and class re-attention.

Results: Affective valence at the end of training was significantly positively associated with the intention to re-attend the class on the within-person level (β=0.880, p<0.001) as well as the between-person level (β=0.831, p<0.001), while higher increases of valence during class were related to smaller intention. For class re-attendance, significant effects of affective states were only found on the within-person level. A one-point increase on the valence scale increased the hazard ratio to re-attend by 8.4% (p<0.05), but this effect

was no longer meaningful after adjusting for intention. No moderation of the relationship between intention and subsequent class re-attendance was found.

Conclusion: The results suggest that positive affective state immediately after exercise does not facilitate translation of intentions into subsequent exercise behavior (i.e., do not close the intention-behavior gap). Rather, affective valence was found to be an important predictor of exercise intentions but seemed indirectly related to behavior *via* intentions. Practitioners should plan exercise programs that allow for positive affective states especially at the end of a training.

KEYWORDS

exercise, core affect, affective states, affective valence, intention, behavior

Introduction

Numerous studies have shown evidence for the positive associations between physical activity (PA) and health, such as a reduced risk for breast and colorectal cancer, coronary heart disease, cardiovascular disease, and overall mortality (Lee et al., 2012; Reiner et al., 2013; Warburton and Bredin, 2017). Sustainable health improvements can only be achieved by regularly accumulating the recommended amount of PA (Haskell et al., 2007; Powell et al., 2011). However, only 22.6% of adults in Germany meet the recommendations for aerobic and muscle strengthening PA (Finger et al., 2017; World Health Organization, 2020). Moreover, maintaining regular participation in PA seems to be difficult for many people, as has been shown through high rates of relapsing into lower activity levels within months or even weeks after having started to exercise (Annesi, 2003; Finne et al., 2019).

If the objective of engaging in structured PA is the improvement or maintenance of at least one component of physical fitness, it is defined as exercise (Caspersen et al., 1985). In past health behavior and exercise research, social-cognitive approaches were the predominant explanations of behavior and behavior change (Jekauc et al., 2015; Rhodes et al., 2019). A central social-cognitive construct is intention, which plays a crucial role, for example, in the widely used Theory of Planned Behavior (TPB; Ajzen, 1991). Intention is described as representing a person's motivation and behavioral orientation toward a behavior (Hagger et al., 2002). Intention is a necessary prerequisite of PA adoption, as almost nobody reports PA implementation without intention (Rhodes and Bruijn, 2013), and intention has been shown to be an important predictor of PA behavior (McEachan et al., 2011; Rhodes and Bruijn, 2013).

However, intentions leave a large part of behavioral variance unexplained. For example, a meta-analysis showed that only 42% of people translate PA intentions into PA behavior, 36% do not engage in PA although they intend to do so, while the rest expressed no intention (Rhodes and Bruijn, 2013). This discrepancy between behavioral intention and actual behavioral implementation is often described as intention-behavior gap. Whether intentions are implemented or not may also depend on additional psychological factors moderating the intention-behavior relationship (Sniehotta et al., 2005). In that sense, social-cognitive approaches have been increasingly criticized for focusing on rational decision making and disregarding non-reflective processes of motivation and behavior regulation, such as affective processes (Sniehotta et al., 2014; Hagger, 2016; Rebar et al., 2016).

Affect plays a central role in several current theoretical models of physical activity that take a dual process approach (Brand and Ekkekakis, 2018; Stevens et al., 2020; Strobach et al., 2020). These state that PA behavior is regulated by a reflective pathway mediated by higher cognitive processes as well as by an implicit and automatic pathway in which processes are mainly executed unconsciously.

According to the feedback theory of Baumeister et al. (2007), automatic affect can be understood as a simple and quick valuation of the situation, that something is pleasant or unpleasant. This is expressed in a feeling that is not reflective and suggests to us that the situation is good or bad, liking or disliking, to be approached or to be avoided. Although affect is seen as an automatic response, it contains a cognitive component, and the resulting feeling can be conscious. In this conception, "automatic affective responses can preserve the lessons and information from previous emotional experiences" (Baumeister et al., 2007, p. 172). This previous affective experience contributes to the anticipation of an affective state of a future event and influences the decision about future behavior (see in the context of physical activity, Feil et al., 2022). As similar concept, in the circumplex model of affect, the mental structure of core affect can be reflected by the two dimensions valence (pleasure vs. displeasure) and activation (high vs. low arousal; Russell, 1980, 2003). With its evaluative and reinforcing role, valence is considered the relevant affect dimension for influencing future behavior (Baumeister et al., 2007; Stevens et al., 2020). Valence is seen as the most basic building block of emotional life and might be a strong catalyzer

Abbreviations: PA, Physical activity; HR, Hazard ratio.

for motivational processes (Barrett, 2006). The dimension of affective arousal on the other hand is seen as orthogonal dimension without a hedonic value. Therefore, arousal is expected to show minor importance as input for motivational effects compared to valence. There are indications, however, that arousal impacts attention and memory processes (Storbeck and Clore, 2008).

Affective states during the execution of a behavior or immediately after its completion are termed "affective response" within the Affect and Health Behavior framework (Williams and Evans, 2014; Stevens et al., 2020). According to this framework, affective responses are cognitively processed both automatically (non-reflective) and reflectively, resulting in affectively charged forms of motivation (non-reflective) on the one hand and behavioral intentions and goals (reflective) on the other hand. Thus, affect may directly influence subsequent behavior *via* the implicit pathway, or indirectly by informing reflective processes, leading to intentions in terms of future behavior.

The role of affective states within the dual process approach is also addressed by the Physical Activity Adoption and Maintenance (PAAM) model (Strobach et al., 2020). The authors assume an additional moderating effect of affective states on the relationship between intention and physical activity. It is hypothesized that intentions are more easily translated into action when accompanied by positive affective states (Strobach et al., 2020). Conversely, it is difficult to put an intention into action when affective resistance is high. The permanent overcoming of negative feelings requires a lot of energy to regulate affective states, so that the cognitive capacities of a person can deplete. This effect, also called ego depletion, increases the likelihood that intention will not be translated into action (Englert, 2017). Hence, as a third mechanism, affect may moderate the intention-behavior relationship and could in this way help to close the intention-behavior-gap.

According to the Law of Effect (Thorndike, 1911), positively experienced behavior has a higher probability of being repeated than behavior not associated with positive affective states. A number of empirical studies seem to support this hypothesis and substantiate the role of affect-related variables as determinants of physical activity behavior (for overviews see for example Rhodes et al., 2009; Rhodes and Kates, 2015; Stevens et al., 2020). However, not all studies consider the affective state ("core affect" or "affective response") itself, and different affect-related variables are sometimes summarized under the term "affect."

Stevens et al. (2020) review the literature according to the distinction of four affect-related concepts based on the Affect and Health Behavior Framework (Williams and Evans, 2014). Besides affective response to health behavior and incidental affect (not behavior-related), these rather reflect cognitive processing of the experienced affective states, resulting in reflective constructs like affective attitudes, enjoyment, expectations of future affective responses to behavior or affectively charged forms of motivation. Affective state itself can only be measured within a situation while experiencing it (Williams and Evans, 2014; Stevens et al., 2020).

Rhodes and Kates (2015) in their systematic review included 24 studies and found that positive affective responses during moderate exercise but not post-exercise affect were related to future PA, while relationships of affective responses with subsequent intentions were very small, albeit only few studies examined responses during exercise in this context. Furthermore, the majority of studies focused on cross-sectional associations. Very few studies so far have experimentally manipulated affect-related variables (see for example Jekauc, 2015 who measured enjoyment pre- and post-an intervention).

Several individual studies point to an influence on intentions. For example, Kwan and Bryan (2010a) found a small relationship between positive affective states during and post-exercise with intentions to exercise, measured 3 months later. In another study, Raedeke et al. (2007) found that post-exercise affective states, aside from distinct categorical feeling state responses to acute exercise, were significantly and substantially related to subsequent intentions for continued exercise behavior. A review (Rhodes and Kates, 2015), however, concluded that there might only be a negligible association between post- or during-exercise affect and exercise intention. Nevertheless, several of the included studies were small and lacked sufficient capability to detect smaller effects. Thus, there is some evidence for an effect pathway from affect to intentions, but the results are not conclusive (Rhodes et al., 2022). Moreover, most studies so far focused on between-subject effects and did not consider fluctuations of affect over time within subjects. Consequently, it should be noted that there is a dearth of studies that map the dynamics of affective states over weeks and analyze the relationship with intentions over time. Especially because affective states are highly volatile, it can be assumed that within-subject fluctuations are particularly important for the prediction of intentions and future behavior.

One purpose of our study was to examine the link between affective states and the intention to re-attend an exercise class at the next opportunity, with focus on the valence dimension of affect and the variation of within and between subjects. Another aim of this study was to examine the potential influence of affective states on the translation of intentions into behavior, that is, the potential moderating effect of affective states (Strobach et al., 2020).

Derived from the outlined research findings and proposed theories, three different hypotheses about the interplay between affective states (valence) and behavioral intentions as determinants of exercise behavior, i.e., class re-attendance, have been proposed and tested (see Figure 1).

i. (Positive) Affective states contribute to the formation of intentions.
ii. Affective states moderate the intention – exercise class re-attendance relationship.
iii. Affective states directly influence exercise class re-attendance.

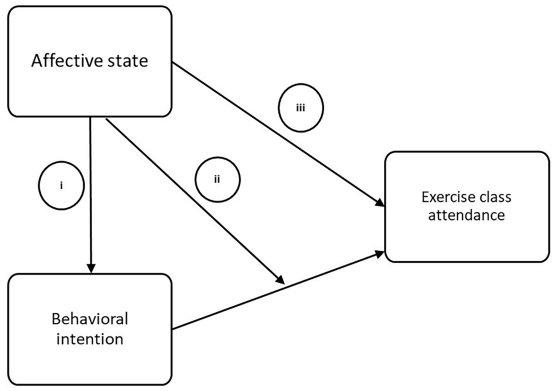

FIGURE 1
Research hypotheses tested in this study.

Materials and methods

Participants

We recruited participants from 10 different sports and gym classes at two German universities during the winter semester 2015/2016. To be considered for this study, participants had to have baseline data and sufficient data from at least one of the weekly short questionnaires, resulting in 268 participants ($N = 141$ and $N = 127$ for the two universities, respectively). The sports and gym courses are offered for low fees by the department of collegiate sports to all students and employees of the universities. About 91% of the participants were students ($N = 241$), and 67.9% were females ($N = 182$). The mean age was 24.50 years (SD = 5.60, range = 16–57).

Classes are offered each semester, starting and ending identically to the lecture period. Participants must register for specific courses on time, and available spots for the semester are assigned under the principle of "first come, first served."

For this study, only classes with a medium size (about 15–30 participants) and a weekly practice time of 60 to 90 min were selected, based on an agreement with the head of collegial sports (classes were a convenience sample, but participants were not self-selected). Class instructors were informed about the study and had to consent prior to asking individual participants of the course. Individual study participation was voluntary and the participant's written consent was obtained prior to study begin. Nearly all class participants gave consent. However, due to data protection regulation, neither the complete list of class participants could be obtained and thus, nor the exact response rate. The study was approved by the Data Security Commissioner and the Ethics Committee of Bielefeld University.

The classes comprised various types of sports, such as aerobic exercise, including specific dance steps (Zumba, Bokwa), martial arts (Kickboxing, Taekwondo, Capoeira), Freeletics (a specific set of endurance and strength exercises), and basketball training. Course duration varied slightly. 13 weeks was the minimum duration at both universities, and only these weeks were considered for the statistical analysis, as only a few people attended more weeks.

Extensive prior knowledge about the expected effects at different levels as well as on variances and covariances is necessary to calculate the required sample size in mixed-effect models in order to attain sufficient statistical power. For our study, most of this knowledge was lacking. We aimed for a sample size of about 300 individuals from 10 gym classes. This was for practical reasons as well as to obtain a cluster size of about 30 at the second level and a sufficiently large sample size at the lowest level.

Procedures

Individuals agreeing to participate signed a consent form when attending the class for the first week, and filled in a baseline questionnaire. All selected courses were attended on a weekly basis by student assistants who documented participation, issued a short questionnaire to all attending study participants when the session started, and collected them at the end of the session. Each participant had an individual, unique code consisting of letters and numbers of their family names, birth year, and place of birth in order to match the questionnaires to individual participants.

Measures

Only measures relevant for the analyses depicted in this paper are described. The baseline questionnaire asked about the participant's age (year of birth extracted from self-generated id code), gender, and student status (yes/no). To adjust for past behavior, participants were asked if they had already been exercising on a regular basis (yes/no) before registering for the class and if so, for how long (in months or years). Exercise was defined as any leisure time activities that included physical exercise, regardless of whether these activities were performed alone, in a team, or at a sports club. Some examples were given. For those who reported no previous regular exercise, months were set to 0.

Items for the weekly short questionnaire were based on existing studies and were adapted to the specific context of this study. Data on current affective states was collected at the beginning of the training, in about the midst of it (making use of short breaks for drinking or the like), and immediately after the end of the training, using two items, originally referring to the circumplex model of affect (Russell, 1980) which distinguishes between the two dimensions affective valence (pleasure vs. displeasure) and energetic arousal (low vs. high).

To explore whether the affective state immediately at the end of training has an impact on exercise class re-attendance, affect data collected at the end of the session was used for analysis (post-exercise affect). To incorporate changes in affective states in response to exercise we computed the difference in affect ratings

as affective state at the end of a session minus state at the beginning of the session (Δ affect). Affective valence was measured using the Feeling Scale (Hardy and Rejeski, 1989), and for arousal, the Felt Arousal Scale was used (Svebak and Murgatroyd, 1985). The item for valence read "How do you feel at this moment?" and was answered on a scale from "very bad" to "very good." In the original version, response options range from −5 to 5, but to fit with other scales, in our study it was adapted to the scale of 1 to 10. To measure arousal, we asked "How awake and active do you feel right now," again with a 10-point-answer scale from 1 ("extremely tired") to 10 ("extremely energized"). At the end of the weekly training, an additional item asked about the intention to re-attend the course the next week: "Do you intend to participate in this course again next week (next time)?" with possible answers ranging from 1 ("absolutely not") to 10 ("at any rate"). This one-item intention measure was adapted from similar items of the theory of planned behavior (Bruijn et al., 2014).

Additionally, the weekly attendance of each participant was recorded by a student assistant on-site (1 = present, 0 = absent, or missing when class was canceled that week).

Statistical analysis

For categorical data, descriptive statistics were calculated as percentages, and for continuous variables as means and standard deviations. In addition, the median is reported for very skewed variables. Attendance over time is described as the weekly participation rate, presented as the proportion of study participants attending a specific week of all participants who had the opportunity to attend. Some participants entered the study after the semester had already started, thus having fewer opportunities to participate. For each participant, the counting of weeks started with their first course attendance ("participant weeks" was defined as opportunities to attend an exercise class). All predictors were grand mean centered to predict weekly intention and re-attendance by affect. Additionally, for weekly measured variables, the variation was decomposed into a between- and a within-person-component. The between-component is the mean of the grand mean centered variable per person, while the within-component is the deviation of the weekly score from the overall mean per person (time-varying; Bolger and Laurenceau, 2013). Intention showed a highly skewed ("J-shaped") distribution with mostly maximum intention values. Values were therefore transformed as 1/(11-intention)*10 before centering, arriving at a reduced skewness, using the same 1–10 range of the scale, and resulting in reasonably distributed residuals in the analyzed models.

All models included tests of time (participation week) and a quadratic time effect as additional predictors. There was also a 2-week holiday break at Christmas time during which classes did not take place. To consider the possibility of a change in intention or participation probabilities after this break, a further dichotomous variable, taking on the value "0" before Christmas break and "1" afterward, was included in the considered models (Singer and Willett, 2003; Bolger and Laurenceau, 2013).

To examine whether weekly affect values predicted the intention to re-attend at the next occasion, a hierarchical linear model was built in a stepwise manner. Participant week (level 1) was nested in ID (level 2) and class (level 3) and the models allowed for auto-correlated errors. The intra-class correlation coefficient (ICC) was calculated to show how much variance in intention can be explained by differences between participants (Bolger and Laurenceau, 2013). Restricted maximum likelihood estimation was used to estimate the model parameters. For model comparisons by likelihood ratio tests, the models additionally were fitted with ML. After fitting an empty (null) model as baseline for our comparisons, we first modeled the time-dependency of measures by comparing different constellations of time effects (see above). We then tested relevant background variables as potential confounders (university, gender, age, student status, and past exercise behavior before study start). When adding arousal variables to a model already including valence variables this caused multicollinearity problems. Since we laid our emphasis on valence, we restricted the models to this affect dimension. Post-exercise arousal and change in arousal during training were examined as supplementary model (see Supplementary material).

After adjustment of time course and background variables, post-exercise affective valence was entered as predictor (Model 1), and the change in valence during the class (Δ valence) was entered in a next step (Model 2). Random slopes were included for the within-components of the affect variables and for participation week. Additionally, the interaction effect between within-person and between-person components of valence was tested.

To predict participation in exercise classes throughout the term from weekly affect data, mixed-effect Cox proportional-hazard models were estimated as variant of survival analyses for recurrent events. The models predict the "hazard" to participate in the exercise class again (event) by considering the length of the time interval until this event occurs (time-to-event). Interval length was counted in opportunities to participate and constituted the time-to-event that represented the analyzed outcome. The resulting hazard ratio (HR) can be interpreted as the ratio of re-attendance rate at any given point in time that is associated with an increase in the corresponding predictor by 1, compared to the reference value. Therefore, a higher chance to re-attend can be seen as representing more regular class attendance.

In our sample, the event could happen every week, up to 13 times, but for most cases, at least some periods between events were longer. To the data, each person contributed up to 12 intervals between two attended classes, starting with the week of the first class attendance, so that the intervals were nested within the persons. Thus, we allowed for random effects of the person (level 2—also known as "frailty" in literature on survival models) and, additionally, the specific exercise class in which a person participated as another level of nesting (level 3). For example, a person attending a course every second week would contribute

with several two-week intervals, a person attending only once at the beginning of the semester would contribute only a single open-ended interval, which is thus censored at the end of the course. Intervals were censored in case the information on the decision to re-attend the class was missing because the course (a) ended after about 3 months or (b) was intermittently canceled due to illness of the course instructor. In both cases, we had no information on whether a person would have possibly attended. Thus, information on if and when the event would have happened was missing. Every person was "at risk" of coming back after each attended (or intermittently canceled) class, i.e., a new time-to-event interval started. We used the Anderson-Gill approach to define the risk set for each interval (Andersen and Gill, 1982).

The proportional hazard assumption was tested by using standard survival models with an added frailty term to account for non-independence of observations of the same individual.

The statistical package R (R Core Team, 2018) was used for the calculations. Hierarchical linear models were estimated by the package "nlme" (Pinheiro et al., 2019), and, for mixed-effects Cox models, "coxme" (Therneau, 2019) was used for the survival analysis of recurrent events.

Results

Descriptive statistics

Of a total of 281 participants answering the questionnaires, 268 (4.6% excluded due to missing information) provided data on affective states and intention and were included in the analyses.

Nearly three quarters of the participants ($N = 192$, 68.3% of non-missing values) stated that they were already exercising on a regular basis. On average, they reported 91.2 months of regular exercise in the past (SD = 96.6, Median [Md] = 46, range = 0 to 384) and had 12.02 (SD = 2.79) opportunities to participate in the examined gym classes (range = 4–13), resulting in 5.17 (SD = 3.48) weeks of average class participation (Md = 4.5, range = 1–13).

Detailed descriptions of participation rate, intention, valence, and arousal over the 13 time points can be found in Table 1. The number of attending participants decreased strongly from 268 participants in the first week to 35 participants in the last week. The participation rate shows a relatively stable decline over time. Only slightly more than half of all participants re-attended the class as early as the following week. Overall, the participation pattern was irregular for many cases. Proportion of re-attendance increased slightly between participation week 8 and 11. For the majority of participants, Christmas holidays fell into this period. Therefore, the Christmas break was included in the survival analysis as a possible confounder, since it seems to predict the probability of participation.

Despite the irregular participation of most participants, intention to re-attend the class in the following week in general was rated very high with mean values around 9 (before transformation) on a scale from 1 to 10 for every week (overall mean = 9.06, SD = 1.54). No clear temporal pattern in intention was found when looking at the weekly mean values (see Table 1). However, these means only represent the intention of those participants who attended the class during the week in question and thus are not based on the same sample for each week. Therefore, the means cannot be interpreted as a within-person

TABLE 1 Participation in exercise classes and changes in psychological variables over time.

Week (interval)	*N*	*N* attended	Participation rate	*N* analyzed	Intention		Affect valence		Δ valence		Affect arousal		Δ arousal	
					M	SD	M	SD	M	SD	M	SD	M	SD
0	268	268	1.000	246	9.10	1.54	7.70	1.84	0.74	2.01	7.15	2.13	1.04	2.40
1	266	156	0.583	143	9.24	1.39	7.81	1.64	0.80	1.76	7.55	1.82	1.12	2.35
2	266	144	0.541	140	8.97	1.77	7.61	1.71	0.83	1.90	7.17	1.85	0.99	2.38
3	264	134	0.508	126	8.99	1.72	7.95	1.42	1.32	1.80	7.56	1.68	1.25	2.14
4	250	100	0.400	95	9.15	1.47	7.72	1.53	1.01	1.55	7.28	1.72	0.88	2.20
5	243	101	0.416	97	9.01	1.38	7.69	1.58	1.08	1.71	7.30	1.77	1.13	2.19
6	243	86	0.354	83	8.87	1.62	7.81	1.34	0.99	1.68	7.61	1.64	1.10	1.91
7	236	76	0.322	75	9.01	1.39	7.67	1.54	1.17	1.61	7.43	1.89	0.85	2.14
8	233	56	0.240	54	9.11	1.57	7.43	1.74	0.76	2.11	7.30	1.94	0.69	2.05
9	243	66	0.272	65	9.34	1.05	7.57	1.72	1.00	2.02	7.43	1.77	0.97	2.15
10	242	72	0.298	67	8.90	1.52	7.61	1.55	1.09	1.73	7.27	1.85	1.03	2.48
11	228	57	0.250	56	8.91	1.67	7.54	1.62	0.80	1.86	7.27	1.95	0.91	2.19
12	203	36	0.177	35	9.09	1.58	7.20	2.18	0.63	1.99	7.17	2.24	1.09	2.20

N, total cases still under observation; *N* attended, number of participants attending the class per occasion; *N* analyzed, number of cases that were analyzed in the prediction models after exclusion of cases with missing information on intention or affect variables; week, week of participation, starting with "0" for the week of first attendance of an individual and counting the weekly occasions to participate (censored cases are those where the course had ended); intention, raw score (untransformed), intention, valence and arousal values range from 1 to 10, M, mean, SD, standard deviation; Δ valence and Δ arousal, changes in affect from beginning to end of class.

trajectory over time. Intention showed a small peak around the same time as participation rate. So, the Christmas break was also factored in when modeling temporal changes in intention.

Affective valence at the end of the training was also rated relatively high, with means near 8 again on a 1-10-point scale. There was a slight decrease in valence over the term (from M = 7.70 [SD = 1.84] at week 0 to M = 7.20 [SD = 2.18] at week 12). Arousal followed a parallel pattern for most weeks, with slightly lower values than valence, but no clear temporal trend. In terms of the changes in affect during the training, valence as well as arousal on average showed increases of about one point from pre- to post-exercise. Again, no clear temporal trends were revealed over the semester.

Prediction of intentions to attend the class again

Model building

The 1,282 observations were nested in 268 individuals that were in turn nested in 10 exercise classes. Therefore, a 3-level model was examined first. However, since the between-class variation in intention was comparably negligible (about 0.7% of explained variance) and neither AIC nor BIC showed an improvement, we stuck to the 2-level-models. For intention, ICC was 0.462 without auto-correlation, and 0.395 when allowing for auto-correlated errors (Phi = 0.348). A model with auto-correlated errors of first order (form = ~week|person) fitted the data better than without (likelihood ratio test: $\chi^2_{(df=1)} = 49.99$, $p < 0.001$). Thus, after accounting for the correlation structure, about 39.5% of the total variance was between persons.

To adjust for the time course of intentions, a model including participation week and a binary predictor distinguishing between the period before and after Christmas holidays showed the best fit. University, gender, age, and past exercise behavior were not significant confounders (results not shown). Therefore, they were excluded from the models to avoid overly complex models and accumulating missing values. Random slopes for the weekly measured variables improved the model (model comparison against random intercept model: $\chi^2_{(df=9)} = 81.09$, $p < 0.001$), thus random slopes were included.

Model results

Table 2 shows the effects of the within- and between-predictors related to affective valence on weekly intention. In model 1, post-exercise valence was the only predictor after having adjusted for time effects. Higher affective valence at the end of the training was significantly associated with a higher intention to re-attend the next week. Results were significant on both within- (level 1) and between-subject (level 2) levels. In detail, in those weeks in which valence was higher than in the others, the intention was also higher within a specific person ("valence within"). Practically speaking, a one-point increase on the valence scale (range 1 to 10) was associated with a 0.721 increase on the intention scale (range 1–10; $p < 0.001$). There was also a significant association with the average valence over the course of all weeks ("valence between"): Those participants with a higher mean valence also reported higher weekly intentions (a one-point increase in valence was related to an estimated increase of 0.793 on the intention scale). There was no interaction effect between within and between components of valence revealed.

TABLE 2 Results of hierarchical linear models for the prediction of weekly intention by affect.

	Model 1 (post-exercise valence)	Model 2 (post-exercise valence + Δ valence)
Fixed effects: β (95% CI)		
Intercept	7.112 (7.451–7.790)	7.438 (7.098–7.778)
Valence between	0.793 (0.584–1.001)***	0.880 (0.647–1.114)***
Valence within	0.721 (0.553–0.889)***	0.831 (0.645–1.017)***
Δ valence between	/	−0.217 (−0.460–0.026)#
Δ valence within	/	−0.165 (−0.271–0.059)**
Random effects: variance (95% CI)		
Valence within	0.543 (0.326–0.905)	0.604 (0.330–1.106)
Δ valence within	/	0.013 (0.001–0.185)
Residual variance level 2 (person)	4.281 (3.061–5.986)	4.425 (3.185–6.147)
Residual variance level 1 (time)	4.626 (3.983–5.373)	4.510 (3.894–5.222)
AIC	6025.205	6023.546
BIC	6092.236	6121.513
LL	−2999.603	−2992.773

One thousand and two hundred and eighty two (1,282) observations nested in 268 individuals; LL, log-likelihood; AIC, Akaike Information Criterion; BIC, Bayes Information Criterion; Δ, difference in valence as valence post-exercise minus valence pre-exercise. All results are controlled for time course (participation week and time period before/after Christmas). #$p \leq 0.10$; **$p \leq 0.01$; ***$p \leq 0.001$.

