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ARTICLE

The Effect of Procrastination on Physical Exercise among College Students—The Chain Effect of Exercise Commitment and Action Control

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ABSTRACT

Background: Exercise procrastination is prevalent among college students, causing decline in physical fitness. It is imperative to investigate the mechanism affecting college students' physical activity behaviors. This study was aimed at investigating the effect of procrastination on college students' physical exercise behavior, and the chain mediation effects of exercise commitment and action control (AC), to provide a theoretical basis for interventions targeting physical exercise behavior among college students. **Methods:** A questionnaire survey was conducted using convenience sampling. The General Procrastination Scale, Exercise Commitment Scale, Action Control Scale, and Physical Activity Rating Scale-3 questionnaires were used. Participants were 581 college students (age 19.27 ± 0.94 years; 243 males and 338 females). Statistical methods of regression analysis and structural equation modeling (SEM) were applied. **Results:** Procrastination, exercise commitment, and action control were found to be significant predictors of physical exercise behavior. Among these predictors, exercise commitment and action control showed full mediation effects in the relationship between procrastination and physical exercise behavior, and explained 25.48% and 30.77% of the total variance, respectively. The chain mediation effect of exercise commitment-action control was significant, accounting for 22.60% of the total variance, and the total indirect effect was 79.33%. **Conclusion:** Therefore, higher procrastination was associated with less participation in physical exercise behavior among college students. Improvements in exercise commitment and volitional decision-making ability for physical exercise behavior promoted physical exercise behavior, and increased exercise commitment promoted volitional decision-making ability among the students. The chain reaction effect of exercise commitment and action control also buffered the negative effects of procrastination on physical exercise behavior, thereby increasing physical exercise behavior among college students.

KEYWORDS

College student; procrastination; exercise commitment; action control; exercise behavior; chain intermediary

Introduction

Physical exercise is a major part of college students' life. This exercise is defined as physical activity of a certain intensity for a certain period of time, primarily through sports programs aimed at enhancing physical fitness, and improving physical and mental health. Surveys have shown that college students generally recognize the importance of physical exercise and

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have positive attitudes and strong will to exercise, despite an absence of action. Exercise procrastination, interruption, or even quitting physical exercise frequently occur among college students. Negative and irregular participation in physical exercise results in a decline in physical fitness [1,2]. Exploring the mechanisms affecting college students' physical activity behaviors is necessary to provide a scientific basis for promoting physical activity behaviors that support health. Attribution studies on physical exercise have concluded that exercise behavior is associated with cognitive, motivational, and behavioral factors [3,4], and individuals' non-participation in physical exercise has been found to be caused partially by procrastination regarding exercise behavior [5,6].

Procrastination, a negative psychological trait involving cognitive, emotional, and behavioral components, is essentially an irrational behavior resulting from individuals' lack of motivation, failure of self-regulation, or lack of self-control [2,7,8]. This irrational and negative tendency to procrastinate may negatively affect individuals' psychological and social adaptation, thus resulting in health problems such as depression, anxiety, and greater perceived stress [9,10]. Procrastination is prevalent among college students, and approximately 70%–85% of college students have been found to have procrastination tendencies in various domains, to varying degrees [11–15]. Although individuals who procrastinate are subjectively aware of the losses, they nonetheless delay starting or completing a given task [16]. Procrastination also has a series of negative effects on individuals, thus affecting their physical and mental health, as well as behavioral outcomes, and consequently weakening their self-determination, sense of accomplishment, and persistence [3]. Therefore, procrastination has a weakening effect on the completion of target tasks.

The goal behavior of physical exercise can be weakened by procrastination and may be influenced by multiple variables. Most prior studies on procrastination in physical exercise behavior have focused on personality traits and mental health domains and have provided little guidance for interventions. Some studies have suggested that self-compassion influences the strength of the relationship between procrastination and physical exercise [17]. In a study examining this relationship by surveying 255 participants regarding self-compassion, procrastination, and their planned and actual sporting activity over 6 weeks, Rapoport has shown that self-compassion moderates the influence of procrastination on postponing sporting activity [6]. Moreover, Zhu has concluded that physical exercise motivation is a mediating variable that influences procrastination and physical exercise behavior [2]. Zhang et al.'s findings support that procrastination affects college students' physical exercise through time efficiency [18]. Pan has demonstrated that peer support methods increase college students' exercise frequency, decrease the occurrence of procrastination, and effectively improve exercise procrastination tendency through changing behavioral styles, strengthening time management skills, improving exercise environment, and stimulating exercise motivation, respectively [19]. Tao et al., in a study exploring the relationship between procrastination and physical activity in college students, has suggested that grit has a mediating role in the prediction of procrastination in physical activity, and this effect is moderated by gender and age [5].