In model 2, change in valence was entered as a second predictor. Overall, the model fit improved slightly in terms of the likelihood and AIC, while BIC clearly preferred the simpler model without the change in valence. A higher increase in valence was associated with lower subsequent intention, although the between-person effect was only marginally significant ($p < 0.10$). Individuals with a one unit larger average increase on the valence scale were expected to show an intention reduced by 0.22 ($p < 0.10$), and within-person an increase one point higher than in the average week resulted in an expected reduction of 0.17 for intention to re-attend ($p < 0.05$).

We found an overall correlation between post-exercise valence and Δ valence of r = 0.52. This means that, in general, a negative affective response (Δ) resulted in a lower valence post-exercise or, to put it the other way round, a more positive response was accompanied by a more positive affective state post-exercise. Both variables therefore shared some information but also provided enough independent contributions to be able to distinguish the effects.

The supplementary models showed a significant increase in intention also with higher post-exercise arousal between and within. In contrast, a higher increase in arousal during class time, similar to valence, resulted in a somewhat lower intention to re-attend (see Table A in Supplementary material). Random slopes indicated that both valence and arousal effects varied between persons.

Prediction of weekly re-attendance

Model building

To predict participation in the exercise class from affect, affective states at the end of each attended training were used as predictors of the hazard to re-attend the class in a mixed-effect Cox proportional hazard model. To use the same variable as predictor that had been the outcome of the linear models described above (see Table 2), weekly intention was not decomposed into between- and within-variance components for the main analysis.

For participation, the temporal course was best described by including week and a quadratic term of week as predictors in the Cox model, meanwhile the Christmas holidays were not meaningful in this case. Unlike in the linear models, including a random effect for class improved the models, so it was included as a third level. Gender was the only potential confounder significantly associated with the outcome (with the chance of re-attendance nearly 20% lower in females than in males). Since including gender violated the Cox proportional hazard assumption, gender was included as a stratification variable in the final models instead of a potential confounder. This results in allowing different baseline hazards for males and females while other results, i.e., the tested effects, remained unchanged. Due to the complexity of the models, no random slopes could be included in the final models. However, we additionally separately analyzed random slopes, varying by course or person, for the affective variables to get an impression of the variability of effects.

Model results

In the first model (model 1; Table 3), post-exercise affective valence was entered as a predictor. A significant effect was only found for within-person fluctuations of valence from week to week, while the average level of valence of a person over the term ("valence between") had no meaningful effect. That is, adjusted for the temporal pattern in participation and stratified for gender, persons with a higher average valence level were not more likely to re-attend, but participants were slightly more likely to re-attend after weeks in which they rated valence higher than in other weeks although the effect was only marginally significant (HR = 1.059, $p < 0.10$).

In model 2, the change in valence from beginning to end of training was added to the model as further affect variable. Only within-person fluctuations of post-exercise valence predicted subsequent re-attendance, while between-person differences and both components of change in valence turned out to be clearly not significant ($p > 0.10$). Specifically, for each one-point increase on the post-exercise valence scale, the chance ("hazard") to re-attend the class increased by 8.4% (HR = 1.084, $p < 0.05$). However, after adjusting for intention in model 3, the effect of valence within decreased in magnitude, and none of the valence variables showed a statistically significant HR. No effect of arousal was detectable in a model excluding valence (see Table B in Supplementary material). Hypothesis 3, which stated a direct positive effect of the affective state or response on re-attendance, was therefore only partially supported for the within-person component of affective valence.

In contrast, higher weekly intention was associated with a significantly higher probability of re-attendance: A one-point increase on the (transformed) intention scale led to a 5.2% increased hazard for re-attendance. The fact that the inclusion of intention resulted in non-significant valence effects points to an indirect effect of valence where intention partially mediates the effects of within-person fluctuations in affective states: the hazard ratio for valence decreased from 1.084 to 1.055 when intention was entered.

In model 4, intention was also decomposed, and the interactions between weekly intention and affect (within and between-persons) were added. For intentions, both within- and between-person component effects were very similar to the overall variable effect. None of the valence variables was significant after this adjustment but the interaction term of intention with valence between-persons was. It showed that the effect of intentions was getting smaller with a higher valence. For example, with a mean valence value higher than that of 90% of the sample the HR of intention was only 1.008, while for an individual belonging to the 10% of those with the lowest valence the predicted HR could reach 1.081, which means an increase in the hazard rate of about 8% when intentions are increased by 1 point. Thus, hypothesis 2, which proposed a moderator effect of affective state, was not supported since it states a *larger* effect of intention with more positive affective response. Only small interaction effects with intention in different directions were revealed for arousal (see Table B in Supplementary material).

In an additional model (model 5), we only kept the post-exercise valence and excluded other non-significant variables not part of the interaction to arrive at a more parsimonious model. This model did equally well as the full model (Likelihood ratio test: $\chi^2_{(df=3)} = 2.32$, $p = 0.51$) and was the best in terms of both information criteria.

Analyses on random slopes showed that the effect of affective valence within persons mainly varied between the courses (from HR = 0.86 to 1.19), but not persons.

Discussion

The purpose of this study was to examine the role of affective states for exercise intentions and class re-attendance. Overall, though affective states were related to both, not all hypotheses

TABLE 3 Results of Cox multilevel survival models for the prediction of re-attendance by affective valence.

	Model 1 (post-exercise valence)	Model 2 (+ Δ valence)	Model 3 (+ intention)	Model 4 (intention decomposed + interactions valence × intention)	Model 5 (parsimonious model)
Fixed effects of predictors: HR (95% CI)					
Valence between	1.040 (0.974–1.111)	1.031 (0.960–1.108)	0.989 (0.919–1.065)	0.980 (0.907–1.059)	0.997 (0.931–1.068)
Valence within	1.059 (0.998–1.124)#	1.084 (1.008–1.167)*	1.055 (0.980–1.136)	1.053 (0.978–1.135)	1.036 (0.976–1.100)
Δ valence between		1.020 (0.948–1.097)	1.030 (0.959–1.106)	1.039 (0.967–1.117)	/
Δ valence within		0.969 (0.914–1.028)	0.977 (0.922–1.036)	0.978 (0.922–1.036)	/
Intention (weekly)			1.052 (1.028–1.077)***	*within:* 1.051 (1.019–1.084)**	*within:* 1.051 (1.019–1.084)**
				between: 1.048 (1.012–1.085)**	*between:* 1.046 (1.010–1.083)*
Intention × valence between				0.978 (0.958–0.999)*	0.979 (0.959–1.000)*
Intention × valence within				1.009 (0.986–1.032)	/
Random effects (variance intercept)					
Individual	0.157	0.154	0.144	0.143	0.146
Class	0.081	0.081	0.078	0.071	0.069
Model fit					
AIC	8512.062	8514.645	8498.069	8498.770	8495.086
BIC	8541.604	8554.034	8542.382	8557.854	8539.399
Integrated LL	−4250.031	−4249.322	−4240.035	−4237.385	−4238.543

N events, 1,016, N intervals, 1,282 entered as "start" and "stop" week; HR, hazard ratio; LL, log-likelihood; AIC, Akaike Information Criterion; BIC, Bayes Information Criterion. All models were adjusted for time course (participation week and participation week squared) and stratified by gender. #$p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

were backed by the data. The following discussion will be structured around the three tested hypotheses.

Hypothesis 1: Affect and exercise intention

The first hypothesis stated that affective states predict intentions to re-attend the exercise class at the next occasion. Hypothesis 1 was confirmed in terms of affective valence on the within- and between-person level.

The effect on the between-level suggests that people who on average feel better than others after exercising have higher intentions to exercise again. The effect on the within-level supports the notion that exercise units with more positive valence lead to stronger immediate intentions to re-attend the exercise class in the following week. A larger increase in valence during the class, when added to the model, however, was associated with a slightly lowered intention, especially within-persons. Other than expected, this effect shows that in those weeks when individual affective valence showed a larger increase than usual and, therefore, a more positive affective response, this coincided with lower motivation to re-attend, at least after adjusting for absolute valence post-exercise. In fact, in a model without post-exercise valence, a positive change in valence was associated with higher intention, albeit less pronounced than for post-exercise valence. Since in general a larger increase correlated with a higher post-exercise valence, the negative difference effect at constant post-exercise valence also points to lower valence at the beginning being associated with smaller intention at the end.

Our results are in contrast to review results, which conclude that, overall, during or post-exercise affective responses in terms of valence do not show meaningful effects on subsequent intentions (Rhodes and Kates, 2015), although in some individual studies the expected associations were found. For example, a study using similar measures as we did showed, in a sample of socially physique anxious female college students, that affective valence and arousal were significantly related to future intentions with valence being the more powerful predictor (Raedeke et al., 2007). This was the only other study we found which also asked for the intention to re-attend an exercise class specifically. Most other studies focused on more general intentions on future PA.

In a sample with a similar age as in our study, changes in positive or negative affect during exercise were indirectly related to intention, mediated by other TPB-constructs (not measured in our study), and for baseline valence an additional direct effect was revealed (Kwan and Bryan, 2010a). However, affect was used to predict exercise intentions 3 months later and not for the next occasion (which is usually within the next 1 or 2 weeks for regular exercise classes). The results are therefore not directly comparable.

In general, we are not aware of other studies showing negative effects of increasing valence. But, as mentioned above, we found this negative effect of increasing valence only for constant post-exercise valence (i.e., adjusted for post-exercise valence) where it

also implies a lower valence at the beginning of the exercise session. This might be seen as confirming the role of baseline valence in the study of Kwan and Bryan (2010a). However, the studies differ in various aspects.

Overall, the confirmation of the hypothesis that more positive affective states result in higher intentions to re-attend the class at the next occasion in our study is in line with feedback theory of Baumeister et al. (2007) and dual process approaches like the PAAM model (Strobach et al., 2020). These state that automatic (implicit) affective valuations besides an implicit pathway of behavior regulation can be further processed by the reflective system and result in conscious motivation (like intentions).

In our study, arousal as additional affect dimension, when unadjusted for valence also showed significant associations with intentions at the within- as well as between-person-level (see Supplementary material), which was unexpected because of the assumed neutral valence. It was, however, highly correlated with valence and effects, therefore, may mirror those of a positive valence.

Hypothesis 2: Affective states as moderators of the intention-behavior relationship

The second hypothesis stated that affective states moderate the relationship between intention to exercise and the actual re-attendance of the class in that more positive affect increases the chance that intentions are implemented in actual behavior. This hypothesis is part of the PAAM model (Strobach et al., 2020). No significant moderator effects could be found in our study, neither at the within- nor at the between-person level. The found interaction effect for valence and intention within, on the contrary, pointed to a slightly lower chance of high intentions leading to behavior with a more positive valence, while intention was still an independent significant predictor of behavior. The effect of short-term exercise intentions on behavior, therefore, might not depend on post-exercise affective states or changes in affect due to exercise. From our study, it can be concluded that affective valence supports the building of intentions, but do not facilitate the translation of intentions into behavior. The supplementary results for affective arousal were similar, although an additional small interaction for change in arousal was found.

Only one other study on the moderating effect of affect was found, which, in contrast to our study, confirmed the expected interaction between positive affect and translation of intentions into behavior (Kwan and Bryan, 2010b). However, its methods and design are not comparable to those of our study. Affective states were measured within different affect categories under lab conditions. Exercise behavior was measured 3 months after the measurement of affect and intention and operationalized as voluntary exercise frequency within the last 3 months. Therefore, only between-subject effects, but not within-subject effects, could be estimated, while our main focus was on the latter.

An explanation to why the results were not significant in the current study could also lie in the fact that exercise was objectively measured through observing re-attendance of the class and not by self-report questionnaires. We suppose that other results might support the moderation hypothesis, at least partially, due to a method effect. Measuring several constructs with the same method (e.g., questionnaire) might induce common variance between constructs, which can be caused by inter-individual differences in the response tendencies (Bolger and Laurenceau, 2013). Nevertheless, further studies are required to clarify this issue.

Getting back to the PAAM model, this stresses habits as further important implicit concept besides affect. It predicts that positive affective response would increase habit strength (i.e., automaticity of behavior) and this increases the chance of enacting exercise or other PA behavior. Habit was not included in the presented analyses. But we found support for affective valence post-exercise as well as an increase in valence during exercise promoting the development of automaticity of the decision to attend an exercise class in a previous analysis (Weyland et al., 2020). The possible indirect effect of affective valence on behavior *via* habit strength postulated by the PAAM should be tested in future studies.

Hypothesis 3: Direct effects of affective states on subsequent behavior

The third hypothesis stated that affective states directly impact on the probability of actual re-attendance of the class at the next occasion, thus referring to a more regular class attendance. This would be in line with hedonic and some dual process theories, namely that affective valence is directly related to future exercise behavior *via* an implicit, associative learning pathway (Williams and Evans, 2014; Brand and Ekkekakis, 2018; Stevens et al., 2020).

Our data supported this hypothesis only partially. First, although intra-individual fluctuations in post-exercise valence were related to re-attending the class in the first survival models we tested, no meaningful effect was revealed on the between-person level or for changes in valence during the class. Second, even this effect could not be demonstrated after adjusting the valence effects for intentions in the more comprehensive models.

This means that immediate post-exercise valence predicted exercise class re-attendance independent of the baseline valence level. And this effect did not depend on the average level of valence, but related to short-term intra-individual fluctuations in affective experiences relative to this average level of a person: after those exercise units, in which affective valence was more positive, the likelihood for re-attendance increased. Therefore, situational factors concerning affective states in single exercise units may be more important for exercise class re-attendance than stable inter-individual differences. The fact that supplementary analyses mainly showed variations in the valence effect between different courses indicates that, besides occurring differences in

participation rates between courses, characteristics of the type of exercise or trainer, which were not analyzed in our study, may have impacted the affect-behavior relationship.

Other studies support direct effects of affective responses during exercise but not post-exercise on future behavior (for an overview see Rhodes and Kates, 2015; Stevens et al., 2020). However, the analyzed effects were in general not adjusted for intentions.

In a study by Kwan and Bryan (2010b) increases in positive affect during exercise were related to a higher PA frequency at 3 months follow-up. No such association was found for affective responses (positive or negative affect) 15 min post-exercise. Williams et al. (2012) showed that valence during and immediately after a 10-min treadmill walk predicted subsequent self-reported lifestyle PA up to 6 months later. The predictive potential of valence for PA behavior was also confirmed in other studies (e.g., Williams et al., 2016), while further studies confirmed the relationship for implicit (affective) attitudes as related concept with PA (Conroy et al., 2010; Hyde et al., 2012).

Overall, a direct effect of affective response during exercise on future PA behavior can be assumed from previous research (without adjustment for intentions). For post-exercise affect there seems to be a difference between measuring valence immediately after exercise versus after a time delay after ending of activity. As for example Williams et al. (2012) did, we measured valence immediately at the end of training. It is theoretically assumed that to measure affective state itself it has to be *in vivo* during an activity because a retrospective evaluation would be further cognitively processed and relate to the reflective path in terms of dual process models (Williams and Evans, 2014; Brand and Ekkekakis, 2018; Stevens et al., 2020). We think that a measurement immediately after the activity still captures the acute affective state and the difference from beginning of a class to this point relates to the acute affective response. Moreover, according to the peak-end-rule in hedonic theory (Kahneman et al., 1993, 1999) affective experiences at the end of a behavior, besides those with the highest intensity, are critical for overall evaluations and future behavior.

To complete a questionnaire while exercising was not possible in the kind of group activities we observed without interrupting the class. So, even measurement earlier in class time would have taken place while taking a break from activity. We cannot rule out the possibility that knowing that the training has been accomplished was a factor that also impacted on the affect measurement (rebound effect). However, in general, valence in the midst of the class (during a break) was very similar to our post-exercise measurement. This was also mentioned by Kwan and Bryan (2010a). On average, during class valence increased in our sample and, therefore, did not show the characteristic decline which would be expected at high-intense exercising (Williams, 2008).

Though a difference between in-task and post-task affect seems obvious from existing studies, the time points for the post-measurement differed between studies (Rhodes and Kates, 2015), and the exact point in time when a retrospective evaluation as opposed to an acute affective response is to be assumed has still to be determined.

The non-significance of valence variables in our study after adjusting for intentions points to an indirect rather than a direct effect of valence on re-attendance. It seems as if the increase in intention explains a large portion of the found effect on re-attendance. When looking at Figure 1, this indirect path mediated by intention is implied by hypothesis 1, which was confirmed, while the (additional) direct path proposed by hypothesis 3 was not.

Besides possible indirect effects *via* habit (implicit path) as described above, indirect effects of affective valence *via* intentions (reflective path) should be further explored in the future.

We analyzed affective arousal separately in supplementary models because of its high correlation with valence. We did not find any direct association of arousal variables with re-attendance, neither for the effects unadjusted, nor adjusted for intention.

Strengths and limitations

A strength of this study is the continuous weekly measurement of exercise class attendance over a period of one semester. In this manner, exercise behavior could be observed over the course of several months. The effects of affective states could be differentiated on the between-subject and within-subject level, providing valuable knowledge on affective and motivational processes. Furthermore, PA attendance was measured quasi-objectively by observation. In this way, systematic bias of subjective measures of PA could be avoided (Jekauc et al., 2014). However, there are also some limitations to consider.

A limitation of this study concerns the high percentage of missing data, which is mainly due to low participation and high dropout rates (Jekauc et al., 2012). We therefore adapted our analysis and used a survival model with time-to-event intervals of different lengths, instead of predicting weekly re-attendance. However, we have no data on participants dropping out, nor on the reasons for their dropout. It cannot be assumed that not attending the exercise class is equivalent to not adhering to exercise, as there is no data on whether a person was exercising in another class or was active otherwise in his or her leisure time. However, the intention we asked for and the behavior we were interested in were directly related to re-attending this specific exercise class, but not to the overall amount of PA. We therefore precisely observed the behavior that the intention item referred to.

Another limitation is that intention to re-attend was not predicted over time, but measured at the same instant as affective states post-exercise. The association with affective states may therefore be overestimated, especially as feeling states might overall impact response behavior. Furthermore, no causal inferences are possible. It is likely that affect not only influences intentions, but that a reciprocal effect exists, which previously was not considered (Kwan and Bryan, 2010a).

Intentions as well as affective states were measured on single-item scales with uncertain measurement properties, since only very short weekly questionnaires were possible for the benefit of repeated measurements. Although the scales used for affect variables are well established internationally, no validated German version existed at the time of data collection. Moreover, we adjusted the answer scales of the Feeling Scale and the Felt Arousal Scale to parallel those of other items (10-point scale) while the original scales are used with a 6 or 11-point scale. This was done to allow for an easy and fast completion of the short questionnaires during class time. Evmenenko and Teixeira (2020) additionally point out that the usefulness of these single-item affect scales might vary, depending on the method of application and kind of activity. Although not common practice, exercisers may also profit from a training in understanding and answering the scales (Ekkekakis, 2013), and no standard in terms of the exact best time points for measurement during or post-training exists, since these may also depend on the activity itself.

Especially the intention item was very skewed, indicating a ceiling effect. It could be used after a transformation, resulting in approximately normally distributed model residuals. However, the development of reliable and valid short scales is indicated for future studies with frequent measurements. A recent study by Maibach and colleagues validated a German version of both affect scales by analogy with similar studies on the original English versions. It found good convergent validity, comparable to the original versions, using a non-verbal criterion (Maibach et al., 2020). Since the Felt Arousal Scale was validated with a 6-point answer scale and the bipolar scale was translated differently from ours, we cannot be sure to have used a valid version that reflects the same construct as the validated German or the original English version. Unfortunately, the validation took place after we had already finished our data collection. For future German studies, employing these validated versions of both scales would be recommended.

Due to high correlations between the time points within an exercise class, we could not include different time points of affect measurement into one model or adjust for baseline exercise affect, for example. Previous research found affective states during exercise more relevant than post-exercise affective states. We included affect measurement immediately after training and the change from pre- to post-exercise as measure for affective response to exercise. This point was discussed above in the context of hypothesis 3. The inclusion and comparison of different measurement points would be preferable in future studies to better represent affective responses to exercise. However, we repeated our analyses employing valence measured midst-session instead of post-exercise, and the results were very similar with the exception that within-person effects were smaller (results not shown).

Last but not least, since our sample mainly consisted of university students, the generalizability of the results to other population groups is questionable. However, besides the fact that no meaningful effects of student status were found in our analysis of potential confounders, most theories explaining PA intentions and behavior were developed to apply to all people but not only to specific subpopulations. As such, theoretical hypotheses derived from such theories should hold for different population groups, including university students. Furthermore, university students are generally young and well-educated, and both characteristics are deemed to make regular exercising more likely. Yet, our study points to a large intention-behavior-gap even in this population and this despite high intention values. The questions addressed thus seem very relevant for this group, too. Nevertheless, although valence and especially intention showed statistical significant effects, they cannot explain the high attrition in our study.

Implications

Notwithstanding these limitations, some future research and practical implications can be derived from this study. Exercise promotion interventions and instructors should structure exercise programs in order to attain a positive affective response especially post-exercise, considering the effects of affective states on intentions and behavior. Affective responses to exercise seem to vary with exercise intensity. In general, intensities below the ventilatory threshold elicit positive affective responses, and self-selected exercise intensity seems preferable for valence (Williams, 2008).

While it is still difficult to plan an exercise program that elicits positive affective responses in each individual, some studies found positive results for changing social and environmental factors (Jekauc, 2015). An experimental study provided evidence that a systematic manipulation of teacher's feedback led to a change of perceived competence, which in turn supported the development of positive or negative affective states in physical education (Bruijn et al., 2014). Hence, teachers and coaches may play a crucial role in the promotion of positive affective states. Promotion of health, rather than an appearance oriented leadership style, led to a better affective response (Raedeke et al., 2007), as well as exercising in a group of people compared to exercising alone in other research (Dunton et al., 2015; Graupensperger et al., 2019). Another promising approach would be to educate teachers (Leisterer and Jekauc, 2019) and coaches (Hagger et al., 2002; Strauch et al., 2018) in social–emotional skills, which in turn have been shown to be related to positive affective states of participants (Strauch et al., 2018). Regarding research, future studies should investigate the relationship between affective states, intention, and exercise adherence by continuous measurements over a longer period of time (e.g., 6 months or longer). This would allow for an examination of the effects of affective states on long-term maintenance, which have not been examined yet. Furthermore, studies should include measures for non-participating individuals and dropouts in order to discover the underlying mechanisms. This could be realized, for example, by ecological momentary assessment or online-questionnaires although, presumably, regular answers would have to be encouraged by incentives to achieve the drop outs.

Conclusion

The results of this study suggest that more positive affective state, especially immediately after training, supports the process of the formation of short-term exercise intentions which, in turn, are predictive of subsequent exercise class attendance. However, we could not find evidence that affective states moderate the intention-behavior relationship in that a higher valence relates to more emphasized intention effects and therefore helps closing the intention-behavior-gap. Rather, affect-behavior relations seemed to be mediated by intention. Although this does not conform to the tested hypothesis, the possibility of a mediated effect is also implied by dual process approaches. Further studies should further explore the possible indirect effects of exercise-induced affects *via* the implicit versus explicit pathway, which are postulated by dual process theories.

As a consequence, interventions should be developed, that promote positive affective responses, and education curricula should be extended to promote social–emotional competences in coaches and physical education teachers. However, further longitudinal studies with frequent measurements are needed.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of Bielefeld University (Bielefeld, Germany). The participants provided their written informed consent to participate in this study.

Author contributions

EF designed and coordinated the study, supervised data collection, conducted the statistical analysis, and wrote the paper. CN, SW, and BW wrote the paper. OS helped with the analysis. DJ designed and coordinated the study and wrote the paper. 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/fpsyg.2022.815466/full#supplementary-material

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Evaluating behavior change factors over time for a simple vs. complex health behavior

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Background: Researchers are working to identify dynamic factors involved in the shift from behavioral initiation to maintenance—factors which may depend on behavioral complexity. We test hypotheses regarding changes in factors involved in behavioral initiation and maintenance and their relationships to behavioral frequency over time, for a simple (taking a supplement) vs. complex (exercise) behavior.

Methods: Data are secondary analyses from a larger RCT, in which young adult women, new to both behaviors, were randomly assigned to take daily calcium (N = 161) or to go for a daily, brisk walk (N = 171), for 4-weeks. Factors (intentions, self-efficacy, intrinsic motivation, self-identity, habit strength) were measured weekly. Multi-level modeling evaluated their change over time. Bivariate correlations and multiple regression determined the relationships between factors and the subsequent-week behavioral frequency (self-report and objective).

Finding: Results were partly in-line with expectations, in that individuals' intentions and self-efficacy predicted initial behavioral engagement for both behaviors, and habit strength increased for both behaviors, becoming a significant predictor of behavioral frequency in later weeks of the study in some analyses. However, results depended on whether the outcome was self-reported or objectively measured and whether analyses were bivariate or multivariate (regression).

Discussion: The factors theorized to play a role in behavioral maintenance (intrinsic motivation, self-identity, and habit strength) started to develop, but only habit strength predicted behavioral frequency by study-end, for both behaviors. Differences in initiation and maintenance between behaviors of differing complexity may not be as stark as theorized, but longer follow-up times are required to evaluate maintenance factors.

KEYWORDS

behavioral maintenance, theories of behavior change, exercise, adherence, habit formation

Introduction

Far too few individuals meet recommendations for engagement in healthy behaviors, including sufficient regular exercise (<5% of the US population), healthy diet (<25%), and medication adherence (<50%) (Spring et al., 2012). Interventions are needed to improve our success at both initiating and maintaining health behavior change (Sheeran et al., 2017). To improve the success of behavior change interventions, researchers are working to improve our understanding of the dynamic factors involved in behavioral initiation (including preparation for initiating the behavior, initial attempts at the behavior, and short-term repetition of the behavior; Prochaska and Velicer, 1997), behavioral maintenance (including longer-term behavioral repetition and relapse prevention; see Dunton et al., 2022), and the dynamic transitions between these phases. Ongoing research questions that we address in the present study include: first, what factors promote behavioral initiation and which become more or less important as behavior is repeated, heading toward behavioral maintenance? And second, how might these factors and their relationship to behavioral engagement (i.e., frequency) over time depend on the complexity of the behavior—how many steps and how much time is required to prepare for and enact the behavior and whether the behavior as meaningfully separable parts that can be differentially targeted with intervention (see Phillips and Mullan, 2022)?

Widely studied theoretical factors involved in behavioral initiation include self-efficacy (Health Action Process Approach; Schwarzer, 2008), motivation that varies in quality from intrinsic to purely extrinsic (Self-Determination Theory; Deci and Ryan, 2000), and behavioral intentions (Theory of Planned Behavior; Ajzen, 1991), among others. These factors are posited to differ from factors involved in behavioral maintenance (Rothman, 2000), and recent research has found that they are better predictors of behavioral engagement among those in an initiation vs. maintenance stage of change (More and Phillips, 2022).

Factors posited to be involved in behavioral maintenance include behavioral habit, autonomous motivation, and self-identity. The factors are included in some theories and frameworks presented in existing literature, such as the multi-process action control approach (M-PAC; Rhodes et al., 2021), habit theory (e.g., Lally and Gardner, 2013; Gardner, 2015), and in a review of 117 behavioral theories regarding processes of behavioral maintenance by Kwasnicka et al. (2016).