The above studies have provided a theoretical basis for understanding the relationship between procrastination and physical exercise, as well as the lack of physical exercise interventions. However, the prior research has two main limitations: first, the research variables, such as self-compassion and autonomy motivation, were relatively idiosyncratic and not highly amenable to interventions. For example, self-compassion is appropriate for a specific environment and group of people and is difficult to incorporate into intervention programs. Regarding exercise motivation, which is a dynamic variable, the formation of autonomous motivation requires long intervention periods, which are difficult to operationalize, and the results are uncertain. Second, research is lacking regarding the relationship between procrastination and physical exercise, particularly the complex psychological mechanisms of procrastination on influencing physical exercise behavior; consequently, the mechanisms underlying the relationship between procrastination and physical exercise remain largely unknown. Therefore, exploring the psychological variables amenable to intervention, further studying the complex psychological mechanisms, and formulating intervention programs would aid in decreasing college students' tendency to procrastinate in physical exercise, as well as in establishing healthy lifestyles.

Procrastination is an individual's avoidance of the implementation of a specific intention, thus inhibiting positive behaviors. Consequently, the execution and persistence of behaviors are affected, i.e., a discrepancy exists between behavioral intention and actual behavior [2,6,20–22]. As described above, exercise procrastination is a negative behavioral characteristic in that individuals fail to effectively implement physical exercise plans or even cancel their plans. Procrastination has been found to inhibit individuals' internal motivation. A stronger tendency to procrastinate leads to worse self-regulation of exercise and more negative exercise behavior [3,12,23,24]. Tao et al. [5] have studied the relationship between procrastination and physical activity among college students and have found a significant negative correlation between procrastination and physical activity. Rapoport et al. [6] have provided further evidence supporting that procrastination negatively affects health behaviors and physical activity in adults. The above studies suggest that procrastination influences individuals' health promotion and decreases physical exercise, thus negatively influencing physical exercise behavior.

Exercise commitment, a positive and rational type of psychological decision-making, is a powerful factor in maintaining exercise adherence, mapping the intention and motivational intensity of individuals' desire and determination to persistent participation in exercise [25–27]. As a motivational factor for behavior initiation, commitment can create a contractual constraint on behavior. Individuals with clearer behavioral motivation to engage in a task have lower tendency to procrastinate on the corresponding task, thus leading to an increase in the behavior, whereas individuals with higher tendency to

procrastinate often have weaker behavioral motivation [3,22,28]. A series of empirical studies have indicated that exercise commitment is a psychological contract for individuals to exercise, which predicts exercise motivation and avoidance of exercise withdrawal: stronger exercise commitment contributes to more persistent exercise behavior. Therefore, exercise commitment is a factor predicting exercise behavior [29–32]. A study by Koppenborg et al. [33] has shown that interdependence and positive commitment among members in group work decreases the effects of procrastination on academics. Therefore, a greater tendency to procrastinate results in lower motivation and contractual spirit among college students to participate in exercise, thus leading to laziness and more negative attitude toward physical exercise. In fact, increasing commitment to exercise can effectively counteract the tendency to procrastinate, thus increasing the regularity of exercise behavior participation. Therefore, exercise commitment mediates the effect of procrastination on physical exercise behavior.

To achieve predetermined goals, individuals rely on volitional control to implement self-monitoring and maintenance in action execution, in addition to the motivational factors to initiate behavior (exercise commitment), and additionally avoid additional factors interfering with motivation [23,34–37]. According to action control theory, proposed by the German psychologist Kuhl [38], action control (AC) is the psychological factor that allows individuals to eliminate the interference of other competing intentions in executing their goals, and to maintain initiation of the committed intention to move toward the goal. As an action-oriented self-regulatory strategy, action control incorporates three cognitive self-regulation processes: consciousness standard, self-monitoring, and self-regulation efforts [39,40]. The core question in procrastination regarding a decision is whether to act now or later [41]. Procrastinators tend to have insufficient self-regulation and self-control, to lack responsibility and self-discipline, and to have high impulsivity [8,42]. Executive intention, i.e., action control, is necessary to maintain initiation of the committed intention and achieve the goal. Action control attenuates the inhibitory effect of procrastination on target behavior and additionally is an important predictor of physical exercise behavior [37,43–45]. Tao et al. [5] have indicated the positive role of "grit" in the relationship between procrastination and physical exercise behavior. Grit, also known as volitional control, significantly mediates the above relationship. Therefore, action control has a mediating effect on procrastination in physical exercise behavior.