Probably the most widely studied behavioral maintenance factor has been behavioral habit strength. Habits can be defined as automatic impulses to engage in a behavior that are triggered by learned/conditioned context cues (see Gardner, 2015), or as an automatic association between a context and an action that is formed through repeated and rewarded action in that context (see Wood et al., 2022). Automaticity, and therefore habit strength, is considered a continuous variable that varies in type (e.g., non-conscious vs. efficient; Moors and De Houwer, 2006). Habit strength is associated with frequency and consistency of behavioral engagement over time, including in the face of common barriers such as time restraints and stress (Verplanken, 2006; Wood and Neal, 2007; Gardner, 2015). For complex behaviors in particular, researchers have posited that intrinsic motivation is a critical component of habit development and continued habitual action of health-promotive behaviors (Phillips et al., 2016; Phillips, 2020; Phillips and Mullan, 2022)[1]. There is observational evidence that autonomous motivation facilitates habit formation and maintenance of complex health behaviors, such as exercise (Gardner and Lally, 2013; Phillips et al., 2016). Gardner and Lally (2013) found that behavioral repetition was associated with habit formation (stronger habits) only when behavior was autonomously motivated. Phillips et al. (2016) found that intrinsic rewards (e.g., enjoyment of and stress reduction from exercise) predicted greater exercise frequency through stronger habits (vs. intentions) for those in a maintenance stage of change. Additional, theoretical arguments are presented in the literature regarding the necessity of intrinsic reward for habit development and maintenance (see Phillips et al., 2016; Phillips, 2020; Phillips and Mullan, 2022). Briefly, without a reward, any habit would cease, eventually, as has been acknowledged since the earliest habit research by behaviorists (e.g., Skinner, 1953). Given the greater time and effort required to enact complex behaviors, these would be even easier to cease if they stopped being rewarding, then simple habits which may be able to continue without conscious awareness of a reward or lack thereof (in the case of no barriers to continuing the behavior). It is important to note that there are other types of motivation that may also facilitate habit formation, although they are not the focus of the current investigation; for example, autonomous motivation includes intrinsic motivation (e.g., behavioral enjoyment) and identified regulation (motivation to behavior in line with one's personal values).

In addition to habit and intrinsic motivation, we focus on behavioral self-identity (e.g., identity as an exerciser) as a mechanism of behavioral maintenance. Self-identity based on one's engagement in a behavior is associated with behavioral maintenance (Caldwell et al., 2018; Verplanken and Sui, 2019) but has primarily been studied in exercise contexts (Anderson and Cychosz, 1994; Rhodes et al., 2021). Identity may play both a reflective and reflexive role in behavioral engagement (Stets and Burke, 2000; Strachen et al., 2009). Acting in line with our identity is rewarding (causes positive affect; e.g.,

1 N.B. The present study focuses on health promotive behaviors. The role of rewards in habit development and cessation may differ for health risky behaviors, in that health risky behaviors are thought to be inherently rewarding (e.g., addictive) for those who engage in them—e.g., consuming sugary beverages and smoking cigarettes have naturally rewarding biological mechanisms that make them easier to become habitual or addictive.

Stets and Burke, 2000) and may therefore serve as a form of intrinsic reward for continued behavioral engagement; it may also therefore serve a direct role in habitual action, given that intrinsic behavioral rewards strengthen habit. Identity also plays a reflective (conscious, deliberative) role in behavioral engagement, in that we behave in ways that we reflect are in line with our identities (Burke, 2006).

Although some behavior theories propose transitions in predictive factors from initiation through maintenance, little research has empirically evaluated how these factors change over time and how they change in relative importance for promoting behavioral engagement over time, with behavioral repetition. Additionally, researchers have yet to evaluate how behavioral initiation and maintenance factors and the transition between them for predicting behavioral engagement may differ across behaviors that vary in complexity. For example, a simple behavior, such as taking pill, may be motivated by the desire for better health (identified regulation; Deci and Ryan, 2000), but not necessarily intrinsic motivation, which is posited to be more important for initiation (and maintenance) of complex behaviors, such as exercise (Phillips et al., 2016). Further, strong habit may be sufficient for maintenance of a simple behavior, in a stable context, whereas a complex behavior may require self-identification with the behavior and intrinsic motivation, in addition to or as part of a strong habit (Phillips and Mullan, 2022).

Therefore, the purpose of the current study is to evaluate changes in behavior change factors over time and their importance for predicting subsequent behavior for a simple vs. a complex health behavior. Calcium supplementation and exercise were chosen for the current study for the following reasons: First, they fit with the concept of relatively simple and complex behaviors, respectively, since taking a pill takes relatively fewer steps and less time to prepare for and enact than does going for a brisk walk (exercising) (see Phillips and Mullan, 2022). Second, these behaviors are both target health behaviors for disease prevention and management and therefore have clinical importance. Third, existing research has measured/observed and targeted via intervention medication-taking and exercise-related habits (e.g., Phillips et al., 2016). Lastly, these behaviors can be objectively assessed via sensors in addition to self-reported measures.

Based on widely used theories and frameworks, we focus the current investigation on the behavioral initiation factors of self-efficacy for engaging in the behavior (perceived behavioral control, task self-efficacy), behavioral intentions, and intrinsic motivation; and on proposed behavioral maintenance factors—habit strength, identity, and intrinsic motivation.

We test the following hypotheses: (1) behavioral intentions and self-efficacy (behavioral initiation factors) will be high and remain high or decrease over time for individuals newly engaging in a simple (taking a daily calcium supplement) or complex (going for a daily, brisk, 20 + minute walk) behavior; (2) intrinsic motivation (initiation and maintenance factor for complex behaviors) will start and remain low for calcium supplementation but will increase over time for exercise; (3) habit strength (a maintenance factor) will start low and increase over time for both behaviors; (4) behavioral identity (a maintenance factor) will start and remain low for calcium consumption and will start low but increase over time for exercise.

Additionally, regarding their role in behavioral prediction, we hypothesize that (5) behavioral intentions and self-efficacy will predict initial adherence to calcium supplementation (self-reported and objectively measured, weeks 1 and 2); whereas habit strength will predict calcium supplementation adherence in later weeks (weeks 3 and 4); and (6) behavioral intentions, self-efficacy, and intrinsic motivation will predict exercise frequency and step-counts in initial weeks (weeks 1 and 2); whereas habit strength, intrinsic motivation, and exercise identity will predict exercise frequency and step-counts in later weeks (weeks 3 and 4).

Materials and methods

Participants and procedure

Young adult women study volunteers, who did not previously take calcium supplements and got less than recommended amounts of physical activity (self-reported getting less than 150 min of moderate intensity or greater activity per week), were randomly assigned to have a target behavior of taking a calcium supplement (N = 185) or to go for a brisk, 20-min, walk (N = 182), on at least 5 of 7 days of each week, for 4 weeks. In the whole sample, approximately 76.6% identified as White, 4.6% as Black, 3.8% as South Asian, 4.9% as East Asian, <1% as Native American, 7.1% as "Other," and 2.7% chose not to respond regarding their racial identity. A majority (90.5%) identified as Non-Hispanic, 8.4% identified as Hispanic, and 1.1% chose not to respond to the item regarding Ethnic identity. The average age of participants was 19.11 (SD = 1.56).

The current analyses utilize data from an intervention study that tested a habit formation strategy (action planning) with various timing-manipulations (morning vs. evening cues) and a control group. Both behaviors had the same manipulations/groups, and the data for the current analyses collapse across the experimental conditions for each behavior; however, analyses control for experimental condition. Most of the variables included in the current analyses (intentions, self-efficacy, intrinsic motivation, and identity) are not included in the main evaluation of the intervention. The main intervention study evaluates which group(s) had greater habit formation and behavioral frequency over the 4 weeks of the study (Phillips et al., in preparation). The hypotheses tested in the current analyses and in the main intervention analyses are entirely different

from each other. The data took four semesters (2 academic school years) to collect, prior to the COVID-19 pandemic. Informed consent to participate in the study was provided by all participants, prior to the beginning of the baseline session, and all procedures were approved by the local institutional review board.[2]

All predictors (behavior-specific intentions, self-efficacy, intrinsic motivation, self-identity, and habit strength) were measured at baseline (in-person survey), weekly for 3 weeks (online surveys), and at a final 4-week follow-up (in-person survey). Participants were also provided with a digital sensor for their assigned behavior—a Medication Event Monitoring System Cap (MEMS Cap; Aardex, Belgium) for those taking calcium supplements, and an accelerometer (Fitbit Zip) for those in the exercise conditions. The Fitbits were covered so that participants were not able to see how many steps they were taking. The MEMS Caps gave no information regarding the participants' behavior to the participants themselves, but recorded the exact time the bottle was opened (and a pill taken, theoretically).

Power calculations to determine sufficient sample size were conducted for the main study, to detect differences in behavior change between experimental conditions, rather than for the present analyses. We therefore conducted *post hoc* power analyses at alpha = 0.05, and observed power was 100% for all ANCOVA (i.e., to detect significant main and interaction effects with the three dummy coded co-variates for intervention condition and time and behavior as factors) and linear regression (i.e., to detect a significant increase in R2 with addition of four predictor variables—intention-efficacy, intrinsic motivation, habit strength, and identity) analyses (evaluated with SPSS and G*Power, respectively; Erdfelder et al., 1996).

Measures

Intentions and self-efficacy

Items to assess intentions and self-efficacy for engaging in the target behaviors were created from guidelines for developing Theory of Planned Behavior questionnaires (see Fishbein and Ajzen, 2010). Participants were asked the items about their assigned behavior: "I intend to exercise (e.g., take a brisk walk) for 20 + minutes at a moderate-vigorous intensity on 5 + days during the next week" or "I intend to take calcium on 5 + days during the next week"; and for self-efficacy (perceived behavioral control): "I am confident that I can exercise (e.g., take a brisk walk) for 20 + minutes at a moderate-vigorous intensity on 5 + days during the next week" or "I am confident I can take a calcium supplement on 5 + days during the next week." These two items were highly correlated with each other, at r = 0.85 in the calcium data and r = 0.76 in the exercise data. Further, we evaluated the trajectory of change in these variables over time separately, and the trajectories were equivalent (each individual trajectory was the same as seen for the combined variable, in **Figure 1A**). Lastly, the correlations between the intention and self-efficacy variables with outcomes were meaningfully equivalent (i.e., in size of effect and statistical significance level). Therefore, the items were combined (averaged) to represent participants' intentions-efficacy for engaging in the target behavior in the subsequent week.

Intrinsic motivation

Intrinsic motivation to exercise was measured with two items from the intrinsic regulation subscale of the Behavioral Regulation of Exercise Questionnaire (BREQ-3; Markland and Tobin, 2004; Wilson et al., 2006). The items were tailored to refer to the past week as a reference point (vs. no time reference in the original items), and the calcium group was asked about calcium supplementation instead of exercise. The items are rated on a Likert scale from not true for me (1) to very true for me (5): "In the past week, I enjoyed going for my brisk walk (or equivalent activity)/taking my calcium supplement" and "In the past week, I got pleasure and satisfaction from taking my brisk walk (or equivalent activity)/taking my calcium supplement."

Habit strength

Habit strength was measured with two items from the 4-item Self-Reported Behavioral Automaticity Index (SRBAI; Gardner et al., 2012). The items were rated on the Likert scale, strongly disagree (1) to strongly agree (5): "In the past week, going for my brisk walk (or equivalent activity)/taking my calcium supplement was something I did without thinking" and "In the past week, going for my brisk walk (or equivalent activity)/taking my calcium supplement was something I did automatically."

Identity

The degree to which an individual identifies as an exerciser was assessed with one item from the Exercise Identity Scale (Anderson and Cychosz, 1994). It is rated on the Likert scale, strongly disagree (1) to strongly agree (5): "I consider myself an exerciser." Participants in the calcium group were given an item created for the current study, as a literature search did not find any existing items related to medication-adherence identity:

2 Informed consent did not include consent to publicly share individual-level data. Therefore, we will privately provide access to the original data, codebook, and analysis syntax to any researcher wishing to verify the data presented in this paper. A limitation of this study is that it was not pre-registered, since the study was designed and data collection begun before our lab made it a regular practice to pre-register studies in a publicly accessible repository. However, we aim for transparency by following a multiverse approach to data analysis, which evaluates the robustness of the results. And we encourage interested parties to request the data.

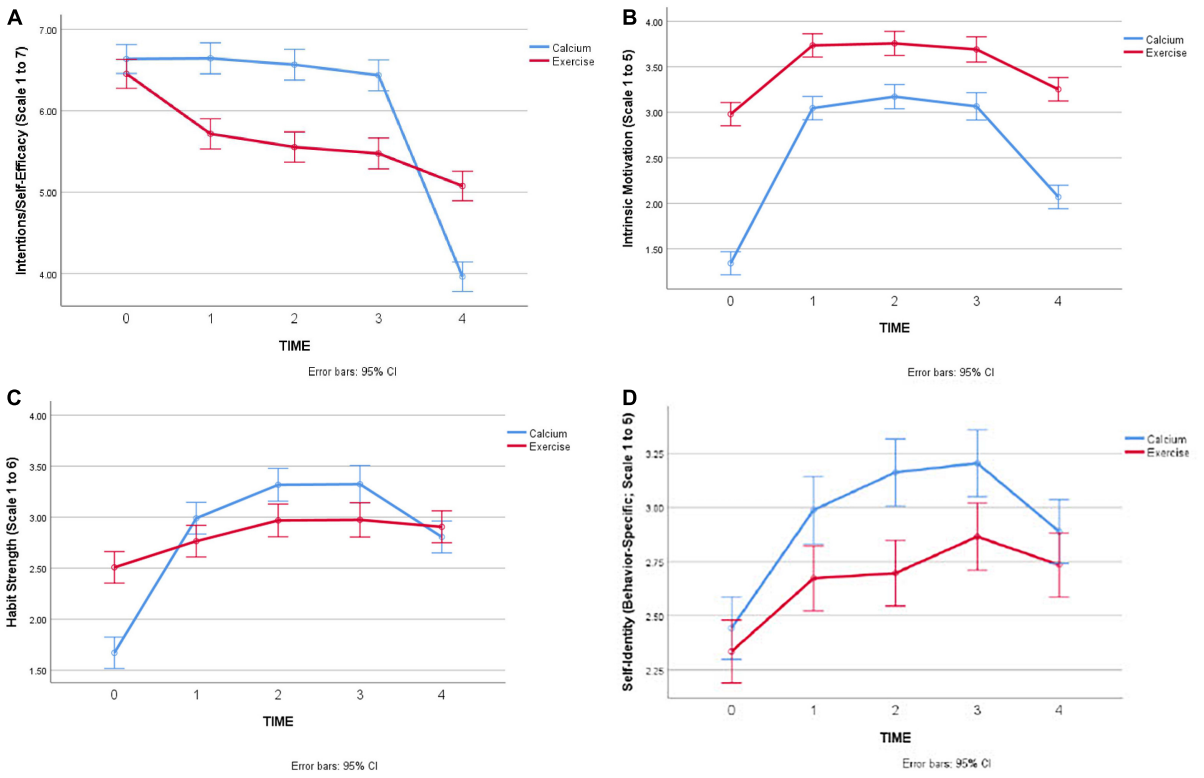

FIGURE 1
(A) Change in intentions-efficacy over time, by behavior. **(B)** Changes in intrinsic motivation over time, by behavior. **(C)** Changes in habit strength over time, by behavior. **(D)** Changes in behavioral identity over time, by behavior.

"I consider myself to be someone who makes an effort to get enough calcium."

Behavioral engagement

The outcome measure for calcium supplementation was the number of days per week the supplement was taken, measured via electronic monitoring pill bottles and self-report. The self-report item was, "On how many days in the past week did you take calcium?" The outcome measures for brisk walking were the number of days per week with a brisk walk, measured via self-report, and the average daily number of steps per week, measured via an accelerometer (Fitbit Zip). The self-report item was, "On how many days in the past week did you exercise at a moderate to vigorous intensity (e.g., brisk walk)?"

Analysis plan

Preliminary analyses

Some self-report/survey data and some sensor data were missing, at various timepoints, for some participants. The percentage of observed timepoints for all participants that had missing survey data is 6.8%, across both behaviors (125 observations out of 1,835 total observations). For sensor data, 14.2% of observations had missing data. The missing data were scattered throughout, and only two individuals showed true attrition, meaning they had baseline data and then were missing all subsequent follow-up timepoints; these two individuals were excluded from all analyses.

We evaluated univariate outliers by determining if there were scores on the variables that were ± 3 standard deviations from the averages for those variables. Multivariate outliers were determined through evaluating Mahalanobis distance values at standard protocol significance level of $p < 0.001$ (Tabachnick and Fidell, 2007). After accounting for univariate outliers, there were no multivariate outliers. There were only two individuals who were univariate outliers and they were outliers on only the Fitbit measure of average steps per day, per week, for weeks 1, 2, and 3. Their values were in the realm of possibility (human capability), and so we Winsorized their outlying values so that they were still greater than the other participants' values but only 3 SD above the mean (instead of 6 and 8 SD above the mean).

There were 13 individuals who failed a random response check, where they were asked to indicate a specific response to a Likert scale item, embedded within other Likert scale items. We compared correlations between the current study variables with and without these random responders included, and the correlations/effects and significance values did not meaningfully

change. Therefore, we analyzed tests of the hypotheses including all participants.

Tests of hypotheses

We conducted 2 (behavior) × 5 (time-point) ANCOVAs for each behavior change factor to evaluate Hypotheses 1–4—i.e., to see the average rate of change in the factors, by behavior, over time, controlling for the intervention conditions in dummy coded variables. For hypotheses 5 and 6, bivariate correlations and multiple regression analyses (controlling for intervention conditions) were conducted for each behavioral outcome at weeks 1, 2, 3, and 4, with predictor variables measured at the preceding time-point entered into the model. That is, baseline (W0) predictors were used to predict week 1 behavioral engagement, week 1 predictors were used to predict week 2 behavioral engagement, and so forth.

Results

Hypothesis 1 (behavioral intentions and self-efficacy will be high and remain high or decrease over time for simple and complex behaviors). There were significant main effects for Time and Behavior, qualified by a significant interaction between Time and Behavior ($F = 47.33$, $p < 0.001$) in predicting intentions-efficacy over time (see Figure 1A, which shows 95% confidence intervals for mean levels of intention-efficacy). Intention-efficacy was not significantly different for calcium and exercise groups, at baseline, and both behavioral groups showed a marked decrease in intentions and self-efficacy at the final-timepoint. Exercise participants showed a more gradual decline than calcium participants, who only decreased in intentions and self-efficacy at the final timepoint.

Hypothesis 2 (intrinsic motivation will start and remain low for calcium supplementation but will increase over time for exercise). There were significant main effects of Time and Behavior in predicting intrinsic motivation over time, but these were qualified by a significant interaction between Time and Behavior ($F = 23.57$, $p < 0.001$). Figure 1B shows the results for intrinsic motivation, with 95% confidence intervals on the mean levels of intrinsic motivation for each behavior at each timepoint: As hypothesized, intrinsic motivation was higher for exercise than calcium at the start and throughout the study. However, intrinsic motivation did increase (and then decrease) for calcium consumption, which was not expected.

Hypothesis 3 (habit strength will start low and increase over time for both behaviors). There were significant main effects of Time and Behavior in predicting habit strength over time, which were qualified by a significant interaction between Time and Behavior ($F = 19.54$, $p < 0.001$). As seen in Figure 1C, there was an overall increase in habit strength, with a slight decrease at the final timepoint for calcium supplementation. We note that neither behavior shows an average level of habit strength = 4, which is a rough level associated with "having a habit," since individuals have to agree on average with the statements that their engagement in the behavior is "automatic," or habitual, to have a score of 4.

Hypothesis 4 (behavioral identity will start and remain low for calcium consumption and will start low but increase over time for exercise). Differently to the other variables, there was a non-significant interaction between Time and Behavior in predicting behavioral identity over time ($F = 1.81$, $p = 0.12$). There were significant main effects of Time ($F = 21.25$, $p < 0.001$) and Behavior ($F = 32.85$, $p < 0.001$), as shown in Figure 1D. Unexpectedly, the calcium group showed slightly higher identity scores at the end of weeks 1–3, than the exercise participants, with a slight decrease at the final timepoint. As expected, exercise participants did show a slight increase in exercise identity over the course of the study.

Hypothesis 5 (behavioral intentions and self-efficacy will predict initial adherence to calcium supplementation, whereas habit strength will predict calcium supplementation adherence in later weeks). Regarding initial adherence to calcium supplementation: In week 1, as hypothesized, intentions-efficacy was the only baseline-measured factor to predict self-reported and objectively measured calcium supplementation, in bivariate and regression analyses. However, by week 2, intentions-efficacy was not the only predictive factor of calcium adherence: intrinsic motivation was a significant predictor in both bivariate and regression analyses of self-reported and objectively measured calcium adherence. Habit strength predicted both of these outcomes, but only in bivariate analyses. Table 1A shows correlational analyses, and Table 2A shows regression analyses (for weeks 1 and 4 outcomes), for calcium supplementation variables.

Regarding adherence in later weeks of the study: For week 3 outcomes, intentions-efficacy, intrinsic motivation, and habit strength again predicted calcium supplementation adherence, both self-reported and objectively measured, in bivariate analyses. In simultaneous regression of self-reported adherence, only intentions-efficacy remained a significant predictor; however, for objectively measured adherence, intentions-efficacy and habit strength remained significant predictors. Therefore, there was partial support of the hypothesis that habit strength would become more predictive of behavior in later weeks of the study. However, for Week 4 outcomes, the reverse was true: intentions-efficacy is the only factor that remains a significant predictor in regression analysis of objectively measured adherence, but intentions-efficacy and habit strength remained significant predictors in regression analysis of self-reported frequency. Therefore, overall, we did not find support for the hypothesis that, for calcium supplementation, habit strength would take over as a predictor of behavioral frequency in later weeks, from intentions and self-efficacy, which was expected to predict behavioral frequency initially.

Hypothesis 6 (behavioral intentions, self-efficacy, and intrinsic motivation will predict exercise frequency and step-counts in initial weeks, whereas habit strength, intrinsic

TABLE 1A Correlation results for calcium supplementation variables.

	Week 1		Week 2		Week 3		Week 4	
	Self-report	Objective	Self-report	Objective	Self-report	Objective	Self-report	Objective
1. Intentions-efficacy	0.363**	0.370**	0.492**	0.472**	0.487**	0.438**	0.675**	0.481**
2. Intrinsic motivation	0.017	0.013	0.282**	0.269**	0.229**	0.190*	0.359**	0.241**
3. Identity	0.099	0.055	0.085	0.066	0.096	0.122	0.341**	0.108
4. Habit strength	0.012	0.021	0.277**	0.252**	0.298**	0.358**	0.561**	0.296**

The predictors used to calculate each correlation were measured at the preceding timepoint to the outcome. Therefore, for W1 (week 1) Self-report and objective outcomes (calcium supplementation frequency), the predictors were measured at baseline (W0). For W2 outcomes, predictors were measured at W1, and so forth.
*$P < 0.05$ and **$P < 0.01$.

TABLE 1B Correlation results for exercise variables.

	Week 1		Week 2		Week 3		Week 4	
	Self-report	Objective	Self-report	Objective	Self-report	Objective	Self-report	Objective
1. Intentions-efficacy	0.230**	0.103	0.524**	0.202*	0.499**	0.132	0.596**	0.043
2. Intrinsic motivation	0.095	0.196*	0.242**	0.214*	0.317**	0.131	0.413**	0.201*
3. Identity	0.087	0.117	0.135	0.277**	0.231**	0.177*	0.383**	0.219*
4. Habit strength	0.042	0.159	0.195*	0.221*	0.332**	0.175	0.459**	0.131

The predictors used to calculate each correlation were measured at the preceding timepoint to the outcome. Therefore, for W1 (week 1) Self-Report and Objective outcomes (exercise frequency and step counts), the predictors were measured at baseline (W0). For W2 outcomes, predictors were measured at W1, and so forth.
*$P < 0.05$ and **$P < 0.01$.

TABLE 2A Regression results for calcium supplementation variables (weeks 1 and 4 outcomes only, for comparison and space reasons).

	B	SE	Beta	T	Sig.
Predicting self-reported calcium supplementation in week 1					
(Constant)	1.31	0.99		1.32	0.19
Intentions-efficacy, W0	0.66	0.14	0.37	4.84	0.000
Intrinsic motivation, W0	−0.02	0.17	−0.01	−0.14	0.89
Identity, W0	0.15	0.11	0.11	1.34	0.18
Habit strength, W0	−0.05	0.13	−0.03	−0.41	0.68
Predicting objective calcium supplementation in week 1					
(Constant)	2.02	0.85		2.36	0.02
Intentions-efficacy, W0	0.60	0.12	0.37	5.05	0.000
Intrinsic motivation, W0	−0.03	0.15	−0.02	−0.19	0.85
Identity, W0	0.09	0.10	0.08	0.95	0.34
Habit strength, W0	−0.02	0.11	−0.02	−0.21	0.84
Predicting self-reported calcium supplementation in week 4					
(Constant)	−1.28	0.63		−2.03	0.04
Intentions-efficacy, W3	0.86	0.11	0.55	7.77	0.000
Intrinsic motivation, W3	0.00	0.13	0.00	−0.003	0.997
Identity, W3	0.10	0.11	0.06	0.90	0.37
Habit strength, W3	0.34	0.10	0.24	3.34	0.001
Predicting objective calcium supplementation in week 4					
(Constant)	−1.11	0.90		−1.17	0.85
Intentions-efficacy, W3	0.95	0.16	0.54	6.05	0.000
Intrinsic motivation, W3	0.18	0.16	0.11	1.14	0.26
Identity, W3	−0.06	0.14	−0.04	−0.42	0.67
Habit strength, W3	−0.03	0.13	0.02	0.23	0.82

Regression analyses control for intervention group assignment. Results do not meaningfully differ when intervention condition is controlled for or not.

TABLE 2B Regression results for exercise variables (weeks 1 and 4 outcomes only, for comparison and space reasons).

	B	SE	Beta	T	Sig.
Predicting self-reported exercise frequency in week 1					
(Constant)	0.25	1.13		0.22	0.83
Intentions-Efficacy, W0	0.49	0.17	0.23	2.95	0.004
Intrinsic Motivation, W0	0.02	0.15	0.01	0.15	0.88
Identity, W0	0.07	0.17	0.04	0.40	0.69
Habit Strength, W0	0.07	0.13	0.05	0.53	0.60
Predicting objective physical activity in week 1					
(Constant)	4404.60	1705.87		2.58	0.01
Intentions-Efficacy, W0	264.34	252.37	0.09	1.05	0.30
Intrinsic Motivation, W0	442.63	256.10	0.18	1.73	0.09
Identity, W0	−143.92	285.32	−0.05	−0.50	0.62
Habit Strength, W0	308.90	206.96	0.14	1.49	0.14
Predicting self-reported exercise frequency in week 4					
(Constant)	−0.55	0.48		−1.15	0.25
Intentions-Efficacy, W3	0.57	0.08	0.50	6.96	0.000
Intrinsic Motivation, W3	−0.06	0.16	−0.03	−0.36	0.72
Identity, W3	−0.03	0.12	−0.02	−0.23	0.82
Habit Strength, W3	0.50	0.14	0.30	3.49	0.001
Predicting objective physical activity in week 4					
(Constant)	5338.93	1515.74		3.52	0.001
Intentions-Efficacy, W3	−233.66	234.76	−0.11	−1.00	0.32
Intrinsic Motivation, W3	465.61	454.51	0.14	1.021	0.31
Identity, W3	587.29	312.13	0.22	1.88	0.06
Habit Strength, W3	−62.63	387.28	−0.02	−0.16	0.87

Regression analyses control for intervention group assignment. Results do not meaningfully differ when intervention condition is controlled for or not.

motivation, and exercise identity will predict exercise frequency and step-counts in later weeks). Regarding initial exercise frequency: Baseline levels of intentions-efficacy predicted self-reported exercise frequency in week 1, in both bivariate and regression analyses. Intrinsic motivation was the only bivariate predictor of Fitbit steps per day in week 1, and no predictors were significant in regression analysis of Fitbit steps. These regression results were the same, with week 1 factors predicting week 2 exercise outcomes—only intentions-efficacy predicted self-reported exercise frequency. In bivariate analyses, however, intentions-efficacy, intrinsic motivation, and habit strength predicted both self-reported and objectively measured exercise. These bivariate analyses partially support the hypothesis that intentions-efficacy and intrinsic motivation would predict exercise frequency in initial weeks. Table 1B shows correlational analyses, and Table 2B shows regression analyses (for weeks 1 and 4 outcomes), for exercise and step-count variables.

Regarding exercise frequency in later weeks of the study: There was partial support for the hypothesis, in that intrinsic motivation, identity, and habit strength (measured in weeks 2 and 3, respectively) were significant bivariate predictors of self-reported exercise frequency in Weeks 3 and 4 (respectively). Counter to expectations, intentions-efficacy remained a significant predictor of self-reported exercise frequency in both weeks 3 and 4. In regression analysis of self-reported exercise frequency in weeks 3 and 4, intentions-efficacy and habit strength were significant predictors. None of the factors were significant predictors in regression analysis of Fitbit activity, and only identity (in week 3) and identity and intrinsic motivation (in week 4) were significant predictors of Fitbit activity in bivariate analyses.

Overall, these results indicate that intentions and self-efficacy remain important for exercise engagement through 1-month post-initiation, and that habit strength, identity, and intrinsic motivation may become more important for exercise frequency over time.

Discussion

Overall, the results were partly in-line with expectations, in that individuals' intentions and self-efficacy predicted initial behavioral engagement for both calcium supplementation and exercise, and habit strength increased for both behaviors and became a significant predictor of behavioral frequency in later

weeks of the study. However, there were some mixed and unexpected findings that warrant discussion. First, intentions and self-efficacy went starkly down at the end of the study, most likely because participants were only planning to engage in the behaviors for the duration of the study. This speaks to the difficulty in changing behavior when motivation for change is extrinsic (Deci and Ryan, 2000; Ryan and Deci, 2000). The education provided to participants on the importance of getting regular calcium and exercise may not have been enough to persuade the participants to continue with the behaviors after the end of the study. It is unusual for intentions and self-efficacy to be combined. The statistical similarity of the variables to each other and to the outcomes in this study is likely due, at least partially, to the short and similar measures of these constructs.

Second, intrinsic motivation increased (and then decreased) for calcium consumption, which was not expected, since it was not thought that taking calcium supplements could be enjoyable (as might be the case if the calcium supplements were in candy form). However intrinsic motivation items do capture "pleasure and satisfaction" from taking calcium supplements; therefore, participants may have felt a sense of satisfaction in taking their calcium supplements, which may have driven the observed effects. Indeed, medication adherence literature has focused on autonomous motivation (vs. merely intrinsic motivation, or enjoyment) in predicting adherence (e.g., Williams et al., 1998; Kennedy et al., 2004).

Third, habit strength increased for both behaviors, as expected, but it was not expected that habit strength would decrease at the final time-point. A recent study found that some individuals showed a similar "discontinuous habit formation" trajectory, for a nutrition-related behavior (Keller et al., 2021). The dip observed in habit strength and other variables in the present study may be due to the sample and method of compensation (students who were compensated with course credit)—issues of participant motivation; that is, participants' motivation may have been sufficiently low that they were not invested in the behavior enough to form a habit and to want to continue the behavior after the end of the study. This raises interesting questions about the need for intrinsic or autonomous motivation for forming even relatively simple health-related habits, not just for complex behaviors, such as exercise.

Fourth, counter to expectations, identity with calcium supplementation was higher than for exercise identity throughout, which may be due to a lack of direct comparability between behaviors on identity items. That is, the items differed in ways that may make them inappropriate for direct comparison (i.e., "I see myself as someone who regularly takes calcium" vs. "I see myself as someone who regularly exercises"). Further, we also found that identity did not predict exercise frequency in later weeks, in multivariate analyses. This does not fit with extensive literature showing that exercise identity is associated with exercise frequency (Anderson and Cychosz, 1994; Caldwell et al., 2018; Verplanken and Sui, 2019; Rhodes et al., 2021). Behavioral identity may take much longer to develop than the time observed in this study. Future research should evaluate the mechanisms that may lead to behavioral identity formation (e.g., goal attainment, peer group changes, social identities; Stevens et al., 2017).

Other factors that warrant discussion include the fact that there were mixed results between self-reported and objectively measured behavioral outcomes, for some of the factors. These differences may have been due to common method variance between the self-reported outcome with the self-reported predictive factors. Most of the disagreement was between Fitbit-measured activity and self-reported exercise frequency. These discrepancies are likely due to the fact that the Fitbit-measured variable was not exercise frequency but overall physical activity. Although we would expect greater exercise frequency to manifest in greater activity overall, and therefore concordance between self-reports and Fitbit data, this is not necessarily the case, since some individuals are active throughout the day but never engage in leisure-time purposeful physical activity ("exercise sessions"). Exercise and physical activity are considered distinct constructs with potentially different predictors (Dasso, 2019).

Results also differed between bivariate and multivariate analyses for some of the hypothesis tests. Attenuation of bivariate relationships in multivariate analyses is likely due to the theoretical overlap between factors (intrinsic motivation and habit, intrinsic motivation and intentions, etc.). Future research should evaluate the relative importance of these factors (and whether each construct is a necessary but not sufficient condition) for behavior change and maintenance (Rothman, 2004).

Another limitation is that there were some missing data points, although, the missing data in this dataset are not due to typical attrition seen in other health-behavior intervention trials. The mode of compensation could account for this—the participants were compensated with course credit upon completion of the study and going to a final in-person session to turn in their devices and answer the final survey questions. A final limitation is that the current study compared one simple behavior to one complex behavior, and there may have been other differences between these behaviors that could have affected the results, beyond their relative complexity. The exercise task of going for a brisk walk may not have been particularly difficult or complex for individuals, as well, since the participants were students on a college campus and likely walk a substantial amount incidentally. Future research could compare multiple types of simple and complex behaviors to each other.

The current findings contribute to theories of behavior change and maintenance, in that they suggest the transition to maintenance action control may take longer than a month for both simple and complex health behaviors. This corroborates extant literature that has found habits take a range of times, but with most estimates longer than 4 weeks (Lally et al., 2010;

Keller et al., 2021). Further, although the M-PAC (Rhodes et al., 2021) was designed to explain physical activity behavior, the results suggest that identity, intrinsic motivation, and habit strength may be important for simple behaviors and not just for exercise-related behavior. How the MPAC might apply to other health behaviors, whether simple or complex, may also depend on whether the behavior is an action or inaction, intended or counter-intentional behavior, which future research can evaluate. Overall, the current findings suggest that differences in initiation and maintenance between behaviors of differing complexity may not be as stark as theorized (as in Phillips and Mullan, 2022). However, much longer follow-up times are required to evaluate maintenance factors. Lastly, the current findings are too preliminary to suggest specific intervention tactics. For example, even if intentions become less important and habit strength increases as behavior is repeated over time, this does not mean that interventions need focus on intentions and then switch to habit formation strategies. Indeed, habit formation, although a maintenance mechanism, might best be started at behavioral initiation (Lally and Gardner, 2013).

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 human participants were reviewed and approved by Iowa State University IRB. The patients/participants provided their written informed consent to participate in this study.

Author contributions

LP conceived and designed the study, helped the collect data and supervised data collection, cleaned and analyzed the data, and wrote the manuscript. KM helped the collect data and supervised data collection, provided critical feedback on the current study analyses and manuscript, and edited the manuscript. 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.

Publisher's note

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The effects of a cluster-randomized control trial manipulating exercise goal content and planning on physical activity among low-active adolescents

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The purpose of the present two studies was to investigate whether in framing messages that target salient beliefs of youth, the type of goal framed matter to promote physical activity (PA) participation among low-active adolescents (i.e., participating in less than 1 h/day of moderate-to-vigorous PA). More specifically, the main trial (study 2) compared the effect of intrinsic and extrinsic-goal framing messages alongside planning (IMC + P and EMC + P) to a control condition (CC) on low-active adolescents' physical activity (PA), intention, attitude, and exercise goals, and examined the potential meditational effect of these variables between condition and PA. Low-active students (n = 193; M age = 16.89) from fifteen classes were assigned to one of these three conditions. PA was assessed using an accelerometer, and the socio-cognitive mediators were measured at baseline (i.e., 2 weeks before the intervention) and post-test, and the intention was measured again at follow-up (i.e., 2 weeks after the intervention). Results showed that compared to adolescents in the CC group, those in the experimental conditions did not do more moderate PA, but carried out more light PA, and yielded an increase in attitude and intention. Mediational analysis revealed no significant effect of the potential mediators.

KEYWORDS

framing message, self-regulation, physical activity, self-determination theory, theory of planned behavior

Introduction

Despite the fact that participation in regular physical activity (PA) has numerous health benefits for young people [e.g., lower incidence of a broad variety of chronic diseases, and generating positive mental health outcomes; for more details see Hallal et al. (2006), Biddle and Asare (2011)], many children and adolescents are physically inactive and become even less active as they become older. Self-reported

PA collected across 105 countries reveals that 80% of youths aged 13–15 years old do not reach the recommended public health guidelines of 60 min PA per day (World Health Organization, 2009, 2010, 2011); for a review, see Hallal et al. (2012), Inchley et al. (2016). This rate is even lower when PA is measured with objective measures (i.e., accelerometers). For example, a study of 10 to 12-year-old European children reported that only 4.6% of girls and 16.8% of boys achieved these recommendations (Verloigne et al., 2012). These percentages are alarming and imply an urgent need to develop effective theory-based PA promotion programs for low-active adolescents (Gourlan et al., 2016).

Among the different models of health behavior change, it is now assumed that there are at least two main stages or phases of behavior change, a *motivational* stage that ends with the formation of a behavioral intention, and a *volitional* stage that ends with successful performance of the behavior; see Gollwitzer (1999), Schwarzer (2008). For the motivational stage there is an on-going debate over the content of the message to address to those targeted. While the proponents of the theory of planned behavior (TPB, Ajzen, 1991) assume that health messages should frame people's salient beliefs in order to change their behavior, adherents of the self-determination theory (SDT; Ryan and Deci, 2017) suggest that the impact of messages on the behavioral change process may vary according to the nature of goal content (i.e., intrinsic *versus* extrinsic) framed.

Therein, the present study is a theory-based intervention that aimed to examine whether message promoting PA behavior should be framed only to fit the salient beliefs of individuals targeted, as presumed by the TPB (Ajzen, 1991), or whether the goal content framed in the message needs to be considered, as presumed by the SDT (Ryan and Deci, 2017).

The TPB (Ajzen, 1991) assumes that a person's intention to perform a given behavior, such as PA, is a central determinant of that behavior. Intention is an indicator of how hard people are willing to try, and of how much effort they are planning to exert toward the performance of a behavior (Ajzen, 1991). Intention is determined by three conceptually distinct variables: attitude toward the behavior (i.e., a summary evaluation captured in evaluative dimensions such as good–bad, harmful–beneficial and pleasant–unpleasant), subjective norm (i.e., the perceived social pressure that individuals may feel to perform a given behavior or not) and perceived behavioral control (i.e., the perceived ease or difficulty associated with execution of the behavior in the future) (Ajzen, 1991).

Because attitude, subjective norm, and behavioral control are assumed to be based on corresponding sets of beliefs – namely, behavioral beliefs, normative beliefs, and control beliefs – behavioral interventions have to change such beliefs in order to change intention and eventually behavior (Ajzen, 1991). For this, the theory advises providing persuasive communications targeting modal accessible beliefs (i.e., the most commonly held beliefs in the population). For example, studies (e.g., Hagger et al., 2001) showed that youth-salient behavioral beliefs (i.e., the beliefs that are readily accessible in the memory) toward PA include "to get fit/stay in shape," "to have fun," "to improve their skills," "to make friends," " to explore something new," "to fulfil a fantasy or dream," "to have a sense of escape or adventure." As a result, according to TPB, messages should be framed to fit the modal beliefs of the target population. The greater the perceived probability that the behavior will produce such desirable outcomes, the stronger the impact of the beliefs on the attitude and in turn on the intention. In other words, it is assumed that people's behavioral beliefs or goals are all equally effective for changing their behavior, and that what matters is that the messages be congruent with people's salient beliefs. This may not be true for the proponents of SDT.

Within the Goal Content Theory (GCT), a sub-theory of SDT, researchers consider the content of the goals people value. They have differentiated *intrinsic goals* from *extrinsic goals* (Deci and Ryan, 2000). *Intrinsic goals* are those focused toward developing one's personal interests, values and potentials and are inherently satisfying to pursue. In contrast, *extrinsic goals* are primarily characterized by having an "outward" orientation, with one's pursuit being directed toward external indicators of worth such as wealth, fame and an appealing image (Vansteenkiste et al., 2006). In the PA domain, the goals of skill development, social affiliation, and health management have been characterized as intrinsic goals, and image improvement and social recognition as extrinsic goals (Sebire et al., 2008). Research has revealed that the two goals are differently associated with PA: intrinsic goals are indirectly and positively related to PA, whereas extrinsic goals are indirectly and negatively related to PA *via* self-determined motivation (Gillison et al., 2006; Sebire et al., 2011).

Little research has examined the effect of goal-framing manipulation on PA behavior (Vansteenkiste et al., 2004a,b; Gallagher and Updegraff, 2012; Gillison et al., 2013; study 3). Vansteenkiste et al.'s work examines the effect of intrinsic goal-framing (i.e., exercise could help you attain the goal of physical fitness) *versus* extrinsic goal-framing (i.e., exercise is useful for attaining the goal of appearing physically attractive) conditions on 10th to 12th grades students' performance and persistence in the tai-bo martial art. In their study Gillison et al. (2013) examined the effect of manipulating adolescents' goal contents (i.e., health and fitness *versus* looking good to others) on their participation in school physical education. Finally, Gallagher and Updegraff (2012) examined the interaction effect between gain-and loss framed messages, intrinsic and extrinsic goal-framing messages (i.e., well-being *versus* appearance), and the need for cognition on undergraduate students' PA behavior. Results revealed that the effect of goal-framing messages on PA is inconsistent: Vansteenkiste et al. (2004a) showed that an intrinsic goal-framing message was more efficient than an extrinsic goal-framing message in improving sport

performance and persistence, but Gillison et al. (2013) revealed the superiority of extrinsic goal-framing conditions on PA intention, while Gallagher and Updegraff (2012) showed that goal-framing manipulation had no effect on PA participation. This inconsistency may be due to differences in the measure of the dependent variable: there is a gap between intention and the actual PA behavior (Rhodes and de Bruijn, 2013), and between a self-reported and an objective measure of PA (Dale et al., 2002). Thus, to more accurately assess the effect of the goal-framing manipulation on PA duration and intensity, an accelerometer was used in the present study. Another important result from the literature is that intrinsic goal-framing messages did not seem efficient in improving adolescent's PA participation, in particular when health was targeted. Indeed, health is not a salient goal for healthy young individuals because they do not interpret PA as health behavior (Renner et al., 2007). As a result, knowing whether the goal contents targeted in the messages are all equally effective for changing adolescents' PA behavior remains an open question. To examine this more fully, the intrinsic goal-framing condition of the present study targeted well-being – a more salient belief for adolescents – rather than health.

Finally, the lack of evidence of the efficacy of framed messages promoting PA on PA behavior shows that intention is a necessary but not a sufficient condition (Rhodes and de Bruijn, 2013). In other words, to improve PA behavior it is not only necessary to increase intentions but also crucial that these intentions do not remain as purely wishful thinking. Planning is therefore a promising strategy for converting intention into action.

Two conceptually distinct forms of planning have been identified in the health domain (Carraro and Gaudreau, 2013; Hagger and Luszczynska, 2014; Hagger et al., 2016). The *action planning* (AP) approach involves specifying multiple cues and complex behavioral responses (Hagger and Luszczynska, 2014). It assumes that cues-to-action should make reference to time-related cues ("when"), the complex external environment ("where"), and the specification of "how" the behavior should be done. AP is generally accompanied by additional coping plans. *Coping planning* (CP) involves the anticipation of barriers or obstacles that could get in the way of the goal striving process, and the generation of alternative behaviors to overcome these difficulties (Sniehotta et al., 2005).

Planned self-regulatory strategies are used in the post-intention phase to bolster intentions to promote recall and enactment of the intended behavior. This action plan makes the goal much more attainable because the mental representation of the anticipated situation becomes highly activated and thus easily accessible (Gollwitzer, 1999). Action initiation becomes swift and efficient and does not require conscious intent, because the direct control of the behavior passes into the environment (Gollwitzer, 1999). In a meta-analysis, Carraro and Gaudreau (2013) revealed a small-to-medium summary (i.e., including the effect of both AP and CP) effect size on PA in experimental studies ($\varphi = 0.24$) when comparing all experimental conditions *versus* all controls, and a medium-to-large summary effect ($\varphi = 0.37$) when comparing purely planning conditions *versus* neutral controls.

In addition to its effect on the post-intention phase, planning has been shown to be an effective strategy in the pre-intention phase by yielding an implemental mindset. Focusing on information that helps people to achieve the chosen goal, this implemental mindset is associated with higher personal control and probabilities of success; see Achtziger and Gollwitzer (2010), Gollwitzer et al. (2010). In the PA domain, Tessier et al. (2015) compared the effect of planning interventions with two persuasive communications–one framing non-salient beliefs (i.e., health) and another targeting salient beliefs (i.e., fun, affiliation, success, challenge, skills development, and fitness)–on PA behavior, intention, attitude, and perceived behavioral control of low-active adolescents. Results showed a positive effect of a planning intervention on low-active adolescents' perceived behavioral control and intention to carry out PA, but no effects from the two persuasive communications on PA behavior and TPB variables. In sum, this study highlighted two interesting findings: (1) planning is an effective strategy for increasing intention, and (2) a communication targeting adolescents' salient beliefs, and close to intrinsic goals (i.e., fun, affiliation, success, challenge, skills development, and fitness), seems inefficient in increasing intention and PA behavior of low-active adolescents.

The purpose of the two present studies was to investigate whether, in a framing message that targets young people's salient beliefs, the type of goal framed plays a role. In the first study we examined the effect of intrinsic *versus* extrinsic-framing messages on intention and exercise goals. Then, in the second study, we investigated the effects of these two goal-framing conditions combined with planning on the low-active adolescents' objectively assessed PA behavior, in comparison with a control condition. In this second study, we also examined the mediation effects of TPB variables and the two exercise goals between conditions and PA behavior. In sum, the first study was a pilot study that aimed to develop and test the two goal-framing messages, and the second study was the main trial including a control condition, a planning intervention, an objective measure of PA behavior, and a mediation analysis.

Study 1

Study 1 consisted in constructing the intrinsic-(i.e., targeting well-being) and extrinsic-(i.e., targeting appearance) framing messages, and testing the effect of these messages on low-active students' intention, attitude, perceived

behavioral control, and exercise goals (i.e., intrinsic and extrinsic). It was hypothesized that the message targeting well-being would increase intrinsic exercise goals but not extrinsic ones, and that the message targeting appearance would increase extrinsic exercise goals, but not intrinsic ones. In addition, it was anticipated that both messages would increase intention and attitude, but not perceived behavioral control, because salient behavioral beliefs, but not salient control beliefs, were targeted in these two messages.

Materials and methods

Participants and procedure

Ten classes of 10th and 11th grades from a high school in a middle-size town in South East France volunteered to be involved in this study. Only the low-active students were included in the intervention. To be considered as a low-active student, the eligibility criterion was to carry out less than 1-h per day of MVPA (World Health Organization, 2010). All the parents were informed and authorized their child to complete the measures. After the study, all students were thanked for their participation and debriefed.

The design was a cluster-randomized trial. Using a random-number table, the study's main researcher assigned five classes to each of the two conditions of the trial: (a) the extrinsic (EMC) and (b) the intrinsic (IMC) framing-message conditions. Participants were blind to the condition to which their class was assigned. They were told that the study was a survey about PA at adolescence.

The study was conducted in two steps by a researcher during the students' usual classes. Baseline data were collected 2 weeks before the intervention. The adolescents completed a questionnaire measuring their attitude, perceived behavioral control, intention to be physically active over the next 2 weeks, exercise goals, and past PA behavior. Post-test data collection was conducted immediately after the intervention. Participants completed the same measures as for baseline, except PA. PA was only completed at baseline in order to identify the low-active adolescent (i.e., those who carried out less than 1-h per day of MVPA) within each class. The other students (i.e., more active ones) did not attend the intervention, and did not complete the post-test.

On the basis of the effect size (η^2 = 0.10) on intention observed in Gillison et al. (2013), and the correlation between repeated measures of intention (r = 0.78) reported by Tessier et al. (2015), we calculated using G*Power (Faul et al., 2007) software that 90 participants are needed to reach a power of 0.80 in a design composed of two groups and two times measurements. Among the students who completed baseline measures, 88 were low-active students. All these 88 completed the post-test measures. The sample represented 39 students in the EMC (M age = 16.89; 28 females and 11 males) and 49 in the IMC (M age = 16.89; 38 females and 11 males).

Measures

Translation into French

Before the study, each measure was translated into French following the guidelines recommended by Brislin (1980). Each English measure was translated into French using a professional English-French translator. Once done, two native French graduate students who are fluent in both languages then carried out separate back-translations into English. Any discrepancies that emerged between the translators were discussed until a consensus translation was found.

Self-reported physical activity

The French adaptation of the International Physical Activity Questionnaire for Adolescents (IPAQ-A, Hagströmer et al., 2008) was used to assess the frequency and intensity of adolescents' PA behavior over the week prior to baseline (Tessier et al., 2015). This questionnaire covered four domains of PA: (1) school-related PA, including activity during PE classes and breaks, (2) transportation, (3) household, and (4) leisure time, including sport in clubs and unstructured sport activity. Outcome measures were minutes per day reported in walking, moderate and vigorous activity. Time spent in moderate and vigorous activities were summed to obtain an MVPA score for each participant. The IPAQ-A was found to be valid for assessing activities of different intensities and for total PA in healthy European adolescents aged 15–17 years (Hagströmer et al., 2008).

Intention

Items drawn from Rhodes and Courneya (2005) were used to measure intention: "Over the next 2 weeks, I intend to do physical activity," which was anchored by (1) "never" to (7) "every day," and "I intend to do moderate to vigorous physical activity for at least 7 h/week, over the next 2 weeks," which was anchored by (1) "definitely no," to (7) "definitely yes." Measure of intention reached a satisfactory level of internal consistency at pre-test (α = 0.76) and at post-test (α = 0.80).

Perceived behavioral control

Perceived behavioral control was measured by three items drawn from Rhodes and Courneya (2005): "How confident are you that over the next 2 weeks you could exercise at least 5 h/week if you wanted to do so," which was anchored by (1) "very unconfident," to (7) "very confident"; "How much personal control do you feel you have over exercising at least 7 h/week in the next 2 weeks," which was anchored by (1) "very little control," to (7) "complete control"; and "How much I exercise in the next 2 weeks is completely up to me," which was anchored by (1) "strongly disagree," to (7) "strongly agree." Measure of perceived behavioral attained a satisfactory level of internal consistency at pre-test (α = 0.79) and at post-test (α = 0.83).

Attitude

Attitude was measured using responses to one open-ended statement: "For me, exercising 7 h/week over the next 2 weeks would be." This statement was paired with 5 bipolar seven-point adjective scales (useless–useful, bad–good, harmful–beneficial, unenjoyable–enjoyable, boring–interesting) as previously utilized by Chatzisarantis et al. (2008). Measure of attitude reached a satisfactory level of internal consistency at pre-test ($\alpha = 0.81$) and at post-test ($\alpha = 0.82$).

Exercise goal content

The Goal Content for Exercise Questionnaire (GCEQ; Sebire et al., 2008) is a 20-item measure that assesses the importance that people place on three intrinsic (health management, skill development, and social affiliation) and two extrinsic (image and social recognition) exercise goals, each indexed by four items. Participants responded to the stem "please indicate to what extent these goals are important for you while exercising" using a seven-point scale ranging from 1 (not at all important) to 7 (extremely important). In the present work, only the items considered as relevant to the message content (i.e., well-being and appearance) were used. Fourteen of the twenty items were identified as relevant: the eight extrinsic items and six of the twelve intrinsic items. Indeed, two items measuring health management (i.e., to increase my resistance to illness and disease; to improve my overall health), one item measuring social affiliation (i.e., to develop close friendships), and three items measuring skill development (i.e., to acquire new exercise skills; to learn and exercise new techniques; to become skilled at a certain exercise or activity) were not meaningfully related to the psychological and physical well-being targeted in the intrinsic goal-framing message. Confirmatory Factor Analysis (CFA) showed good fit of the data to the two-factor structure, after removing two items from the extrinsic dimension that were associated with multiple standardized residuals $> \mp 2.00$ [$\chi^2(46) = 72.09$; $p < 0.05$; $\chi^2/df = 1.56$; GFI = 0.95; TLI = 0.97; CFI = 0.98; SRMR = 0.06]. The internal consistency for intrinsic ($\alpha_{pre-test} = 0.88$; $\alpha_{post-test} = 0.90$) and extrinsic ($\alpha_{pre-test} = 0.82$; $\alpha_{post-test} = 0.85$) goal content factors reached satisfaction.

Framing-messages

With the aim of improving the population's health by acting on two key determinants – nutrition and PA – the French government has been sponsoring the Program National Nutrition Santé (National Nutrition and Health Program). Adapted from the core information from the Program's website,[1] EMC and IMC presentations were created to promote PA. Messages were structured to answer three questions: (1) what (i.e., presentation of the rational of the intervention); (2) why (i.e., development of the core arguments of the message emphasizing the pursuit of intrinsic or extrinsic exercise goals); and (3) how (i.e., proposition of some guidelines to reach these goals in everyday life). The first and third parts of the intervention were identical in the two conditions (to obtain the slides of the framing-messages, please contact the first author).