In addition, Gollwitzer's [46] motivation and volition model define the relationship between motivation and volition. According to the model, the motivation of commitment occurs in the pre-decision stage, whereas volition, i.e., action control, occurs in the post-decision stage. The motivation (commitment) in the pre-decision stage is the initiating factor for action control in the post-decision stage. Motivation and volition are different stages of behavior execution, in which individuals inevitably encounter various setbacks, and may consequently lower their original motivation to behavior or even quit the behavior. Strong volition helps individuals maintain their current intention to take action and achieve their goals [4,47–49]. Therefore, exercise commitment is predictive of action control.

In conclusion, exercise commitment also has a predictive effect on action control in the chained influence between procrastination and college students' exercise behavior, which constitutes a chain mediation effect, in addition to exerting the respective mediating effects of exercise commitment and action control.

Therefore, the following four hypotheses were formulated in this study. Hypothesis H1 was proposed: procrastination has a significant negative effect on exercise behavior among college students. Hypothesis H2 was proposed: the mediating effect of exercise commitment significantly influences the relationship between procrastination and college students' exercise behavior. Hypothesis H3 was proposed: the mediating effect of action control significantly influences the relation between procrastination and exercise behavior. Hypothesis H4 was proposed: when procrastination affects exercise behavior, the chain mediation effect of exercise commitment and action control has a significant influence.

In the field of physical exercise behavior, few studies have examined the chain mediation effect. The present study not only assessed the mediating effects of individual mediators but also examined the interrelationships among mediating variables. Based on the existing literature and research hypotheses, this study framed the concept and established a mediating chain model (Fig. 1), to promote physical exercise behavior among college students and improve their physical health status, as well as provide references to help authorities make decisions.

Participants and Methods

Participants and procedure

The participants were 610 junior undergraduate students from three types of universities in China (i.e., normal education; science and technology; and medicine). The only inclusion criterion was students currently enrolled in universities in mainland China, and no exclusion criteria were involved in this study. All participants were recruited from colleges through convenience sampling. After removal of individuals with invalid responses (carelessly answered questionnaires such as monotonic responses, lack of attention to reversely worded items, and missed answers), 581 (95.24%) valid samples were collected. The participants were comprised of

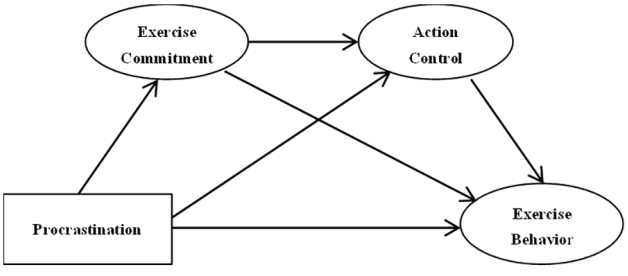

FIGURE 1. Research hypothesis model.

243 males and 338 females. Their ages ranged from 17 to 22, with a mean age of 19.27 (*SD* = 0.94) years.

This study was supported by university administrators and physical education teachers. Administrators, teachers, and participants were introduced to the purpose of this study, and answers were provided anonymously. During the study, the anonymity of the participants was ensured, on-site Q&A was provided, and items with reverse wording were incorporated into the surveys. The questionnaire required approximately 15 min to complete. This protocol was approved by the ethics committee of Beijing Sport University (No. 2022-JNV-001), and all study procedures were in accordance with the most recent version of the Declaration of Helsinki. All participants provided written informed consent to participate.

Research method

The General Procrastination Scale; Exercise Commitment Scale; Action Control Scale; Physical Activity Rating Scale-3; and demographic information, such as gender, grade, and birthday were included. The details are as follows.

The Chinese version [11] of the General Procrastination Scale [50] was used to measure procrastination among the students. The scale contains 20 items rated on a 5-point Likert scale ranging from 1 ("does not apply to me at all") to 5 ("applies to me very much"), including ten reverse-scored items. The minimum score is 20, and the maximum score is 100. The scale was a single dimension, and a higher total score indicated more severe procrastination. Example items included: "I often find myself performing tasks that I had intended to do days before" and "When preparing for deadlines, I often waste time doing other things." The scale had good reliability of Cronbach's α = 0.807 in this study.

Exercise commitment among college students was assessed with the revised Exercise Commitment Scale by Chen et al. [51], which consists of 23 items rated on a 5-point Likert scale from 1 ("strongly disagree") to 5 ("strongly agree"). The scale includes 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 had a reliability of Cronbach's α = 0.936 in this study. Item scores were averaged to create the composite scores for commitment.

Action control was measured with the Action Control Scale by Yang [44], which consists of six items rated on a 5-point Likert scale ranging from 5 ("strongly agree") to 1 ("strongly disagree"). Action control consists of three factors: awareness of standards, self-monitoring, and self-regulation efforts, with two items each (e.g., "In the past one month, I have constantly monitored myself regarding whether the frequency of exercise is enough", etc). The overall reliability coefficient of the scale was Cronbach's α = 0.885 in this study.

Physical exercise behavior was measured with the Physical Activity Rating Scale-3 revised by Liang [52], which had a test-retest reliability of 0.82. The scale contains three questions on exercise intensity, duration and frequency, and uses a 5-point Likert scale. Total exercise = intensity × (duration − 1) × frequency, and the three items of the scale belong to different dimensions of physical exercise level. Example items include: "What is the intensity of your physical exercise?"

Statistical methods

Descriptive statistics was used to summarize the data characteristics. Pearson correlation analysis was used to investigate the associations among study variables. Linear regression models were used to test the effects of predictors and the mediation effect of each mediator. After multiple mediation effect testing according to Fang et al. [53], we tested the mediating effect of exercise commitment and action control in the relation between procrastination and exercise behavior. Subsequently, the chain mediation effects of both mediators were tested with serial hierarchical regression analysis [53,54]. The above analyses were performed in SPSS 23.0. Subsequently, to further examine the internal mechanism of the effect of procrastination, we tested the chain mediation effect within the structural equation modeling (SEM) framework with AMOS 21.0. A bootstrapping method with 5000 samples was applied to test the mediation effects. The bias-corrected bootstrap confidence interval was used to test the significance of indirect effects. A threshold *p*-value of 0.05 was used to determine statistical significance.

Results

Direct effects of procrastination, exercise commitment, and action control on exercise behavior

Table 1 shows the Pearson correlations among the study variables. Exercise commitment, action control, and exercise behavior were significantly and positively associated with one another ($p < 0.01$). Procrastination was significantly and negatively associated with other variables ($p < 0.01$). The results show that the correlation between all variables was small to moderate level, thus indicating both correlation and independence among variables, and providing a basis for subsequent analysis of mediating effects.

Table 2 shows the simple linear regression results for each of the predictors on exercise behavior. Procrastination ($F_{(1,\ 579)} = 7.123$, $\beta = -0.110$, $p < 0.01$), exercise commitment ($F_{(1,\ 579)} = 164.459$, $\beta = 0.470$, $p < 0.001$), and action control ($F_{(1,\ 579)} = 233.118$, $\beta = 0.536$, $p < 0.001$) each significantly influenced exercise behavior, accounting for 1.2%, 22.1%, and 28.7% of the total variance, respectively.

Chain mediation effect of exercise commitment and action control

To test the chain mediation effect of exercise commitment and action control, we first tested the effect of procrastination on each of the mediators.

As shown in Table 3, procrastination significantly predicted exercise commitment, $F_{(1,\ 579)} = 13.486$, $\beta = -0.151$, $p < 0.001$, accounting for 2.3% of the variance. Procrastination significantly predicted action control, $F_{(1,\ 579)} = 31.549$, $\beta = -0.227$, $p < 0.001$, accounting for 5.2% of the variance. In addition, the prediction effects between mediators were tested. Exercise commitment significantly

TABLE 1

Descriptive statistics and Pearson correlation among study variables (N = 581)

Variables	Procrastination	Exercise commitment	Action control	Exercise behavior	*M*	*SD*
Procrastination	1				2.65	0.49
Exercise commitment	−0.151**	1			3.01	0.75
Action control	−0.227**	0.552**	1		3.37	0.84
Exercise behavior	−0.110**	0.470**	0.536**	1	33.29	25.13

Note: **$p < 0.01$.