The EMC and the IMC presentations consisted in delivering a sixteen-slide PowerPoint message. The EMC presentation was entitled "physical activity is good for my appearance," and the IMC presentation was entitled "physical activity is good for my well-being." The duration of both interventions was 20 min. Part 1 comprised four slides: two slides were devoted to describing the decrease of PA during adolescence, and two other slides presented guidelines in terms of the intensity and frequency of PA considered good for health: "It is recommended to accumulate at least 1 h or more of MVPA every day of the week. PA can be done in one go or in 10 to 30-min sessions."

In part 2, nine slides presented the main benefits of PA in terms of appearance and image for EMC, and in terms of well-being for IMC. For example, in the EMC presentation it was said that "doing PA regularly makes you slimmer because your metabolism burns fat," "doing PA regularly tones the figure, for example running tones up your leg muscles," "doing PA regularly makes the body appear more dynamic and attractive; people are more interested in and more tolerant toward attractive people." In contrast, in the IMC presentation it was stated that "doing PA regularly is good for your psychological well-being because of its anxiolytic effect and because it enhances mood, restores mental availability and aids concentration," "doing PA regularly is good for your physical well-being because it increases your fitness which is related to the feeling of vigor and energy; and also it is strengthens your cardio-vascular system which increases your ability to make sustained effort in your everyday life."

In part 3, three slides were dedicated to explaining that, "you can reach these recommendations by doing any sports you like (e.g., football, dancing, swimming, and jogging), by setting realistic goals (i.e., progressivity is the key principle), and that every day there are occasions to accumulate short bouts of PA (e.g., going to school on foot or by bike)."

The interventions were delivered by the main researcher at the beginning of the usual lessons. For each condition, the message was standardized and rehearsed several times to ensure the intervention was delivered in the same way in the different classes.

Data analysis

Given the nesting nature of the data (i.e., students are nested within classes), intraclass correlations (ICC) were performed. Results revealed that all ICCs were below 5%, meaning that

1 http://www.mangerbouger.fr

the dependent variables were not influenced by a class-effect. Thus, series of 2 Conditions (EMC *vs.* IMC) × 2 Times (baseline *vs.* post-test) repeated measure ANOVAs were performed in order to compare the effects of each condition on exercise goal contents, intention, attitude, and perceived behavioral control. When variance analyses were significant, we conducted pair-wise mean comparisons using the Newman-Keuls *post hoc* procedure.

Results

Examination of the differences between the two conditions at baseline indicated no differences for intention [$t(86) = -0.40$, *ns*], for perceived behavioral control [$t(86) = 0.47$, *ns*], for attitude [$t(86) = 0.15$, *ns*], for intrinsic goal content [$t(86) = 0.97$, *ns*], and for extrinsic goal content [$t(86) = 0.04$, *ns*].

For extrinsic goal content, the ANOVA revealed that the Condition main effect was not significant: $F(1, 86) = 1.08$, ns, $\eta^2 = 0.01$; the Time main effect was significant: $F(1, 86) = 14.32$, $p < 0.001$, $\eta^2 = 0.15$; and the interaction effect between Condition × Time was significant: $F(1, 86) = 4.11$, $p < 0.05$, $\eta^2 = 0.05$. Pair-wise comparisons revealed that the score for extrinsic goal content increased in the EMC from baseline to post-test (Ms, 3.21 vs. 4.12, $p < 0.001$), but not in the IMC (Ms, 3.22 vs. 3.49, *ns*).

For intrinsic goal content, the ANOVA revealed a main effect of Condition: $F(1, 86) = 6.33$, $p < 0.05$, $\eta^2 = 0.07$; a main effect of Time: $F(1, 86) = 16.37$, $p < 0.01$, $\eta^2 = 0.19$; and an interaction effect Condition × Time: $F(1, 86) = 5.99$, $p < 0.05$, $\eta^2 = 0.07$. Pair-wise mean comparisons revealed that the score for intrinsic goal content increased in the IMC from baseline to post-test (*Ms*, 4.47 *vs.* 5.35, $p < 0.001$), but not in the EMC (*Ms*, 4.16 *vs.* 4.37, *ns*).

The ANOVA carried out on intention revealed a main effect of Time: $F(1, 86) = 20.24$, $p < 0.01$, $\eta^2 = 0.24$; no main effect of Condition: $F(1, 86) = 0.43$, ns, $\eta^2 = 0.005$; and no interaction effect Condition × Time: $F(1, 86) = 0.16$, ns, $\eta^2 = 0.002$. Pair-wise comparisons revealed that the score for intention increased in the whole sample from baseline ($M = 3.55$) to post-test (*M*: 3.55 *vs.* 4.26, $p < 0.01$).

The ANOVA carried out on attitude revealed that the Condition main effect was not significant: $F(1, 86) = 0.07$, *ns*, $\eta^2 = 0.00$; the Time main effect was significant: $F(1, 86) = 13.22$, $p < 0.001$, $\eta^2 = 0.13$; and the interaction effect between Condition × Time was not significant: $F(1, 86) = 0.37$, *ns*, $\eta^2 = 0.003$. Pair-wise mean comparisons revealed that the score for attitude increased both in the IMC (*Ms*, 5.12 *vs.* 5.55, $p < 0.05$), and in the EMC (*Ms*, 5.16 *vs.* 5.47, $p < 0.05$).

The ANOVA carried out on perceived behavioral control revealed no main effect of Condition: $F(1, 86) = 0.10$, *ns*, $\eta^2 = 0.001$; no main effect of Time: $F(1, 86) = 1.96$, *ns*, $\eta^2 = 0.02$; and no interaction effect Condition × Time: $F(1, 86) = 0.23$, *ns*, $\eta^2 = 0.002$.

Discussion

In accordance with the hypothesis, students were sensitive to the goal content framed in the messages. In each condition, the goal content corresponding to the goal-framing message increased. Additionally, both intrinsic and extrinsic framing messages were effective in developing low-active adolescents' intention and attitude. This finding is in agreement with the TPB assumption according to which messages are effective as long as they fit participants' salient beliefs. In addition, and as expected, both framed messages had no impact on perceived behavioral control because the intervention did not target control beliefs (i.e., the antecedents of perceived behavioral control). Taken together, these results revealed that both goal-framing messages that fit adolescents' characteristics have the effect to increase their motivation for PA quantitatively (i.e., intention), but the quality of motivation induced by these messages is different, as they are associated with specific exercise goal content.

One potential limitation of this study concerns confounding effects. Parts 1 and 3 of the messages might be active ingredients which overlapped with the effect of the goal-framing messages (i.e., part 2). Indeed, in regard to the taxonomy of behavior change techniques developed by Michie et al. (2009), part 1 of the messages–the presentation of guidelines in terms of the intensity and frequency of PA for promoting health–could be considered as a technique aiming to "provide information about behavior-health link." In addition, part 3 of the messages–information on the "how" to reach the goals in everyday life–could be regarded as a technique aiming to "provide instruction" (i.e., telling the person how to perform a behavior). In the same vein, one could suspect the existence of a potential Hawthorne effect (McCambridge et al., 2014), that is the tendency for the participants to artificially inflate intention scores at T2 because of their awareness of being studied. One option to overcome these potential confounding effects would be to carry out a control condition. This control group would receive the same intervention as the two experimental conditions, but the core of the message (i.e., part 2) would be a no-goal message. This control condition has been included in study 2.

A second limitation is that the framing effect has not been examined on PA behavior. To strengthen the impact of messages on PA behavior, a planning intervention will be provided in study 2, alongside framing messages. In addition to its influence in the volitional phase, the planning intervention could have an impact in the motivational phase, by increasing the perceived behavioral control as shown by Tessier et al. (2015). As a result, study 2 will extend study 1 by adding a control condition, a planning intervention, and a measure of PA behavior.

Study 2

Study 2 was carried out to test the effect of intrinsic and extrinsic-framing messages alongside planning on low-active adolescents' PA. In addition, one central question in the health PA domain is, not only to design effective interventions to promote PA, but also to understand "why" or "why not" a PA intervention worked (Rhodes and Pfaeffli, 2010). To understand this, it is essential to identify the mediators that are needed to change in order that behavior change follows. Thus, the purpose of this second study was twofold. The first aim was to test the effect of intrinsic and extrinsic-framing messages alongside planning on low-active adolescents' PA, intention, attitude, perceived behavioral control, and exercise goals (intrinsic and extrinsic). The second aim was to examine the mediation effect of these potential mediators within the PA change process. To investigate these two aims, three groups were compared: in one group participants received an intrinsic-framing message and a planning intervention (IMC + P), in a second group participants received an extrinsic-framing message and a planning intervention (EMC + P), and the last group was a control condition (CC) in which participants received a no goal framing message and did not receive a planning intervention. In this study, PA was assessed using an accelerometer during the week after the intervention, and the socio-cognitive mediators were measured at baseline (i.e., 2 weeks before the intervention) and post-test, and the intention was measured again at follow-up (i.e., 2 weeks after the intervention).

It was hypothesized that, compared to CC, adolescents in the two experimental conditions (i.e., IMC + P and EMC + P) would be more physically active, and would report greater intention, more positive attitude, and higher perceived behavioral control. This positive effect of the intervention on intention was expected to be maintained for at least 2 weeks after the intervention. No significant difference was expected between the two experimental conditions concerning the effect of the intervention on TPB variables given that both conditions were elaborated to fit adolescents' salient behavioral beliefs and control belief. In addition, it was anticipated that from pre-test to post-test, (1) adolescents in the IMC + P would report an increase for intrinsic goals compared to EMC + P and CC; while (2) adolescents in the EMC + P would report an increase for extrinsic goals compared to IMC + P and CC. Finally, while it was expected that both IMC + P and EMC + P would affect PA behavior positively, given the inconsistency of the literature on the effect of intrinsic and extrinsic goal framing messages on PA behavior, no specific hypothesis was made concerning the differentiated effect of these two experimental conditions.

As for aim 2, the effect of conditions was examined using two contrast variables: one contrasting the control condition *versus* the experimental conditions, and the second one contrasting the IMC + P *versus* the EMC + P. It was anticipated that intention and perceived behavioral control measured at time 2 would mediate the effect of the variable "control condition *versus* experimental conditions" on PA behavior, and that intrinsic and extrinsic exercise goals measured at time 2 would mediate the effect of the variable "IMC + P *versus* EMC + P" on PA behavior. All these mediation effects are expected to be partial, because the planning intervention included in the experimental conditions is supposed to have a direct effect on PA behavior.

Materials and methods

Participants and procedure

The sample size was determined on the basis of two formal power analyses (conducted *via* GPower; Faul et al., 2007), one on intention and another on PA behavior. To reach 80% power to detect an effect size of $\eta^2 = 0.10$ of the framing messages on intention (observed in Gillison et al., 2013), and a correlation between repeated measures of intention of $r = 0.78$, (reported by Tessier et al., 2015), the power analysis indicated that 74 participants are needed in a design composed of three groups and two measurement times. The second power analysis, which assumed an effect size of $\varphi = 0.24$ for the planning intervention on PA behavior (based on the meta-analysis of Carraro and Gaudreau, 2013), indicated that 171 participants are needed to reach 80% power in a design composed of three groups and one measurement time. Thus, we choose this latter power analysis, which is more conservative than the former, to determine the sample size.

The school administrators of 25 high schools in a middle-size town in South East France were contacted by mail. Three high schools with similar socio-demographic variables volunteered to participate in this study, resulting in the involvement of fifteen classes composed of 193 low-active students.[2] In multiple measurement occasions, all 193 low-active students were included in the trial. All the parents were informed and authorized their child to complete the measures. After the study, all students were thanked for their participation and debriefed. As for study 1, the design was a cluster-randomized trial. The fifteen classes of 10th and/or 11th grade were randomly assigned to each of the three conditions of the trial: (a) five classes were assigned to EMC + P, (b) five classes were assigned to IMC + P, and (c) five classes were assigned to CC.

The participants were blind to the condition to which their class was assigned, of the participation in the study of other classes from the same school, and no reference was made to the participants about the objective of the study. Instead, they were told that the researchers were carrying out a survey about PA at adolescence.

2 As for the pilot study, to be considered as a low-active student, the eligibility criterion was to carry out less than 1-h per day of MVPA (World Health Organization, 2010).

The study was conducted in three steps by a researcher within the students' usual PE classes. Baseline data were collected 2 weeks before the intervention. The post-test data collection was conducted immediately after the delivery of the intervention. Finally, the follow-up took place 2 weeks after the intervention.

At baseline, the adolescents completed a questionnaire assessing attitude, perceived behavioral control, intention, exercise goals, and PA behavior. This self-reported measure of PA behavior referred to a normal week and allowed the low-active adolescents–carrying out less than 1-h-per-day of MVPA–in each class to be selected. Just after the intervention (i.e., post-test), the participants completed all baseline measures, except PA. In addition, they received an accelerometer that they had to wear for 1 week. At follow-up the participants completed another measure of intention, in order to test whether the effect of the intervention on intention would be maintained over time.

The flow diagram of progress through the trial is depicted in **Figure 1**. The baseline sample of 15 10th and 11th grade classes represented 193 low-active adolescents (69% female; *M* age: 15.62 years). At post-test, 186 students (69% female; *M* age: 15.71 years) completed the second wave of data collection. The retention rate at post-test 1 was 96%. The 186 persisting students did not differ significantly from the seven students who dropped out at post-test, on the dependent measures (*t*s < 1.5, *ns*). Finally, at follow-up, 177 students (71% female; *M* age: 15.45 years) completed the last wave of data collection. The retention rate at follow-up was 98%. The 177 persisting students did not differ significantly from the nine students who dropped out at follow-up, on intention (*t*s < 1.5, *ns*).

Intervention

Interventions in the three conditions were made by a researcher at the beginning of the usual lessons. For each condition, the message was standardized and rehearsed several times to ensure the intervention was delivered in the same way in the different classes. In the two experimental conditions, the intrinsic or extrinsic framing message was delivered first, followed by the planning intervention. The EMC and IMC were the same as in study 1. The planning intervention was based on Gollwitzer and Brandstätter's (1997) study. A three-slide power point presentation was devoted to informing students on the beneficial impact of planning: "often, it is not easy to organize oneself to successfully reach one's goals. Many reasons can interfere with your wish to do more. PA planning has been found to facilitate the enactment of the individuals' desired actions. PA planning is essential for meeting daily recommendations and overcoming potential barriers. For example, if 1 week you have too much homework that does not allow you to be sufficiently active, you may plan to participate in PA during the weekend. "Then, participants were instructed to fill out a week's timetable. Firstly, they had to write in the timetable slots how long their past PA behaviors lasted in terms of transportation (e.g., walking 10 min to go to school), sport club training/competitions and PE classes (e.g., 2 h football training every Wednesday afternoon, and 1-h PE class each Monday morning and Thursday afternoon), and unstructured leisure time activities (e.g., swimming on Sunday morning for 1 h). Then, if the sum of the usual weekly leisure time PA was less than 7 h, they were invited to plan how to achieve the 7 h of MVPA by adding supplementary PA that they felt able to carry out over the next 2 weeks. Using the *if-then* format, they had to write the type of activity, the day, the time, and the duration of this activity (e.g., If, on Tuesday I get back home at 5pm, I will go for a 30-min run). Finally, the students who planned to do more activities were invited to indicate three possible obstacles that could occur during the pursuit of their goal (i.e., doing at least 7 h of MVPA a week), and three strategies for managing those obstacles (e.g., "If I feel too tired at the end of the day to carry out PA, then I will tell myself that carrying out PA will give me more energy). The duration of the planning intervention was 10 to 15 min. Participants were given a copy of their written plan and were advised to keep this sheet so that it was accessible daily.

The CC consisted in delivering a sixteen-slide PowerPoint message, and the duration of the intervention was 20 min. The structure of the message was similar to those of the EMC and the IMC presentations, except that the seven slides relating to parts 1 and 3 were grouped at the beginning of the message. The CC was entitled "Physical activity and adolescence" (to obtain the slides of this message, please contact the first author). The core component of the message consisted in a nine slide no-goal-framed message that is, a presentation of neutral information that explained the reasons why PA decreases during adolescence. Reasons related to cognitive development (e.g., "during adolescence cognitive skills broaden to virtual objects which increases the tendency to spend more time on the internet and video games leaving less time for PA"), goal conflicts (e.g., "during adolescence the range of interests increases, and adolescent need to make choices between different leisure activities; often PA is sacrificed"), and gender identity (e.g., "adolescents who developed a masculine gender are more likely to do sport, because perseverant stereotype in the sport domain remains: sport is for men.") were developed. In the CC, the students did not receive the planning intervention.

Measures

Measures of *self-reported Physical activity* (i.e., the IPAQ-A), *exercise goal content* (i.e., the 12-item adapted version of the GCEQ), and *TPB* (i.e., intention, attitude, and perceived behavioral control) were the same as in study 1.

Direct physical activity measure

Objective PA was measured using the GT3X (Actigraph®). The GT3X is a lightweight and compact accelerometer (i.e., 27 grams; dimensions: 3.8 cm × 3.7 cm × 1.8 cm), worn on the waist with an elastic belt. Participants were asked to wear the

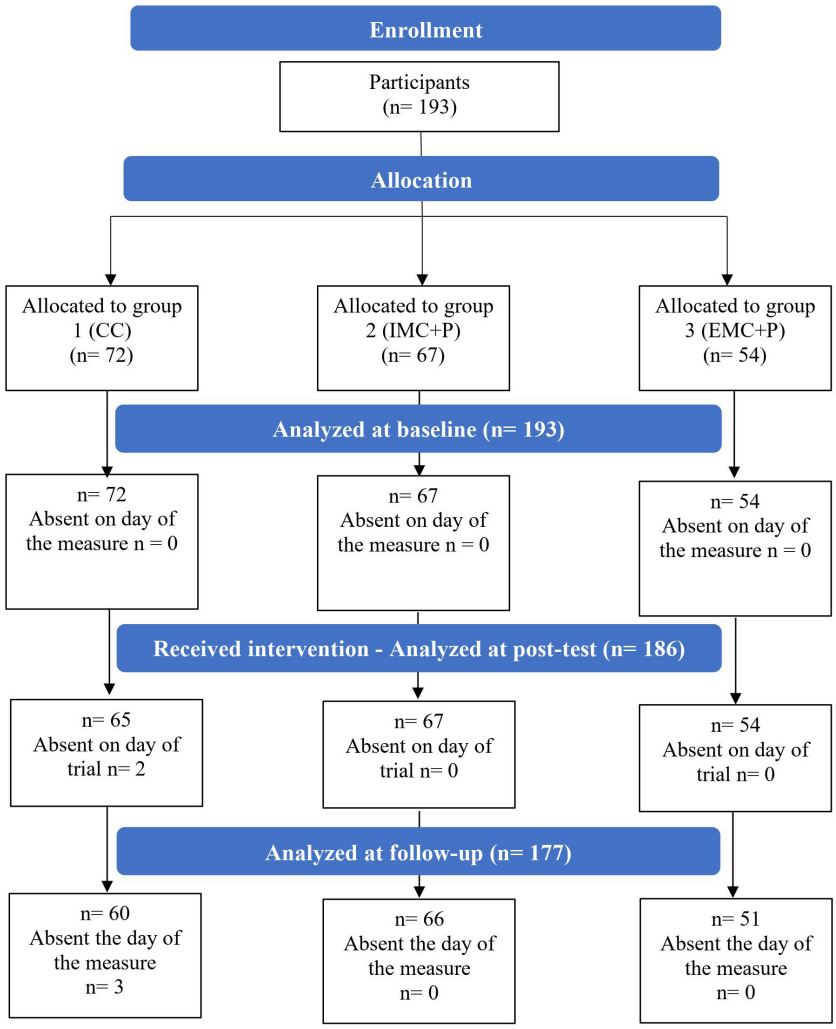

FIGURE 1
Flow diagram of progress though the trial.

accelerometer on the right hip during all waking hours (Ward et al., 2005) and remove it only for water activities, bathing or showering. The GT3X accelerometer has shown to be marked by adequate validity, reliability and feasibility when employed in studies of young people (Verloigne et al., 2012). An epoch length of 15 seconds was chosen to capture short durations of high intensity PA (Rowland, 2007). Outcome variables extracted from the accelerometer data were [light PA (LPA); moderate PA (MPA), and vigorous PA (VPA)]. MVPA is defined as the sum of MPA and VPA. Time spent in different PA intensities was determined using age-specific cut-points developed by Freedson et al. (2005). PA intensities were defined as light, moderate, or vigorous for 1.50–2.99, 3.00–5.99 METs[3], ≥ 6 METs, respectively [i.e., cut- points were between 1,017 and 1,547 counts per minute (cpm) for 3.00 MET at all age groups].

Data were downloaded with ActiLife software. Meterplus version 4.2 was used to screen and clean the data. Consistent with a recent study assessing PA in a representative sample of French children and adolescents (Van Hoye et al., 2014), non-wear time was defined as periods of more than 30 min of consecutive zero counts. Participant data were considered valid and retained for further analysis if data was recorded for a minimum of 8 h per day, on at least three days (i.e., 2 weekdays and 1 weekend day) (Ward et al., 2005). As a result, 49 participants were excluded for insufficient wear time. Data from participants who wore the GT3X for 7 days were used for analysis regarding the number of active days (N = 131). The 49 students who were excluded did not differ significantly from the 131 students who wore the GT3X regularly, on the dependent measures ($ts < 1.5$, ns).

3 The Metabolic Equivalent of Task (MET), or simply metabolic equivalent, is a physiological measure expressing the energy cost of physical activities.

Data analysis

Given the nesting nature of the data (i.e., students are nested within classes), intraclass correlations (ICC) were performed. Results revealed that all ICCs were below 5%, meaning that the dependent variables were not influenced by a class-effect. Thus, to compare the effects of each condition on each variable, series of repeated measures multivariate analysis of variance (MANOVAs) were performed. The required conditions to perform ANOVAs were examined using Kolmogorov–Smirnov and Shapiro-Wilk tests for the normality of the data, and the Levenne test and Cochran, Hartley, Bartlett's tests for homoscedasticity.

To examine the mechanisms at play, path analyses were conducted with AMOS Version 22.0 (Arbuckle, 2013) using the maximum-likelihood estimation. To test the effects of the three conditions on the potential mediators (i.e., intention, perceived behavioral control, and exercise goals) and PA, we computed two orthogonal contrasts (Judd and McClelland, 2008). One contrast compared the CC with the two experimental conditions (by using −2, 1, and 1, respectively, for CC, EMC + P, and IMC + P), and was labeled "CC vs. EMC + P-IMC + P"; the other contrasted the EMC + P with the IMC + P (by using 0, −1 and 1), and was labeled "EMC + P vs. IMC + P." "CC vs. EMC + P-IMC + P" was specified as a predictor of intention, attitude, and perceived behavioral control measured at time 2, and PA variables (i.e., MVPA and LPA). "EMC + P vs. IMC + P" was specified as a predictor of intrinsic and extrinsic goals measured at time 2, and PA variables. Based on TCP, attitude and perceived behavioral control measured at time 2 were specified as predictors of intention measured at time 2. The potential mediators, except for attitude which is not directly related to behavior according to TCP, were specified as predictors of the PA variables. In addition, the auto-regressive effective effect (i.e., the effect of the mediator measured at time 1 on itself at time 2) of these potential mediators, and the effect of sex on PA variables were controlled. Two models were examined separately, one with MVPA and one with LPA. To evaluate overall model fit, several indices were used: the chi-square goodness-of-fit statistic, the Tucker–Lewis index (TLI), the Comparative Fit Index (CFI), and the root mean square error of approximation (RMSEA). According to Hu and Bentler (1999), CFI and TLI values above.95 and RMSEA values of less than 0.06 represent a good model fit.

Results

Preliminary analyses

Supplementary Table 1 presents descriptive statistics for the measures; all measures reached satisfactory levels of internal consistency ($\alpha > 0.70$). Correlations indicated that all TPB measures are positively intercorrelated and positively correlated with goal content. As for PA behaviors, they do not correlate with socio-cognitive variables, except intention.

Examination of the differences between the three conditions at baseline indicated no differences for intention ($p = 0.07$), for perceived behavioral control ($p = 0.53$), and intrinsic goal content ($p = 0.58$), but significant differences for attitude and extrinsic goal content. The participants in the CC had higher attitude scores than those from IMC and EMC (i.e., 5.48 vs. 4.89 and 4.51, *ps* < 0.05), and higher scores for extrinsic exercise goals than those from the EMC (3.7 vs. 2.9, $p < 0.05$). These differences are controlled in the following repeated measures ANOVAs. Possible associations between age and sex with the study's dependent variables were also tested. Sex was associated with 2 of 5 outcome measures assessed at baseline, with males scoring higher than females on intention, $t(191) = -3.25$, $p < 0.01$ (*Ms*, 4.11 *vs.* 3.28), and perceived behavioral control, $t(191) = -2.32$, $p < 0.05$ (*Ms*, 5.03 *vs*. 4.43). Age was correlated with none of the five student outcomes at baseline. Given these associations, we included sex (females = 0; males = 1) as a covariate (i.e., statistical controls) in the analyses related to these variables.

Effects of experimental intervention conditions

For PA behaviors, a MANOVA was performed to compare the three conditions on the PA behaviors. Results showed a significant multivariate effect, *Wilks' lambda* = 0.41, $F(4, 254) = 36.01$, $p < 0.001$. Follow-up ANOVAs were significant for light PA, $F(2, 128) = 82.79$, $p < 0.001$, $\eta^2 = 0.56$, but not for MVPA, $F(2, 128) = 0.73$, *ns*. More specifically, for light PA, pair-wise mean comparisons (i.e., Newman-Keuls *post hoc* procedure) showed that the scores for EMC + P ($M = 118.17$) and IMC + P ($M = 122.23$) were not different, but significantly higher than the score for CC ($M = 66.93$, $p < 0.001$).

For TPB socio-cognitive variables, only attitude and perceived behavioral control were included in the repeated measures MANOVA, because intention was measured three times. Results showed a significant multivariate interaction effect Time × Condition: *Wilks' lambda* = 0.91, $F(4,364) = 4.29$, $p < 0.01$. Follow up ANOVAs were significant for both attitude and perceived behavioral control. More specifically, for attitude the Condition main effect was significant: $F(2, 183) = 3.45$, $p < 0.05$, $\eta^2 = 0.04$, the Time main effect was significant: $F(1, 183) = 16.96$, $p < 0.001$, $\eta^2 = 0.08$, and the interaction effect Condition × Time was significant: $F(2, 183) = 6.68$, $p < 0.01$, $\eta^2 = 0.06$. Pair-wise mean comparisons revealed that the score for attitude increased from baseline to post-test in the EMC + P (*Ms*, 4.52 *vs.* 5.25, $p < 0.001$), and in the IMC + P (*Ms*, 4.89 *vs.* 5.58, $p < 0.01$), but not in the CC (*Ms*, 5.48 *vs.* 5.36, *ns*). For perceived behavioral control, Sex was included as a covariate in the repeated measures ANOVA. Results showed a main effect of Time: $F(1, 180) = 4.99$, $p < 0.05$, $\eta^2 = 0.02$, no main effect of the Condition: $F(2, 180) = 0.37$, *ns*, a significant interaction effect Condition × Time: $F(2, 180) = 7.91$, $p < 0.001$,

$\eta^2 = 0.08$, and a no interaction effect Condition × Time × Sex: $F(2, 180) = 1.79$, *ns*. Pair-wise mean comparisons revealed that the score of perceived behavioral control increased in the EMC + P from baseline to post-test (*Ms*, 4.46 *vs*. 5.22), but not in the IMC + P (*Ms*, 4.56 *vs*. 4.74), and in the CC (*Ms*, 4.73 *vs*. 4.46). As for intention, Sex was included as a covariate in the repeated measures ANOVA. Results showed a non-significant main effect of the Condition: $F(2, 171) = 0.13$, *ns*; a significant main effect of Time: $F(2, 342) = 39.66$, $p < 0.001$, $\eta^2 = 0.19$; a significant interaction effect Time × Condition: $F(4, 342) = 6.56$, $p < 0.001$, $\eta^2 = 0.07$; and a significant interaction effect Time × Condition × Sex: $F(4, 342) = 2.59$, $p < 0.05$, $\eta^2 = 0.02$. Pair-wise mean comparisons revealed that the score for intention in the EMC + P and in the IMC + P increased from baseline to post-test and decreased from post-test to follow-up (for EMC *Ms*, 3.39 *vs*. 5.07 *vs*. 4.38; for IMC *Ms*, 3.32 *vs*. 4.86 *vs*. 4.07). In the CC the scores for intention leveled off (*Ms*, 3.83 vs. 4.23 *vs*. 4.20). The pattern of results is identical for both males and females, but the scores for intentions are higher for males than for females.

For students' goal content, a repeated measures MANOVA was performed to compare pre-test to post-test. Results showed a significant multivariate interaction effect Time × Condition: *Wilks' lambda* = 0.85, $F(4,358) = 7.39$, $p < 0.001$. Follow-up ANOVAs were significant for both intrinsic and extrinsic goals. More specifically, results of repeated measures ANOVA on extrinsic goal showed a main effect of Condition: $F(2, 180) = 1.22$, *ns*; a main effect of Time: $F(1, 180) = 30.60$, $p < 0.001$, $\eta^2 = 0.15$; and an interaction effect Condition × Time: $F(2, 180) = 10.32$, $p < 0.01$, $\eta^2 = 0.10$. Pair-wise mean comparisons (i.e., Newman-Keuls *post hoc* procedure) revealed that the score for extrinsic goal increased in the EMC + P from baseline to post-test (*Ms*, 2.96 *vs.* 3.92, $p < 0.001$), but not in the IMC + P (*Ms*, 3.35 *vs.* 3.53, *ns*), and in the CC (*Ms*, 3.69 *vs.* 3.86, *ns*). As for the intrinsic exercise goal, results of repeated measures ANOVA revealed that the Condition main effect was not significant: $F(2, 180) = 1.19$, *ns*; the Time main effect was significant: $F(1, 180) = 22.05$, $p < 0.001$, $\eta^2 = 0.11$; and the interaction effect between Condition × Time was significant: $F(2, 180) = 3.37$, $p < 0.05$, $\eta^2 = 0.04$. Pair-wise mean comparisons revealed that the score for intrinsic goal increased in the IMC + P from baseline to post-test (*Ms*, 4.91 *vs.* 5.62, $p < 0.001$), but not in the EMC + P (*Ms*, 4.85 *vs.* 5.07, *ns*), and in the CC (*Ms*, 5.04 *vs.* 5.32, *ns*).

Mediational analysis

The models specified yielded a satisfactory fit across indices. For MVPA, $\chi^2(39) = 69.69$, $p = 0.004$; TLI = 0.94; CFI = 0.96; RMSEA = 0.06 [0.02, 0.09]; and for LPA, $\chi^2(39) = 66.72$, $p = 0.004$; TLI = 0.94; CFI = 0.96; RMSEA = 0.06 [0.02, 0.09]. As shown in **Figure 2**, compared to CC, the experimental conditions were positively related to intention at time 2 ($\beta = 0.18$, $p < 0.01$), to LPA ($\beta = 0.74$, $p < 0.001$) but not to MVPA ($\beta = -0.09$, *ns*), and was tendentially associated to perceived behavioral control at time 2 ($\beta = 0.12$, $p = 0.07$). Bootstrap analyses showed that the indirect effects between "CC vs. EMC + P-IMC + P" and LPA/MVPA were not significant through intention at time 2 [−0.09, CI 95%: (−0.97, 0.63); $p = 0.43$, and −0.11, CI 95%: (−0.84, 0.58); $p = 0.76$], and though perceived behavioral control at time 2 [0.21, CI 95%: (−0.20, 0.86); $p = 0.84$, and 0.06, CI 95%: (−0.37, 0.58); $p = 0.73$]. In addition, compared to EMC + P, IMC + P was positively associated with intrinsic goal at time 2 ($\beta = 0.14$, $p < 0.05$), and tendentially related to extrinsic goal at time 2 ($\beta = -0.12$, $p = 0.08$). The experimental conditions were not significantly related LPA ($\beta = 0.07$, *ns*), nor was MVPA ($\beta = 0.10$, *ns*). Finally, none of the socio-cognitive variables measured at time 2 were related to PA behaviors. Bootstrap analyses showed that the indirect effects between "EMC + P vs. IMC + P" and LPA/MVPA were not significant through intrinsic goal at time 2 [0.03, CI 95%: (−0.92, 1.41); $p = 0.71$, and.15, CI 95%: (−0.33, 0.87); $p = 0.28$], and though extrinsic goal at time 2 [−0.11, CI 95%: (−1.71, 1.05); $p = 0.91$, and −0.16, CI 95%: (−0.94, 0.34); $p = 0.28$]. Overall, the models explained 58% of the variance of LPA, and 11% of the variance of MVPA.

Discussion

The purpose of this second study was to test the effect of intrinsic- and extrinsic-goal framing messages alongside planning on low-active adolescents' PA, and to investigate the contribution of the potential mediators: intention, attitude, perceived behavioral control, and intrinsic and extrinsic exercise goals.

Effect of the intervention on physical activity variables

A noteworthy result is that, compared to low-active adolescents in CC, those in EMC + P and IMC + P did not practice more MVPA, but carried out more LPA. This result is in line with the literature reviews showing the efficacy of the behavior change techniques used in this study on PA behavior, that "provide information on consequences of behavior to the individual" framing intrinsic or extrinsic exercise goal content, and "action and coping planning" (Michie et al., 2011; Carraro and Gaudreau, 2013; Dusseldorp et al., 2014). Additionally, these findings obtained using an accelerometer to measure PA are interesting given that most previous studies used an indirect (i.e., self-reported) measure of PA. Indeed, it is now well-established that indirect measures tend to overestimate the score for PA (Troiano et al., 2008), hence the accelerometer is a more conservative measure of PA than indirect measures. Thus, despite the lack of effect on MVPA, the significant effect obtained on LPA is promising. The lack of effect on MVPA may also be due to a dose-response effect. Indeed, the intervention

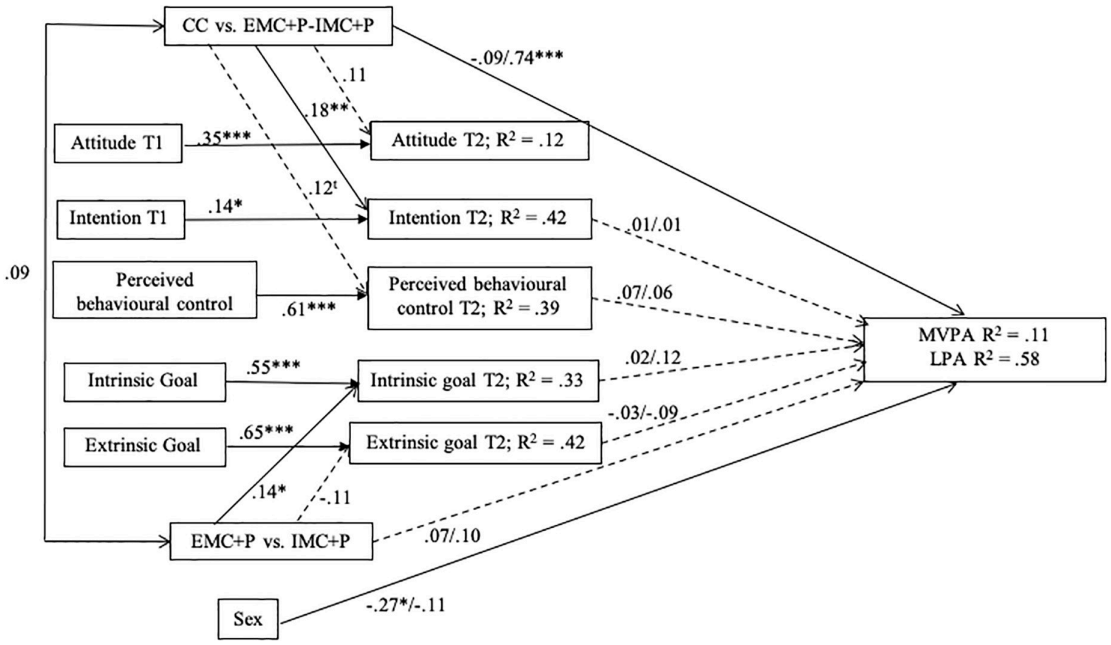

FIGURE 2
Mediational models. When two indices are noted on the path analysis, the first number corresponds to MVPA, and the second one to light physical activity. Sex is coded as 1 = male and 2 = female.

was short (i.e., about half an hour in duration), and delivered only once. Literature shows that the effect of the messages is enhanced by more frequent doses of information see Latimer et al. (2010).

The lack of difference between IMC + P and EMC + P on PA variables is also interesting. Although the results on intrinsic and extrinsic goals confirm that both experimental conditions are different in nature, they had the same effect on PA behaviors. As the planning intervention was the same in the two experimental conditions, it is possible that either, IMC and EMC yielded an identical significant effect on LPA, or that IMC and EMC had no significant effect on PA, and thus the effect observed was only due to the planning intervention. This is an important limitation of the present study. The lack of a factorial research design – which would enable the identify the main effect of each framing message and of the planning intervention as well as the interaction effects among these factors – do not allow to know whether the framing messages influenced, or not, on the PA behavior. Consequently, the results obtained with these combined experimental conditions do not shed new light on the specific effect of extrinsic and extrinsic goal framing messages on PA behavior.

Effect of the intervention on the potential mediators

As in study 1, results showed that in the IMC + P the intrinsic exercise goals increased from pre-test to post-test, and in the EMC + P the extrinsic exercise goals increased over time. In the CC neither intrinsic nor extrinsic exercise goals changed over time. While this result tends to accredit SDT over TPB by showing that students are sensitive to the exercise goal contents framed in the messages, this difference between the conditions seems negligible nevertheless, as no consequence on PA behavior was observed.

In addition, results revealed that both experimental conditions yielded an increase in attitude and intention, but not the CC. These findings confirm the real positive impact of goal framing messages on the variables in the pre-intention phase and, at the same time, the lack of effect of other potential behavioral change techniques included in parts 1 and 3 of the framed messages. Contrary to the limitation evoked for study 1, the information included in parts 1 and 3 of the framing-messages were not active ingredients in the behavioral change process.

In addition, results showed that compared to IMC + P and CC, EMC + P produced an increase of perceived behavioral control. This finding partially confirms the hypothesis. In line with the study of Tessier et al. (2015), it was expected that planning would increase perceived behavioral control in both experimental conditions. In the IMC + P, the increase was not enough to be significant. This may be due to the fact that the baseline level of perceived behavioral control was high in both groups (i.e., > 4 of 7), but slightly more in the IMC + P than in the EMC + P.

Another interesting finding from study 2 is that the framing effect on intention decreased rapidly. Indeed, while in the two

experimental conditions follow-up scores of intentions – taken 2 weeks after the intervention – were significantly higher than the pre-test scores, they significantly decreased from post-test to follow-up. Thus, it can be assumed that the positive effect of this brief intervention was short-lived. However, it must be noted that the frame of this study was focused on the initiation phase, and not on maintenance. The maintenance phase is a complex issue (i.e., PA volume is volatile), that requires the use of specific intervention strategies (e.g., follow-up prompts such as maintaining long-term contact with the participants), and specific methods to evaluate long-term effect of intervention (12 months or longer) (Fjeldsoe et al., 2011).

Mediational analysis

Path analyses revealed three main findings (see **Figure 2**). First, "CC vs. EMC + P-IMC + P" was significantly related to LPA. This result confirms the hypothesis and means that providing information on intrinsic or extrinsic consequences of PA to the individual, alongside action and coping planning, has a greater positive effect on LPA than only informing low-active adolescents of guidelines in terms of PA intensity and frequency (i.e., control condition). Second, "EMC + P vs. IMC + P" was not related to PA behaviors. This means that intrinsic goal framing messages had no added-value compared to extrinsic goal framing messages in terms of PA in the short term. This finding tends to confirm the results of Gallagher and Updegraff (2012) who showed no effect of goal-framing manipulation on PA participation. Finally, results showed that none of the potential mediators was significantly related to either MVPA or LPA. This finding invalidates the hypothesis, showing that the effect of the intervention on LPA is not mediated by TCP variables nor intrinsic and extrinsic exercise goals.

General discussion

The purpose of the two present studies was to investigate whether, when framing messages that target young people's salient beliefs, the type of goal that was framed is important in promoting PA among low-active adolescents.' Results showed that both experimental conditions had similar effects on intentions (studies 1 and 2) and on PA behavior (study 2). Thus, while low-active adolescents were sensitive to the message content – as the change in intrinsic or extrinsic goals corresponded to the goal content framed – the intrinsic goal framing message did not bring any added-value to the PA behavior change process compared to the extrinsic goal framing message.

Another finding of this research was to reveal that an intervention combining a message providing information on consequences of PA alongside planning could contribute effectively to promoting PA behavior in low-active adolescents. This finding extends earlier work, in particular that in Tessier et al. (2015) that showed that a combination of a persuasive communication based on adolescents' salient beliefs and a planning intervention did not increase self-reported PA behavior among low-active adolescents. However, the present study failed to explain the mechanisms at play. Indeed, TCP variables and intrinsic and extrinsic exercise goals did not mediate the effect of the intervention on PA behavior. Other potential mediators warrant investigation, in particular in the volitional phase.

Finally, the present study confirms previous findings (Tessier et al., 2015), emphasizing the crucial role played by action and coping planning in the motivational phase by improving perceived behavioral control, as well as in the volitional phase by increasing PA behavior.

Limitations and future research

The current set of studies is not without limitations. First, the design does not allow to disentangle the effect of the framing messages and the effect of the planning intervention. To examine separately the main effect of these two interventions, the use of a factorial research design including a fourth condition in which participants would assist to the planning intervention only would be warranted. In addition, to examine the main effect of the framing messages in the IMC + P and the EMC + P, the adding of another measure of the TPB variables and the PA behavior after the delivering of the framing messages would be also warranted. This would imply to implement the planning intervention 1 week apart in these two conditions. Also, to examine the effect of the planning intervention more thoroughly, the inclusion of a self-reported measure of planning at follow-up in all the groups would be necessary. Second, delivering the intervention only once is probably insufficient to increase the MVPA of low-active adolescents. In the future, it would be warranted to have more repetitions of the intervention in order to impact MVPA. Finally, the effects of the intervention at follow-up were examined only at very short term (i.e., within 2 weeks after the intervention) using intention measures. A more useful follow-up measure of this brief intervention focused on PA initiation would have been needed to assess PA behavior two or 3 months after the intervention.

Conclusion

Low-active adolescents are a population to consider in order preventing future health issues. This study is innovative because it combined two efficient behavioral techniques in a natural setting, and used a direct measure (i.e., accelerometer) to assess the effects of the intervention on PA. The results demonstrated that "providing information on consequences" alongside planning is an effective low-cost intervention in order

to increase the LPA of low-active adolescents. In the future, given the lack of interventions to promote PA in low-active adolescents, there is a need to replicate this intervention and to test other innovative interventions to increase PA among this vulnerable population.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://osf.io/vytqp/.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

DT developed the study concept, analyzed, interpreted the data, and drafted the manuscript. DT, VN, and PS contributed to the study conception and design. VN contributed to data acquisition. VN and PS provided critical revisions. All authors approved the final version of this manuscript for publishing.

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Conflict of interest

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

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Supplementary material

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Facilitators and barriers to health enhancing physical activity in individuals with severe functional limitations after stroke: A qualitative study

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Background: Patients with chronic conditions are less physically active than the general population despite knowledge of positive effects on physical and mental health. There is a variety of reasons preventing people with disabilities from achieving levels of physical activities resulting in health benefits. However, less is known about potential facilitators and barriers for physical activity (PA) in people with severe movement impairments. The aim of this study was to identify obstacles and facilitators of PA in individuals with severe disabilities.

Materials and methods: Using a qualitative approach to explore individuals' subjective perspectives in depth, five community-dwelling adults (age 52–72, 2 female, 3 male) living with chronic mobility impairments after stroke that restrict independent PA were interviewed. A semi structured topic guide based on the theoretical domains framework was utilized. The interview data was analyzed thematically, and the theoretical domains framework constructs were mapped onto the main and sub-categories.

Results: The six main categories of facilitators and barriers along the capability, opportunity, motivation–behavior (COM-B) framework were: (1) physical capabilities, (2) psychological capabilities, (3) motivation reflective, (4) motivation automatic, (5) opportunity physical, and (6) opportunity social. The physical capabilities to independently perform PA were variable between participants but were not necessarily perceived as a barrier. Participants were highly motivated to maintain and/or increase their abilities to master their everyday lives as independently as possible. It became clear that a lack of physical opportunities, such as having access to adequate training facilities can present a barrier. Social opportunities in the form of social support, social norms, or comparisons with others can act as both facilitators and barriers.

Conclusion: While confirming known barriers and facilitators that impact the ability of individuals with functional limitations to be active, the findings highlight the need and opportunities for comprehensive service models based on interdisciplinary collaborations.

KEYWORDS

health enhancing physical activity/activities, stroke, behavior change wheel (BCW), capability, opportunity, motivation–behavior (COM-B), theoretical domains framework (TDF)

Introduction

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (WHO, 2010). Being physically active is associated with health benefits and contributes to the cure and prevention of a variety of non-communicable diseases (NCD), such as heart disease and stroke as well as cancer and diabetes. PA also contributes to the prevention of NCD risk factors such as hypertension, overweight, and obesity and is associated with improved mental health, a delay in the onset of dementia, improved quality of life, and wellbeing (WHO, 2020). Given the powerful effects of PA, the term Health Enhancing Physical Activity (HEPA) has been established.

Patients with chronic conditions are less physically active than the general population (de Hollander and Proper, 2018). With only about 21% of individuals attaining the recommended PA, stroke is associated with the lowest prevalence of recommended PA (Brawner et al., 2016; Aguiar et al., 2017; Kang et al., 2021). For non-ambulatory patients with stroke, it is even more difficult to adhere to recommended PA levels (Lloyd et al., 2018).

Habitual PA can positively influence secondary comorbidities that often accompany severe chronic conditions (Durstine et al., 2000). Guidelines recommend similar doses of PA for persons with chronic conditions as for the general population and emphasize the importance of PA for the secondary prevention, e.g., of recurrent cardio-vascular events (Billinger et al., 2014; Pfeifer and Geidl, 2017). As patients with neurological conditions are at a higher risk of experiencing adverse events such as falls or cardiac events during exercise, pre-exercise assessment and tailored exercise programs are needed, also to promote long-term adherence (Billinger et al., 2014).

Approaches such as the Physical Activity for People with Disability (PAD) model relate PA to functioning and disability and outline determinants of PA behavior in people with disability (van der Ploeg et al., 2004). They highlight environmental and personal factors that independently as well as interacting with each other influence the individual's behavior. Shields et al. (2012) divided barriers into four categories: Personal, Social, Environmental, Policy and Programs. For stroke, studies have shown that motivation, anxiety, beliefs about capabilities, environmental context and resources, and social influences modify engagement in PA (Damush et al., 2007; Nicholson et al., 2014; Thilarajah et al., 2020). The most commonly reported barriers were environmental (access, transport, and cost), health problems and stroke related impairments while the main motivator was social support (connecting with other stroke survivors) (Nicholson et al., 2013). A conceptual framework on PA after stroke illustrates the relationship between motivation (desire to be active) and capability (resources to be active), and the related influencing factors, such as the direct effects of stroke as a barrier or social support through health professionals or other survivors as a facilitator (Morris et al., 2017).

A comprehensive framework to understand, predict, and change individuals behavior is the behavior change wheel (BCW) (Michie et al., 2011). It differentiates three levels that contribute to behavior: a behavior system, intervention functions, and policy categories. It includes personal, social, environmental, as well as policy and program factors that have been outlined as main sources of barriers and facilitators in the PA models (van der Ploeg et al., 2004; Shields et al., 2012) but also addresses how to derive tailored interventions. The BCW structures the development of behavior change interventions in three different stages: understanding the behavior, identifying intervention options, and identifying content and implementation options. Within the first stage, it employs the so-called capability, opportunity, motivation–Behavior (COM-B) model as core of the behavior system to understand the behavior in context. This acronym stands for individuals' Capabilities (physical and psychological), Opportunities (physical and social), and Motivation (reflective and automatic) as determinants of Behavior. It can be complemented by the theoretical domains framework (TDF) (Cane et al., 2012). The TDF consists of 14 domains that represent determinants of adherence to a behavior or behavior

change, mapped onto the overarching COM-B model. Despite existing best-practice examples (Connell et al., 2016; Hall et al., 2020a,b) and the recommendations to develop interventions underpinned by behavior change theory as they are more effective than non-theoretical interventions (Craig et al., 2008) and allow testing the specific determinants of behavior and refining the intervention (Davis et al., 2015), the aforementioned tools and processes have not been applied to understand and change PA in individuals with severe disabilities.

Therefore, the current research aims to explore facilitators and barriers to PA in individuals with severe functional limitations using the BCW framework to inform how an intervention should look like that optimally supports individuals with severe disabilities to attain the HEPA recommended PA.

Materials and methods

Study design

A descriptive design with a qualitative approach, underpinned by the COM-B framework was chosen. Semi-structured interviews were used for data collection. All names have been replaced by pseudonyms.

Sampling and recruitment

German-speaking adults with chronic neurological mobility limitation were purposively recruited through staff from outpatient rehabilitation facilities in Switzerland. Inclusion criteria were: severe, chronic (>6 months) mobility limitation that restrict independent PA, no or mild cognitive impairment, and no additional diseases that prevent from PA. The sampling aim was to represent individuals from different age groups, gender, and severity of the condition where possible. If participants expressed interest, the research team informed them about the study and appointments at locations convenient to the participant were scheduled. **Table 1** provides an overview of study participants and their characteristics.

Data collection

A semi structured topic guide was developed based on the TDF (Cane et al., 2012). Each of the 14 domains has been addressed in the topic guide (**Supplementary file**) by one to five main questions and prompts, aimed at eliciting participants beliefs and experiences surrounding capability, opportunity, and motivation in detail. The topic guide was pilot tested in a previous study and adapted to the present study population. Interviews were held by two experienced members of the research team, a physiotherapist (female, LR) and a psychologist (male, FW). No prior relationship between participants and researchers had been established. The interviews were carried out at the rehabilitation clinics, in a café close to the participants home or by telephone between March and May 2022. They were audio recorded and lasted between 20 and 100 min.

Data analysis

All interview recordings were summarized and relevant parts (i.e., opinions on PA, descriptions of PA behavior, and mentioning of influences on PA behavior) were transcribed verbatim. Thematic analysis involves familiarization with the text trough repeated reading, identification of codes and synthesis in thematic categories (Kuckartz, 2014). Coding was guided by the interview guideline (COM-B), but inductive identification of codes and categories was applied when unanticipated topics were found in the material. The authors (LR and FW) discussed the codes and categories to achieve consensus over the results. Finally, the TDF constructs were mapped onto the definite main categories and subcategories,

TABLE 1 Participant characteristics.

	Age	Gender	Occupational status	Living situation	Time since stroke	Walking abilities
B1	59	M	Part-time work (coaching rehabilitation patients and relatives)	Living alone	19 years	Ambulatory with walking aid on level surface (FAC 3–4) for short distances
B2	59	F	Invalidity pension	Living with husband	2 years	Ambulatory with walking aid on level surface (FAC 3–4) for short distances
B3	55	F	Invalidity pension	Living with her children (14–20 years old)	8 years	Ambulatory with walking- aid or supervision for stairs (FAC 4–5)
B4	72	F	Retired	Living with husband (also has a disability)	12 years	Ambulatory with walking aid on level surface (FAC 3–4) for short distances
B5	72	M	Retired	Living alone	N/A	Ambulatory including stairs (FAC 5)

FAC, functional ambulation category; M, Male; F, Female.

and another consensus discussion followed. Quotes are used in the following section to illustrate the categories.

Results

Interview findings were summarized into 6 main- and 23 subcategories. Figure 1 presents the TDF constructs mapped onto the main and subcategories.

Physical capabilities

Participants described different **physical capabilities to independently perform PA** (skills). Important for participants was the ability to walk, *"I can walk like a normal person" (B5).* Limited or no upper extremity function on the affected side limited activities such as swimming. Paresis of the foot flexor was reported as a limitation for walking independently. Over time, participants **developed physical capabilities through training** (skills development):

> *"I can remember, when I tried to go to the supermarket for the first time, 200 m from my house, I took the rollator and it took 2 h. But I have kept working on it, kept trying, and later I could walk with a walking stick" (B4).*

Participants report different levels of **dependence on others to perform PA** *(abilities):* One participant relied on assistance for transportation to the training facility and for the transfer to training devices. PA itself could be performed individually according to all participants. A central theme for participants were their **physical capabilities for daily life activities** (skills and abilities). They all used daily life activities to describe and quantify their physical capabilities. For example, one participant when asked about his muscle strength, answered: "*Well it's enough to do my daily routines on my own" (B1).*

Psychological capabilities

Some participants had acquired **knowledge about PA after stroke** (knowledge of condition) and gave examples of consequences of inactivity in wheelchair users, i.e., the loss of core strength. They were aware that a training program tailored to the individual capabilities is warranted. In **general, knowledge about PA, its benefits and procedures** (knowledge) pertained to its importance, the negative consequences of inactivity and the positive effects on for example the vascular system:

> *"It's really important because everything moves when you move. I'm thinking circulation of the blood. And if you do not move, there is muscle atrophy" (B4).*

The term HEPA was not familiar to participants neither were official PA recommendations (**knowledge about HEPA**). Most participants instead had ideas about how much PA would be

THEME	CATEGORY	TDF
1. Capabilities physical	1.1 Physical capabilities to perform PA independently	Skills
	1.2 Developing physical capabilities through training	Skills development
	1.3 Dependence on others to perform PA	Ability
	1.4 Physical capabilities for activities of daily life	Skills, Skills development, Ability
2. Capabilities psychological	2.1 Knowledge about PA after neurological event	Knowledge of condition
	2.2 Knowledge about PA, its benefit, and procedures	Knowledge
	2.3 Knowledge about HEPA	Procedural knowledge
	2.4 Monitoring and planning of PA	Self-monitoring, Action planning
	2.5 Attention and decision-making regarding PA	Decision making, Attention, Memory
3. Opportunity Physical	3.1 Access to technology	Resources/material resources
	3.2 Usability of technology	Person x environment interaction
	3.3 Access to local training facilities	Barriers and facilitators
	3.4 Environmental influences	Environmental stressors, Barriers and facilitators
4. Opportunity Social	4.1 Social support for physical activities	Social support
	4.2 Participation in activities	Alienation
	4.3 Society and social norms	Social norms
	4.4 Comparison with others	Social comparisons
5. Motivation Reflective	5.1 Perception of self	Self-confidence, Self-efficacy
	5.2 Perceptions of groups	Social identity, Group identity
	5.3 Role models	Identity
	5.4 Goals: Outcomes	Goals
	5.5 Goals: PA	Goals, Action planning
	5.6 Relevance for daily life	Outcome expectancies, Characteristics of outcome expectancies
6. Motivation Automatic	6.1 Experiencing success	Rewards, Incentives
	6.2 External reward	Reinforcement
	6.3 Fear of falling	Fear, Anxiety
	6.4 Body feeling	Rewards (intrinsic)
	6.5 No progress	Pessimism

FIGURE 1
The six themes and 28 categories from the thematic analysis of the interviews and the theoretical domain framework (TDF) constructs. HEPA, health enhancing physical activity; PA, physical activity; TDF, theoretical domain framework.

good or relevant for themselves, ranging from short sessions every day to three times per week 1.5 h. Three participants engaged in some form of **PA monitoring and planning** (self-monitoring and action planning), for example through apps. One participant described planning the amount and frequency of her PA:

> *"I do make plans. For example that every day I walk two rounds in the morning and then cycle for half an hour in the evening" (B2).*

Accounts of participants demonstrated **attention and decision-making regarding PA**. One participant described using exercises for the arm as a strategy to relieve shoulder pain.

Opportunity physical

Several external factors affect participants opportunities to engage in PA. One of them was the **access to technology** (Resources/material resources). It emerged that having access to the latest technology beyond the acute phase of treatment was difficult. One participant described that her rehabilitation clinic has technologies she would like to use, but availability is an issue as the demand is high. Another participant was interested in a robotic device to practice arm movements, but it was too costly to purchase for home use. This theme is linked to a second environmental factor: **access to local training facilities** (barriers and facilitators). According to the interviews, there are not enough facilities that are easy to reach for outpatients and offer the right equipment for wheelchair users. For participants who train with technologies, **usability** (person x environment interaction) can be an issue. One participant who trains regularly with a robotic device described discomfort:

> *"(. . .) you are secured with a harness. And it is not very comfortable, so somewhere it always pinches or cuts in" (B2).*

Another participant who uses an app for training reported having difficulties navigating through the app. **Environmental influences** (environmental stressors, barriers, and facilitators) were a strong determinant for participants in their decision or ability to be physically active. Bad weather presented an obstacle for many because it reduces the motivation to go out, can present a physical barrier (i.e., icy conditions for wheelchair users), but can also impact physical functioning:

> *"Cold temperatures affect my bladder (. . .) so it's really depending on the weather for me, sunshine gets me further" (B1).*

Public infrastructure, such as escalators or stairs, affected participants differently. They offer training opportunities for balance and walking ability but also make moving around difficult. Small details, like having handrails on both sides, can make a difference:

> *"(. . .) you always have to go up and down the stairs and that's always been a challenge for me, step up, step down, and then nothing to hold on to–that was really hardcore" (B3).*

Opportunity social

Social support can make PA possible as the stories of participants demonstrate: *"I also have very good friends who help me. For example, we went canoeing once and I didn't even know if I could get in and then they said, no problem, we'll help you" (B3).*

Social support included direct help from friends or families to execute a certain activity like walking, canoeing or tandem cycling, but also assistance to get to training locations. Some participants reported training together with a friend with a similar condition. PA served to stay connected with others and **participate in society** (alienation):

> *"Colleagues went up the mountain, into the snow, and then I have to say, okay, I just wasn't there, that stresses me out." (Inquiry by interviewer: is it more about being a part of it, or about missing out on the activity?) "Actually, it's about the social aspect, I realize that before I was always there and now, I'm a bit on the outside" (B3).*

Social norms were another enabler or barrier. Generally, participants believed social norms or society do not influence their PA behavior. However, they spoke about insecurities of how they were perceived in public, when for example being out with their partners.

> *"When we're somewhere. . . (me) sitting in a wheelchair. I always say, do they think the poor woman or do they think the poor man" (B2).*

Regarding **comparison with others** (social comparisons) participants compared themselves with someone who is less active as a negative example but also with someone with a similar condition who has different abilities. The following statements illustrates the latter, but also shows how this person puts it in perspective and is aware, that not all comparisons are suitable or beneficial:

> *"I know a woman who suffered a stroke at the same time, and she is very diligent. She's very diligent, she goes swimming. But I can't swim because of this arm. (. . .). I am jealous, of this woman. I would also like to go swimming and I tried, but it was difficult. And she now, she walks at home. But, I can't compare, everyone is different" (B4).*

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Motivation reflective

One theme of reflective motivation was the **perception of self** (self-confidence and self-efficacy): having overcome obstacles helped to build confidence in one-self to be active. One participant described: *"I just needed these obstacles to know, I can do this" (B3).* Participants also stated that a group that trains and is active together could be good for motivation and would be beneficial for people with mobility impairment, i.e., their **perceptions of groups** (group-identity) could be a motivating factor:

> *"A lot of people with handicap distance themselves from others, because they have a handicap and these people have to be brought together" (B1).*

In most interviews, participants brought up a **role model** (identity), somebody that has influenced them in their decision to be active: *"if this man can do it, then maybe I can also" (B5).* Participants described two different types of goals: **goals pertaining to outcomes** (goals) and **goals for PA** (goals and action planning). Outcome oriented goals included end or intermediate results participants wanted to achieve, either relating to body functions, such as regaining muscle function of the foot flexor, or mobility improvements, such as being able to climb stairs.

> *"It was my goal to at least come home on weekends and then I knew, I had to be able to climb the stairs and I have to perform transfers, that was indeed a motivation" (B2).*

Goals for PA were process-oriented, such as walking around the house or training a set amount of time daily. A theme that emerged in all interviews was the **relevance for daily life** (outcome expectancies): The wish to perform daily life activities independently was a strong motivator for many participants and PA or training was described as intertwined with daily life.

> *"If I feel like, this is good for me, I have a training for my everyday life, then that really motivates me" (B1).*

Motivation automatic

Experiencing success (rewards and incentives) motivated participants to keep up their training and to be active. Examples were reaching a goal or a smaller milestone and being able to see progress over time: *"If I've had a small experience of success, then I am more motivated"(B3).* One participant described how a stalled or **no progress** toward her goals has impeded her motivation to train regularly (pessimism).

> *"It's simply my decision (whether to train or not), but I feel like in the beginning the curve has gone up massively and then later the curve flattens and is even a little bit worse, so I think this is part of my decision somehow" (B3).*

External rewards (reinforcements) were mentioned as a motivating influence, such as the affirmation of a care giver or feedback given by a device after a workout. For participants, the **fear of falling** (fear and anxiety) had an influence on their ability to be active, especially when being at home alone or outside. One participant recounted how she had fallen while being home alone and has had great difficulties to stand up without someone's help. *"Falling would actually be a nightmare for me" (B3).* Training or physical therapy elicited an improved **body feeling** (intrinsic rewards) in some participants, which they describe as "it makes you feel good." Others did not observe any changes in how they feel after or during exercise, or described that they feel very tired.

Discussion

This study explored facilitators and barriers to PA in individuals with severe functional limitations, using the comprehensive BCW framework with the COM-B model and TDF. Five semi-structured interviews revealed barriers and facilitators along the six main categories of the COM-B, namely individuals' physical and psychological capability, their physical and social opportunities, as well as their reflective and automatic motivation. The TDF constructs were mapped onto the results of the thematic analysis, providing us with the key behavioral constructs to consider for an intervention.

Participants were highly motivated to be independent in everyday life and have developed and applied strategies to pursue that goal. PA was important to achieve that goal. Aspects of autonomous motivation also played a role. Although detailed knowledge on HEPA was limited, we discovered a general understanding of the importance of PA and knowledge about stroke relating to psychological capabilities and that a lack of physical opportunities, such as having access to adequate training facilities can present a barrier. Finally, social opportunities in the form of support, social norms, or comparisons with others were found to positively influence PA behavior.

These findings complement and confirm other research on individuals with disabilities such as the PAD model by van der Ploeg et al. (2004) or Shields et al. (2012). However, the BCW approach, representing a synthesis of several models, expands other approaches by allowing to identify interventions to tackle the respective barriers and outlining policy categories that can be leveraged to bring these interventions about (see **Figure 2**). Complementary, the TDF constructs mapped onto the results

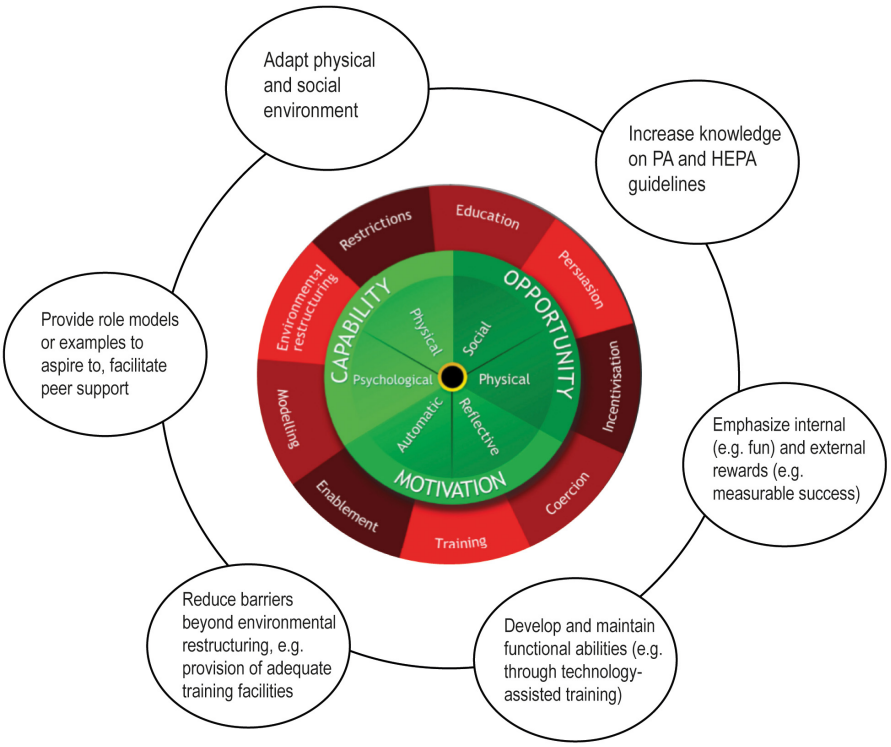

FIGURE 2
The behavior change wheel BCW and possible intervention strategies in the context of this study. Figure based on "The behavior change wheel" by Michie et al. (2011) licensed under CC BY 2.0 (https://creativecommons.org/licenses/by/2.0/).

of the thematic analysis present a link between behavior change theories and techniques of behavior change. The Behavior Change Technique Taxonomy (BCTT, V1) (Michie et al., 2013) is a classification system that allows characterizing the active content of interventions and understand the mechanisms behind behavioral changes such as specific if-then plans (Wieber et al., 2015). We argue that the BCW provides a well-suited framework to address the complexity of the challenges that individuals with functional limitations face to attain HEPA and to develop and implement tailored interventions.

The need to provide persons with mobility restrictions access to HEPA is evident. They are exposed to an increased risk of NCD and relapses of neurological events due to the forced sedentary lifestyle. NCD affect both, physical and mental wellbeing and thus have an impact on health-related quality of life. One element in modifying these risks is regular PA. If those affected want to reduce the health risks through self-determined PA, there are hardly any adapted training options available to them. However, health enhancing PA in people with severe mobility impairment has not been sufficiently studied yet. These persons are therefore at a disadvantage in terms of health, as they cannot take advantage of preventive PA. As age is the single most important risk factor for stroke (Sacco et al., 1997), the demographic development point to an increasing number of such cases in the future, thereby increasing the need to develop effective solutions to provide HEPA to everyone.

Whereas rehabilitation technologies such as a robot for the walking training have proven to enable intensive and effective functional training in persons with impaired mobility (Mehrholz et al., 2017; Wirz et al., 2017) they can also be used to achieve the recommended amount of HEPA and positively affect the determinants of behavior outlined in the BCW and the TDF. For example, technology can provide reinforcement through external rewards in the form of positive feedback for good performance. The results of the present study contribute to the investigation of the potential of rehabilitation technologies to assist people with mobility limitations to become physically active on a regular basis in order to minimize the risk of inactivity-associated conditions.

New PA-oriented services for individuals with mobility restrictions are needed as well as their evaluation. To date, there are a few studies who have addressed this topic. However, sample sizes were small and the long-term effect of PA training has not been studied yet. Also, it remains unclear for how long the effects of training persist after discontinuation of the training. The literature supports the assumption that a training with rehabilitation devices, which enable large movements of

multiple body segments, results in immediate physiological responses (Lefeber et al., 2017). Moreover, detailed knowledge about the reasons for (non-) participation in PA and the amount of PA performed inform interventions and strategies for health promoting PA.

A successful and promising training program also holds the potential to be scaled up to other populations. For example, people with progressive diseases or children with neurologic impairments could benefit from comprehensive health service models. Both are populations with unique challenges and requirements, needed to be addressed specifically.

Methodological considerations

The small sample size, the mapping of TDF-constructs by one researcher and the susceptibility of interviews to social desirability limit the informative value of the results. Although more interviews might have allowed to reach saturation, patients from different rehabilitation clinics and centers ensure geographical variety. Moreover, techniques like peer debriefing or triangulation would have further strengthened the validity of the COM-B and TDF framework based analyses but as consistency has been reviewed with a second researcher, the findings still inform the first stage of the BCW approach for intervention development.

Individuals with mobility impairments are a very heterogeneous group. Even though the diagnosis is the same, the symptom presentation after rehabilitation vary greatly (Dunn et al., 2016). In this study, the severity ranged from moderate, corresponding to a functional ambulation category (Holden et al., 1984) of 4–5 to severe, corresponding to a functional ambulation category of 2–3. This challenges adequate tailoring of intervention components and identifying appropriate outcome measures to evaluate the effectiveness of an intervention. Often, the time lag between intervention and expected health outcomes is considerable, and thus difficult to capture in a trial. However, given the increased health risks of individuals with mobility impairments, these difficulties do not justify delaying our efforts to develop effective evidence-based programs that allow individuals with mobility impairments to get access to the HEPA benefits.

Conclusion

The COM-B and TDF framework allowed a comprehensive analysis of the facilitators and barriers for HEPA in individuals with functional limitations. Although they might not know the specific HEPA suggestions, they are aware of the importance of PA and they are strongly motivated to maintain and/or increase their physical abilities to master their everyday lives as independently as possible and to be socially engaged. Despite these facilitators, barriers such as the lack of access to training facilities–without burdening one's social network–keep them from HEPA and call for changes in the training models that are offered. Thus, health service models for individuals with functional limitations to sustainably attain the HEPA suggestions are needed as they represent promising opportunities to foster behavior change and reduce social inequalities. Central stakeholders are called upon to join their forces to develop and implement these models.

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 review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

EG, MW, and FW developed the research question and designed the interview guideline. FW and LR collected the data. LR analyzed the data. All authors contributed to the writing the manuscript and read and approved the final manuscript.

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Conflict of interest

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

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Supplementary material

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The relationship between exercise intention and behavior of Chinese college students: A moderated mediation model

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Inconsistency between intention and behavior is very common in daily life. This study explored the intention-behavior relationship in exercise, focusing on the mediating effect of action planning and the moderating effects of habit strength and gender. For the purpose of providing theoretical reference for the implementation of intervention strategies in the volitional phase, a total of 489 college students (M-age = 20.61, 57.46% female) from Hubei Province, China, were recruited to complete the questionnaire at two time points. The findings showed that exercise intention could positively predict exercise behavior *via* the mediating effect of action planning, with the mediating effect accounting for 48.52% of the total effect. The predictive effect of action planning × habit strength interaction on exercise behavior was statistically significant. As individuals' levels of habitual strength increased, so did the relationship between action plans and exercise behavior. The action planning-exercise behavior relationship was stronger in males than in females. In summary, action planning is a very important predictor of the post-intentional phase and has many advantages. For individuals whose exercise has become habitualized, forming a plan is not counterproductive and can still promote more exercise rather than in a mutually compensating manner.

KEYWORDS

exercise, intention-behavior gap, action planning, habit, dual process

Introduction

It has long been accepted among Chinese college students that more exercise is beneficial to their health, and they frequently express favorable intentions toward exercise (Liang, 2015). The challenging part, however, is figuring out how to keep doing what one wants to do and successfully convert intention to action. Intention is an indication of a person's readiness to perform a given behavior (Ajzen and Madden, 1986). It is considered as a proximal determinant of behavior (Ajzen, 1991). Previous research found a 46% disparity between intention and behavior in the area of physical activity,

and this discrepancy was mostly ascribed to individuals who did not follow through on their intentions (Rhodes and de Bruijn, 2013). Ping (2022) indicated a moderate positive correlation between exercise intention and exercise behavior. Nonetheless, adopting the longitudinal designs with a lengthy assessment interval, the consistency of exercise intention and behavior was low between middle-aged and sub-healthy individuals, implying an intention-behavior gap may exist.

As the classical social cognitive theory suggests, exercise intention is the most direct and important predictor of individual exercise behavior (Blue, 1995), but the explanatory power of the former for the latter is weak in the volitional phase. Currently, it has been demonstrated that aspects such as executive function (Frye and Shapiro, 2021), self-efficacy (Isa et al., 2019; Divine et al., 2021), planning (Lange et al., 2018), and action control (Monge-Rojas et al., 2021) can provide some additional insights. However, while these studies mostly emphasized the importance of conscious regulatory processes, they neglected the implicit effects generated by automatic associations. Thus, this research focused on the formation mechanism of exercise intention to exercise behavior among Chinese college students and combined conscious and non-conscious regulatory processes for analysis, aiming at providing a theoretical reference for the implementation of intervention strategies in the post-intentional phase.

Action planning is a substructure of planning. It is a psychological simulation that associates goal-directed behaviors with specific contextual cues by defining when, where, and how to act (Sniehotta et al., 2005). In the Health Action Process Approach (Schwarzer, 2008), action planning is established as a mediating factor between intention and behavior. Not only is it an extension of intention, but it is also more likely and efficient than intention to trigger actual behavior when contextual cues are more adequate. In recent years, the interaction effects of action planning and other predictors have received much attention. Caudroit et al. (2014) discovered that action planning only worked as a moderator for people who had higher levels of coping planning. Self-efficacy was found to moderate the first and second halves of the action planning mediating process by Barz et al. (2016). This implies that the action planning mediates the predictive effect of exercise intention on exercise behavior may be influenced by a number of potential variables. Therefore, a foundational hypothesis 1 is proposed here: *Action planning mediates the predictive effect of exercise intention on exercise behavior of college students.*

According to contemporary theory and research, a habit is a behavior or behavioral tendency that is carried out automatically in response to a certain set of linked circumstances or contextual cues (Wood, 2017; Hagger, 2018). Once exercise turns into a habit, it will seem less deliberate to perform (Verplanken and Melkevik, 2008). It becomes a fast, automatic, and non-conscious process, similar to the description of "*system 1*" in Dual-Process Theories (Evans and Stanovich, 2013). On the one hand, previous research demonstrated that higher than average levels of intention predict behavior when individual habit strength levels are low (Di Maio et al., 2021). de Bruijn and Rhodes (2011) found the predictive effect of intention on behavior was roughly three times larger when habit strength was low compared to high levels of habit strength. On the other hand, some research pointed out that for high-intensity physical activity, individuals with high levels of habit strength showed a tighter connection between physical activity intention and behavior (Rhodes and de Bruijn, 2010). An identical conclusion was also reached by de Bruijn et al. (2012). Whether habit strength weakens or enhances the influence of exercise intention on exercise behavior is disputed. To be further verified, the following hypothesis 2 is proposed: *Habit strength moderates the predictive effect of exercise intention on the exercise behavior of college students.*

An increasing number of studies have confirmed the perspective that physical activity is the consequence of both conscious and unconscious processes (Rebar et al., 2016). The habit theory suggests that planning, a self-regulatory strategy frequently employed during habit formation, should have a direction that is compatible with the habit strength (Lally and Gardner, 2013). However, Maher and Conroy's (2015) 7-day intervention study found that the conscious-control behavior of creating action plans was counterproductive for individuals with high levels of habit strength; in contrast, individuals with low levels of habit strength engaged in more exercise after creating action plans. Since then, some researchers have repeated the study with inconsistent results, finding that the correlation between action planning and exercise behavior was not inhibited by habit strength (Di Maio et al., 2021). First, is it superfluous to create action plans for individuals with high habit strength? Second, whether making plans and forming habits is an iterative process that can together facilitate the transformation of intention into behavior. Therefore, the above two issues need to be clarified. Hypothesis 3 considers: *Habit strength moderates the predictive effect of action planning on the exercise behavior of college students.*

It is crucial to investigate the effect of demographic variables on intention-behavior relationships because it may imply inequalities in the social structure of the population (Schüz et al., 2017). The latest study by Rhodes et al. (2022) revised a previous systematic review of potential moderators of intention-behavior relationships in the physical activity domain (Rhodes and Dickau, 2013) and reassessed the moderating role of gender. More than 66% of the studies showed that the gender variable did not affect intention-behavior invariance. The remaining studies concluded that females had stronger intention-behavior relationships than males (Nigg et al., 2009; Xin et al., 2019), or the opposite (Plotnikoff et al., 2012). Will an increasing number of findings in the future support the perspective that "females/males are somehow more devoted to pursuing their own intentions"? Out of curiosity, we propose hypothesis 4:

Gender moderates the predictive effect of exercise intention on the exercise behavior of college students.

Martin's (2004) study of student motivation in Australia found that girls were more likely than boys to adopt plans to manage their behavior and to show greater resilience in the face of challenges. To investigate gender differences in the process of health behavior change, Hankonen et al. (2010) conducted a study on people at high risk for type 2 diabetes, trying to test whether changes in action planning could predict changes in exercise behavior. At the baseline level, there was no difference in action planning by gender, but after 3 months, action planning played a more prominent role in exercise behavior change in females than in males. In a study by Magoc et al. (2016), it was found that gender had a moderating effect on the relationship between exercise planning and behavior, with exercise planning being the strongest predictor of exercise behavior among female college students. According to the above findings, there may be gender differences in the field of self-regulation strategy, and action planning may promote exercise behavior in females. Hypothesis 5 is proposed: *Gender moderates the predictive effect of action planning on the exercise behavior of college students.*

In summary, the goal of this study is to discuss the mediating mechanism of action planning and the moderating effects of habit strength and gender by analyzing the intention-behavior relationship in the exercise domain. **Figure 1** depicts the proposed hypothetical model.

Materials and methods

Participants and procedure

A prospective online survey was conducted at two universities in Wuhan, China. Through convenience sampling, the data was collected *via* WeChat groups of 15 sports clubs on campus, which were originally created to advertise in the fall. Specifically, each club leader (i.e., instructor or teacher) assisted us by disseminating the link to the electronic questionnaire to their WeChat group for students to complete. They operated at a more detailed level during the survey, communicating directly with students, but they were not part of the assessment population for this study. At baseline (Time 1; T1), 532 students first provided informed consent, and then filled in the questionnaire assessing exercise intention, action planning, and demographic variables. The follow-up assessment (Time 2; T2) took place 4 weeks later at a club seminar with 489 participants (92% of the initial sample; 43 students lost data), and it included habit strength and exercise behavior. This longitudinal sample's mean age was 20.61 (SD = 2.10; range 16–29), with 42.54% being male. In terms of educational qualifications, 82% of the longitudinal sample were bachelor level students, and the rest were either master level (14.93%) or Ph.D. students (3.07%). Participants who completed two assessments were rewarded with small gifts.

Measures

For the purposes of consistency, the questionnaires completed by these college students measured the relevant variables using a distinct definition of exercise. Exercise was defined as a subset of physical activity that was (1) planned, structured, and involved repetitive bodily movements; (2) not a basic daily activity, performed at your own discretion; and (3) intended to improve or maintain the health of one or more body parts (Caspersen et al., 1974; Bouça-Machado et al., 2019).

Three items from the TPB-related structure scale created by Ajzen (2002) were used to assess exercise intention. Specifically, it included "*I plan/intend/hope to exercise for at least 20 minutes, three times per week for the next four weeks.*" Participants evaluated each item on a 7-point Likert-type scale with a minimum value of 1 (completely disagree) and a maximum value of 7 (completely agree). A previous study demonstrated that the Chinese version of the scale had great reliability and validity among college students (Jian et al., 2020). Cronbach's alpha was 0.91 in this study.

Sniehotta et al. (2005) developed five items to assess action planning, which addressed when, where, who, how long, and how to act. The items were worded: "*For the next four weeks, I have made a detailed plan regarding.*" (1) "*when to exercise,*" (2) "*where to exercise,*" (3) "*how to exercise,*" (4) "*how often to exercise,*" and (5) "*with whom to exercise.*" These items were measured on a 4-point Likert-type scale ranging from 1 (completely disagree) to 4 (completely agree). The original questions were translated into Chinese by two scholars with overseas visiting experience. Cronbach's alpha was 0.95 in this study.

Gardner et al. (2012) simplified a four-item automaticity subscale (SRBAI) to assess habit strength. The stem "*Exercise is something.*" is followed by "*I do automatically,*" "*I do without having to consciously remember,*" "*I do without thinking,*" and "*I start doing before realizing I am doing it.*" These items were also translated into Chinese by the two scholars mentioned above and scored using the 7-point Likert-type scale. A total score was calculated by adding the scores, which higher values indicate a stronger level of automaticity in exercise. Cronbach's alpha was 0.89 in this study.

The Physical Activity Rating Scale-3 (PARS-3) was used to assess exercise behavior (Deqing, 1994). The PARS-3 consists of three items that evaluate the amount of exercise done as a result of intensity, duration, and frequency. These items were measured on a 5-point Likert-type scale. The total score of physical activity is calculated as follows: intensity × (duration-1) × frequency, ranging from 0 to 100. The three levels are

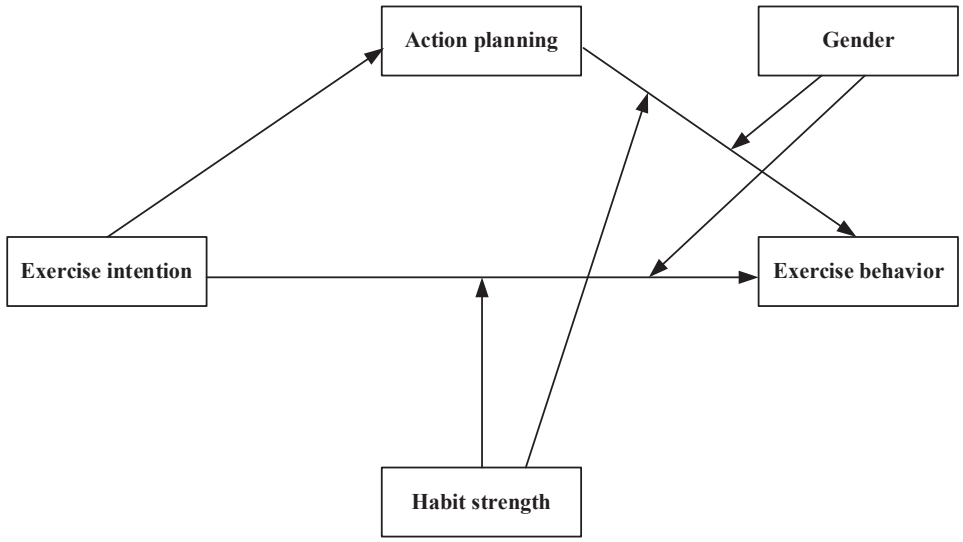

FIGURE 1
The proposed moderated mediation model.

less than or equal to 19 (light), 20 to 42 (moderate), and more than or equal to 43 (vigorous). Cronbach's alpha was 0.62 in this study.

Statistical analyses

Data analyses were carried out using AMOS 23.0 and SPSS 26.0. First, a common method bias test was performed using the unmeasured latent method factor technique based on confirmatory factor analysis (CFA). Second, the differences in exercise intention, action planning, habit strength, and exercise behavior across demographic characteristics were examined using descriptive statistics and independent sample *t*-test. Pearson's correlation analysis was used to test the correlation coefficients between the continuous variables and whether they were statistically significant. Third, hypothesis testing was performed in three phases, evaluating the mediating role of action planning, the moderating role of habit strength, and the moderating role of gender, in that order. The values of the variables used in all regression models were standard scores (i.e., Z-scores).

Results

Common method biases test

A first-order multi-factor oblique intersection measurement model (M1) was constructed using AMOS 23.0. On this basis, a method factor was added to construct the model (M2). Subsequently, the partial fit indices of M1 and M2 were compared. The results showed that ΔRMSEA = 0.015, ΔSRMR = 0.020, ΔTLI = 0.016, and ΔCFI = 0.016. The fluctuations of RMSEA and SRMR did not exceed 0.05, and the fluctuations of TLI and CFI did not exceed 0.1 (Zhonglin et al., 2018), indicating that there was no serious problem of common method bias. For more details on model fit, see the **Supplementary material**.

Descriptive statistics and independent sample *t*-test

Descriptive values of absolute and relative frequencies are shown in **Table 1**. The gender ratio in this sample was balanced, and the majority were undergraduate students. In the past month, 80.16% of them did not participate in offline activities organized by sports clubs, and 60.12% did not achieve a moderate or vigorous amount of exercise.

According to the results of the independent samples *t*-test in **Table 2**, male and female college students had significantly different exercise intention, action planning, habit strength, and exercise behavior (all $p < 0.001$). Male's scores were higher than those of female. Meanwhile, college students who had participated in offline club activities performed much better on all variables (all $p < 0.05$). The average value of postgraduate students' exercise behavior was significantly higher than that of undergraduate students ($t = -3.24$, $p < 0.01$).

In addition, effect size and statistical power were calculated for the results of independent sample *t*-tests using G*Power 3.1. The Cohen's d values were higher than 0.5 and the power (1–β) values were higher than 0.8, after pre-setting $\alpha = 0.05$ and importing the means, standard deviations, and sample size for

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TABLE 1 Frequencies of demographics and amount of exercise.

Variable	Categories	*n*	%
Gender	Male	208	42.54%
	Female	281	57.46%
Educational qualifications	Undergraduate	401	82.00%
	Postgraduate	88	18.00%
Amount of exercise in the past month	Light	294	60.12%
	Moderate	106	21.68%
	Vigorous	89	18.20%
Club offline activities in the past month	Participated	97	19.84%
	Did not participate	392	80.16%

both the male and female groups. Consequently, we considered the sample to be adequate.

Correlation analysis

As shown in Table 3, the correlation coefficients of EI, AP, HS, and EB were all statistically significant. The EI was positively correlated with AP ($r = 0.50$, $p < 0.001$), HS ($r = 0.53$, $p < 0.001$), and EB ($r = 0.42$, $p < 0.001$). The AP was positively correlated with HS ($r = 0.64$, $p < 0.001$) and EB ($r = 0.49$, $p < 0.001$). The HS was positively correlated with EB ($r = 0.51$, $p < 0.001$).

Mediation analysis of action planning

In order to evaluate the mediating role of action planning between exercise intention and exercise behavior among college students while controlling for gender, age, and educational qualifications, Hayes' (2013) PROCESS macro for SPSS 26.0 was used to select "*Model 4*." As recommended by Judd and Kenny (1981) and Baron and Kenny (1986), three regression models were constructed by testing the regression coefficients in sequence. First, the results in Table 4 showed that exercise intention significantly influenced exercise behavior in M3 ($\beta = 0.33$, $p < 0.001$; the "c" in "$Y = cX + e_1$" was statistically significant). Second, exercise intention significantly influenced action planning in M4 ($\beta = 0.46$, $p < 0.001$), and action planning significantly influenced exercise behavior in M5 ($\beta = 0.35$, $p < 0.001$). That is, the "a" in "$M = aX + e_2$" and the "b" in "$Y = c'M + bM + e_3$" were statistically significant. Third, exercise intention significantly influenced exercise behavior in M5 ($\beta = 0.17$, $p < 0.001$; the "c' " in "$Y = c'M + bM + e_3$" was statistically significant). This demonstrated that action planning played a mediating role in the relationship between college students' exercise intention and exercise behavior. Specifically, the indirect effect of the action planning accounted for 48.52% of the total effect ($\beta = 0.16$, *Boot SE* = 0.03, 95% *Boot CI* [0.11, 0.22]).

Moderation analysis of habit strength

Hayes' (2013) PROCESS macro for SPSS 26.0 was used to select "*Model 15*" to test whether habit strength played a moderating role in the direct and second half paths of the aforementioned mediation model, controlling for gender, age, and educational qualifications. The results in Table 5 showed that the effect of exercise intention × habit strength interaction (Int_1) on exercise behavior was not statistically significant ($\beta = 0.03$, $p > 0.05$). Action planning × habit strength interaction (Int_2) significantly influenced exercise behavior in M6 ($\beta = 0.09$, $p < 0.05$). Accordingly, habit strength simply moderated the relationship between action planning and exercise behavior while having no influence on the relationship between exercise intention and exercise behavior.

A simple slope test was performed using the pick-a-point approach (Aiken and West, 1991) to further analyze the action planning × habit strength interaction in Figure 2. The results

TABLE 2 Statistical differences in different categories of variables.

	EI (M ± SD)	*t*	AP (M ± SD)	*t*	HS (M ± SD)	*t*	EB (M ± SD)	*t*
Gender								
Male	16.04 ± 4.04	6.43***	13.53 ± 3.61	5.80***	20.31 ± 4.99	8.76***	30.04 ± 22.91	7.76***
Female	13.49 ± 4.68		11.49 ± 4.13		16.04 ± 5.58		15.32 ± 17.37	
Educational qualifications								
Undergraduate	14.45 ± 4.51	−1.29	12.32 ± 4.04	−0.48	17.70 ± 5.66	−1.31	19.93 ± 19.96	−3.24**
Postgraduate	15.15 ± 4.94		12.55 ± 4.04		18.58 ± 6.06		29.10 ± 24.84	
Club offline activities in the past month								
Participated	15.58 ± 4.75	2.41*	13.43 ± 4.28	2.95**	20.55 ± 5.19	5.31***	37.29 ± 22.09	8.03***
Did not participate	14.33 ± 4.53		12.09 ± 3.94		17.19 ± 5.67		17.69 ± 19.08	

EI, exercise intention; AP, action planning; HS, habit strength; EB, exercise behavior.
*$p < 0.05$; **$p < 0.01$; and ***$p < 0.001$.

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TABLE 3 Correlations for all variables.

	M ± SD	1	2	3	4
1. Exercise intention	14.58 ± 4.59	–			
2. Action planning	12.36 ± 4.04	0.50***	–		
3. Habit strength	17.85 ± 5.73	0.53***	0.64***	–	
4. Exercise behavior	21.58 ± 21.19	0.42***	0.49***	0.51***	–

***$p < 0.001$.

showed that a pattern was observed with a stronger relationship between action planning and exercise behavior at high levels (β = 0.35, $p < 0.001$) of habit strength than at medium (β = 0.26, $p < 0.001$) and low levels (β = 0.17, $p < 0.01$). Additionally, as the habit strength level increased, the effect value of the "EI→AP→EB" mediated process tended to gradually rise as well (low HS, β = 0.08, 95% *Boot CI* [0.02, 0.15]; medium HS, β = 0.12, 95% *Boot CI* [0.07, 0.18]; high HS, β = 0.16, 95% *Boot CI* [0.09, 0.24]).

Moderation analysis of gender

Using the PROCESS macro in Hayes (2013) SPSS 26.0, "*Model 15*" was selected to test whether gender played a moderating role in the direct and second half paths of the aforementioned mediation model, controlling for age and education. The results in **Table 6** showed that exercise intention × gender interaction (Int_3) had a non-significant influence on exercise behavior (β = 0.16, $p > 0.05$). Action planning × gender interaction (Int_4) significantly influenced exercise behavior in M8 (β = 0.09, $p < 0.05$). Furthermore, in **Figure 3**, simple slope analysis revealed that the association between action planning and exercise behavior was larger in males than in females.

Since the gender differences exhibited by the sample in the scores of each variable and the stable effect of gender as a control variable on the outcome variable. Two additional testing procedures were used: first, "*Model 17*" was used to test the dual-moderating effects of habit strength and gender; second, "*Model 19*" was used to test three-way interactions. When the moderating effects of habit strength and gender were examined simultaneously, none of the interactions were statistically significant. There was no significant influence on exercise behavior from any of the three-way interactions (i.e., exercise intention × habit strength × gender, and action planning × habit strength × gender). For more details on the regression model, see the **Supplementary material**.

Discussion

Our aim in the current study was to examine the mediating role of action planning and the moderating role

TABLE 4 Results of the test for mediating effects of action planning.

	Outcome variable: Exercise behavior (M3)				Outcome variable: Action planning (M4)				Outcome variable: Exercise behavior (M5)			
	β	*t*	*p*	95% CI	β	*t*	*p*	95% CI	β	*t*	*p*	95% CI
Gender	0.54	6.50	<0.001	[0.38, 0.71]	0.23	2.73	0.007	[0.06, 0.39]	0.46	5.86	<0.001	[0.31, 0.62]
Age	0.00	0.02	0.983	[−0.05, 0.06]	0.05	1.92	0.056	[0.00, 0.11]	−0.02	−0.69	0.494	[−0.07, 0.03]
Educational qualifications	0.44	2.87	0.004	[0.14, 0.75]	−0.21	−1.34	0.182	[−0.51, 0.10]	0.52	3.55	<0.001	[0.23, 0.80]
Exercise intention	0.33	8.10	<0.001	[0.25, 0.41]	0.46	11.29	<0.001	[0.38, 0.54]	0.17	3.96	<0.001	[0.09, 0.26]
Action planning									0.35	8.16	<0.001	[0.27, 0.43]
R^2	0.26				0.27				0.35			
$F(p)$	42.18 (<0.001)				43.88 (<0.001)				51.65 (<0.001)			

M3, M4, and M5 represent the three regression models constructed sequentially.
The upper and lower limits of the 95% confidence interval do not contain "0" to reach the significant level.

TABLE 5 Results of the test for moderating effects of habit strength.

	Outcome variable: Action planning (M4)				Outcome variable: Exercise behavior (M6)			
	β	*t*	*p*	95% CI	β	*t*	*p*	95% CI
Gender	0.23	2.73	0.007	[0.06, 0.39]	0.39	4.94	<0.001	[0.24, 0.55]
Age	0.05	1.92	0.056	[0.00, 0.11]	−0.02	−0.83	0.407	[−0.07, 0.03]
Educational qualifications	−0.21	−1.34	0.182	[−0.51, 0.10]	0.47	3.33	<0.001	[0.19, 0.75]
Exercise intention	0.46	11.29	<0.001	[0.38, 0.54]	0.13	2.95	0.003	[0.04, 0.22]
Action planning					0.26	5.36	<0.001	[0.16, 0.35]
Habit strength					0.21	4.08	<0.001	[0.11, 0.31]
Int_1					0.03	0.83	0.409	[−0.05, 0.11]
Int_2					0.09	2.46	0.014	[0.02, 0.17]
R^2	0.27				0.39			
F(p)	43.88 (<0.001)				37.74 (<0.001)			

Int_1: exercise intention × habit strength; Int_2: action planning × habit strength.
M4 and M6 represent the two regression models constructed sequentially.

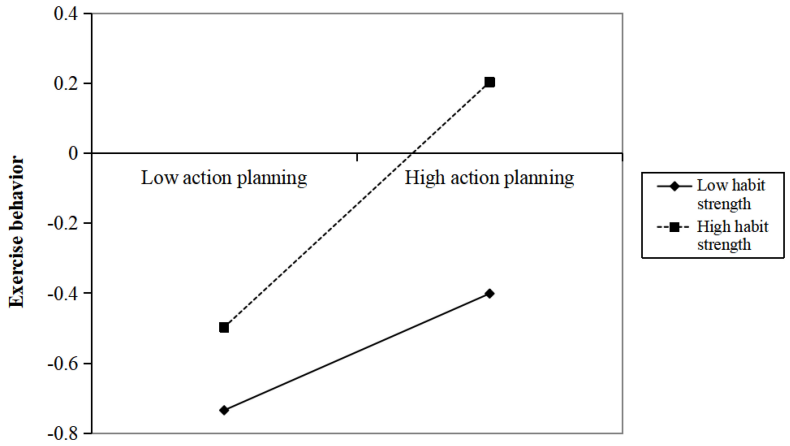

FIGURE 2
Habit strength moderated the relationship between action planning and exercise behavior. Low: 1 standard deviation below the mean; High: 1 standard deviation above the mean.

of habit strength and gender by analyzing the relationship between exercise intention and exercise behavior. Overall, the findings provided support for the idea that physical exercise is determined by a combination of conscious and non-conscious psychological processes.

The mediating effect of action planning

According to the results of this study, supporting hypothesis 1, action planning partially mediated the relationship between exercise intention and exercise behavior, with an indirect effect of up to 48.52%. The effectiveness of action planning continued to be recognized as one of the most frequently used techniques for bridging the intention-behavior gap (Hagger and Luszczynska, 2014). Specifically, after forming the intention to exercise, the action planning's function is to transform the "*unconstrained free reaction*" into a "*conscious planning list*," and thus, bolsters or augments exercise intention with means to promote recall and enactment of the intended behavior.

A study of college students by Fleig et al. (2013) found that intentions facilitated the use of action planning, which in turn promoted exercise. In a young sample from several UK universities, action planning also promoted exercise behavior and partially mediated intention-behavior relationships (Conner et al., 2010). These are consistent with the results of the present study. Looking at past studies on action planning as a mediator, we can see that the above results do not seem to show sufficient novelty. However, it has become an important basis for contributing to the change and maintenance of exercise behavior, the first step on the path from intention to behavior. For example, the so-called volitional

TABLE 6 Results of the test for moderating effects of gender.

	Outcome variable: Action planning (M7)				Outcome variable: Exercise behavior (M8)			
	β	*t*	*p*	95% CI	β	*t*	*p*	95% CI
Age	0.06	2.29	0.023	[0.01, 0.12]	−0.02	−0.62	0.539	[−0.07, 0.04]
Educational qualifications	−0.28	−1.83	0.068	[−0.58, 0.02]	0.48	3.31	0.001	[0.19, 0.76]
Exercise intention	0.49	12.43	<0.001	[0.41, 0.57]	0.12	2.23	0.027	[0.01, 0.23]
Action planning					0.28	5.09	<0.001	[0.17, 0.39]
Gender					0.41	5.22	< 0.001	[0.26, 0.57]
Int_3					0.16	1.80	0.072	[−0.01, 0.33]
Int_4					0.19	2.24	0.026	[0.02, 0.36]
R^2	0.25				0.37			
F(p)	55.28 (<0.001)				39.78 (<0.001)			

Int_3: exercise intention × gender; Int_4: action planning × gender.
M7 and M8 represent the two regression models constructed sequentially.

stage in the theoretical propositions of the HAPA (Schwarzer, 2008) served as an antecedent variable for coping planning (Reyes Fernández et al., 2015; Wee and Dillon, 2022), action control (Reyes Fernández et al., 2015), and preparatory actions (Barz et al., 2014). Therefore, action planning is adopted with a higher priority among the post-intentional predictors of college students' exercise behavior.

Theoretically, action planning should be considered in the intention-behavior relationship. On the one hand, it supports the idea that the successful execution of exercise behaviors by college students is partly attributed to a deliberate and rational approach to processing (Rebar et al., 2016), requiring hypothetical reasoning, selection decisions, and self-evaluations (Bagozzi et al., 2003). On the other hand, it is essential to continue exploring the interaction between action planning and other factors (e.g., habits) and transmission mechanisms of action planning with other factors (e.g., preparatory actions). In reality, the action planning includes two advantages that will assist college students in successfully transforming their exercise intentions into exercise behaviors. It has a low response burden, making its promulgation through multiple modes of delivery comparatively easy, and is relatively low-cost (Hagger and Luszczynska, 2014).

The moderating effect of habit strength

Hypothesis 2 was not supported, and the findings showed that habit strength did not play a moderating role in the relationship between exercise intention and exercise behavior. The result contradicted the view of some dual process models (e.g., Strack and Deutsch, 2004) that suggest conscious processing can be biased by the non-conscious regulatory system through its influence on accessibility to information about behavioral options. Up to now, most of the evidence in

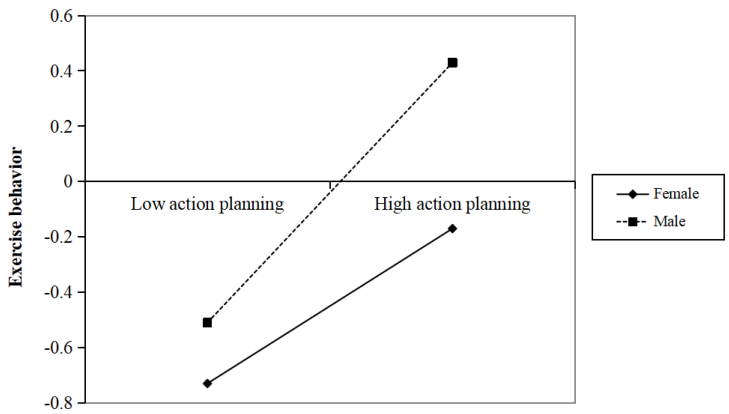

FIGURE 3
Gender moderated the relationship between action planning and exercise behavior.

the physical activity domain tends to show intention to become less predictive of behavior as habit strength increases (Rhodes and Dickau, 2013; van Bree et al., 2013; Hashim et al., 2014; Gardner, 2015; Rebar et al., 2016). The theoretical argument advanced was that once a behavior becomes habitual, it is less susceptible to intentional control than when it is not habitual. In other words, habitual behaviors rely less on an individual's subjective consciousness and do not involve a relatively slow and effortful reasoning process.

In contrast to this, a small number of studies found intention to be more predictive of behavior at stronger levels of habit strength. Undergraduate students who reported high habit levels in the vigorous physical activity condition revealed a greater intention-behavior relationship than their moderate and low habit counterparts, according to Rhodes and de Bruijn (2010). de Bruijn et al. (2012) even came up with the result that intention was a stronger predictor of exercise behavior at higher, rather than at lower, levels of exercise habit strength. Apparently, due to the strenuousness and effortfulness of exercise behavior, strong motivational and automatic components may be required simultaneously, rather than a trade-off between these components (Maddux, 1997; Rhodes and de Bruijn, 2010).

Unfortunately, this current study is not supported by either of these empirical evidences. The "habit-intention interaction hypothesis" not only stated that the association between habit and intention as determinants of behavior is like that of a horse race (Adriaanse et al., 2011), but also added that the influence of habit will depend on the degree of familiarity with the focal behavior in a given situation (Triandis, 1977; Gardner et al., 2020). In unfamiliar settings, in which no action traces exist and behaviors are novel, intentions alone will determine behavior. This means that the reason for the insignificant moderating effect of habit strength could be the unstable context in which the college students performed exercise in the past month. The individual's conscious regulatory processes are dominant in taking action.

When the significant action planning × habit strength interaction was decomposed, findings were also in line with our tentatively formulated hypothesis 3. We found a gradual reinforcement of the predictive effect of action planning on exercise behavior as the level of habit strength increased. It is worth noting that this result opposes the previous general consensus. That is, for individuals with high levels of habit strength for a behavior, developing a plan may disrupt the usual behavior by interfering with the habitual response (Wood and Rünger, 2016). Such as snacking (Adriaanse et al., 2011), recycling behavior (Holland et al., 2006), and smoking (Webb et al., 2009). These studies all found that the stronger an individual's habit, the less effective their implementation intentions will be. In other words, the plans may only be an effective tool to promote more physical activity in college students with lower levels of habit strength (Maher and Conroy, 2015).

Nevertheless, the present findings underpin that even if college students have a high degree of automaticity in performing exercises, forming a detailed and effective action planning will have a positive effect. Di Maio et al. (2021) likewise supported the view that action planning did not become superfluous, although automatic processes were strong. In habit theory, there are mechanisms by which action plans and habit strength are interrelated and iterative, working together to produce changes in exercise behavior (Lally and Gardner, 2013). After the intention is translated into action, the behavior is about to be repeated, which usually requires continuous motivation (Rothman, 2000) and may also be supported by self-regulatory techniques (Michie et al., 2009). Thus far, the moderating effect of habit on the planning-behavior link has received relatively little attention in physical activity domains, with only two studies by Maher and Conroy (2015) and Di Maio et al. (2021). The future remains to be examined further.

The moderating effect of gender

In addition to the initially proposed hypotheses 4 and 5, we further analyzed other potential issues regarding gender. Although hypothesis 4 was not supported by the study results, it is consistent with the prevailing theory (Fishbein and Ajzen, 1975). Exercise intention is a powerful predictor of exercise behavior. Most demographic variables followed the principle of invariance in the intention-behavior relationship (Rhodes et al., 2022). The present study, along with a number of large global surveys, had shown differences in physical activity levels between males and females (Hallal et al., 2012; Guthold et al., 2018; de Looze et al., 2019), but this did not serve as evidence to support a gender moderation of intention-behavior relationship. Gender moderated the relationship between action planning and exercise behavior, and hypothesis 5 was supported. Inconsistent with the findings of Hankonen et al. (2010), the association between action planning and exercise behavior was stronger among males, which we assume was due to sample differences. Females between the ages of 50–65 in economically developed areas with a higher risk of type 2 diabetes were driven by a perceived personal health status and were more likely to make a plan and then take action. Conversely, in areas where traditional gender norms prevail, males dominated the advantage of many social resources (de Looze et al., 2019), which was more conducive to going about their plans and doing more physical exercise. Moreover, we found that the moderating role of habit strength in the relationship between action planning and exercise behavior was not interfered with by gender. This means that continuing to develop an action plan can be a universal program for students who have formed positive exercise habits without the need to make deliberate distinctions by gender.

Limitations and prospectives

The current study adds insights into the intrinsic link between exercise intention, exercise behavior, action planning, and habit strength. In particular, the interaction between action planning and habit strength has a reference value for promoting physical exercise among college students. Undoubtedly, this study has yet to be further improved: First of all, an investigation study in a natural setting cannot provide the same level of power of evidence as a laboratory study, especially with respect to the stability of the control context. This is precisely one of the limitations of the SRHI (Verplanken and Orbell, 2003), which does not capture other components of the habitual experience, such as the dependency on cues and context stability (Hagger, 2018). Follow-up is necessary to clarify whether patterned action, stimulus-response bonding (Grove et al., 2014), and the degree of consistency of cues at the onset of each behavior (Pimm et al., 2016) may bias the results of this study. Secondly, for the sampling procedure, participants who were easily accessible and cooperative were selected for reasons of feasibility of implementing the survey. This may affect the radiometric scope of the findings of this study. Finally, exploring the potential mechanisms of the two manifestations of habit (i.e., habitual instigation and habitual execution; Gardner et al., 2016) in the intention-behavior relationship of exercise, some researchers have suggested that habitual instigation may be more important than habitual execution (Feil et al., 2021). Future studies should pay close attention to all of these.

Conclusion

Self-reported data from Chinese college students indicates that action planning is a very important predictor of the post-intentional phase and partially mediates the influence of exercise intention on exercise behavior. Habit strength did not play a moderating role in the relationship between exercise intention and exercise behavior. It may be due to an unstable activity context in which no performance history exists and where behaviors are novel, and intentions alone will determine behavior. The predictive effect of action planning on exercise behavior gradually enhances as the level of habitual strength increases, suggesting that for individuals whose exercise has become habitualized, having a plan is not counterproductive and can also promote more exercise.

Data availability statement

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

Ethics statement

This study was reviewed and approved by the School of Physical Education at Hubei Business College, Wuhan, China. The benefits and potential risks of participation in this study were explained to participants, and written informed consent was obtained from them.

Author contributions

LZ: conception, design of the study, and writing. JH: data collection, data organization, and writing. BZ: data analysis. XX: data organization and formatting. JW: revision and finalization of 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.

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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.2022.1006007/full#supplementary-material

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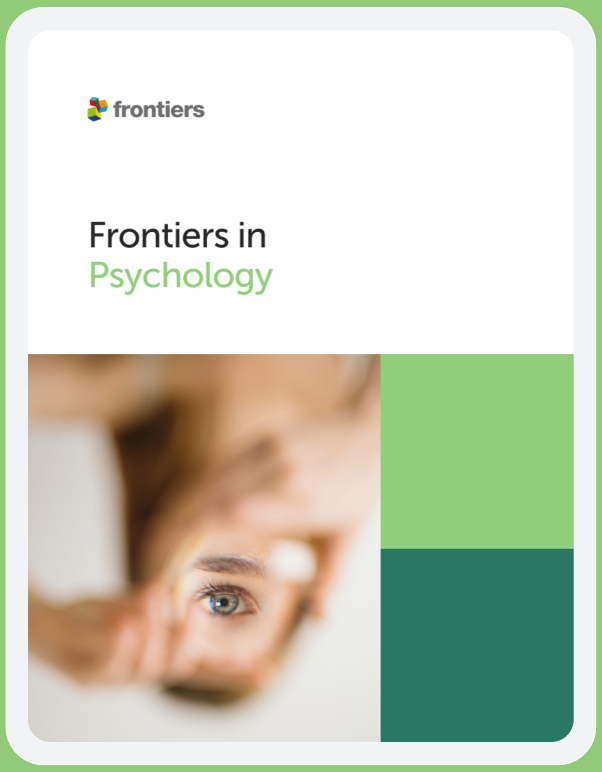

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