TABLE 2

Simple linear regression on exercise behavior

Predictor	Exercise behavior					
	B	*SE*	*β*	*t*	*F*	R^2
Procrastination	−0.183	0.068	−0.110	−2.669	7.123**	0.012
Exercise commitment	0.503	0.039	0.470	12.824	164.459***	0.221
Action control	0.515	0.034	0.536	15.268	233.118***	0.287

Note: *SE* = standard error; **$p < 0.01$; ***$p < 0.001$.

TABLE 3

Simple linear regression of Procrastination to each of the mediators

	Exercise commitment				Action control			
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Intercept	3.626	0.172		21.134	4.405	0.188		23.404
Procrastination	−0.234	0.064	−0.151***	−3.672	−0.392	0.070	−0.227***	−5.617
F	13.486				31.549			
R^2	0.023				0.052			

Note: ***$p < 0.001$.

predicted action control, $F_{(1,\ 579)} = 254.000$, $\beta = 0.552$, $p < 0.001$, explaining 30.5% of the variance (Table 4).

Next, the mediation effects of exercise commitment and action control was tested separately.

First, as shown in Table 5, procrastination significantly predicted exercise behavior, $F_{(1,\ 579)} = 7.123$, $\beta = -0.110$, $R^2 = 0.012$, $p < 0.01$. After entering exercise commitment, it had a significant influence on exercise behavior, $F_{(2,\ 578)} = 82.842$, $\beta = 0.464$, $T = 12.516$, $p < 0.001$, $R^2 = 0.223$, whereas procrastination had a non-significant effect on the outcome, $\beta = -0.040$, $T = -1.084$, $p > 0.05$. The above results showed that after entering exercise commitment, the effect of procrastination on exercise behavior changed from −0.110 to −0.040, and ΔR^2 was 0.211. The results suggested a complete mediation effect of exercise commitment on the relationship between procrastination and exercise behavior.

TABLE 4

Regression of exercise commitment to action control

	Action control					
	B	*SE*	*β*	*t*	*F*	R^2
Intercept	1.517	0.12		12.682		
Exercise commitment	0.615	0.039	0.552***	15.937	254.000	0.305

Note: ***$p < 0.001$.

Second, as shown in Table 5, procrastination significantly predicted exercise behavior, $F_{(1,\ 579)} = 7.123$, $\beta = -0.110$, $R^2 = 0.012$, $p < 0.01$. After entering action control, it significantly influenced exercise behavior, $F_{(2,\ 578)} = 116.438$, $\beta = 0.539$, $T = 14.934$, $p < 0.001$, $R^2 = 0.287$, whereas procrastination had non-significant effects on the outcome, $\beta = 0.012$, $T = 0.338$, $p > 0.05$. The above results showed that after entering action control, the effect of procrastination on exercise behavior changed from −0.110 to 0.012, and ΔR^2 was 0.275. The results suggested a complete mediation effect of action control on the relationship between procrastination and exercise behavior.

Finally, we conducted regression on exercise behavior with mediators added sequentially (Table 6). In step 1, procrastination significantly affected exercise behavior,

TABLE 5

Mediating effect of each of the mediators

Predictor	Exercise behavior											
	Step 1						Step 2					
	B	*SE*	*β*	*t*	*F*	R^2	*B*	*SE*	*β*	*t*	*F*	R^2
Intercept	3.599	0.185		19.496			1.797	0.218		8.241		
Procrastination	−0.183	0.068	−0.110**	−2.669	7.123	0.012	−0.067	0.061	−0.040	−1.084		
Exercise commitment							0.497	0.040	0.464***	12.516	82.842	0.223
Intercept	3.599	0.185		19.496			1.319	0.219		6.026		
Procrastination	−0.183	0.068	−0.110**	−2.669	7.123	0.012	0.020	0.060	0.012	0.338		
Action control							0.517	0.035	0.539***	14.934	116.438	0.287

Note: **$p < 0.01$, ***$p < 0.001$.

TABLE 6

Regression models on exercise behavior with mediators added sequentially

Predictors	Exercise behavior											
	Step 1				Step 2				Step 3			
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Procrastination	−0.183	0.068	−0.110**	−2.669	−0.067	0.061	−0.040	−1.084	0.031	0.058	0.019	0.541
Exercise commitment					0.497	0.040	0.464***	12.516	0.269	0.044	0.252***	6.161
Action control									0.385	0.040	0.401***	9.670
F	7.123**				82.842***				95.240***			
R^2	0.012				0.223				0.331			

Note: **$p < 0.01$, ***$p < 0.001$.

$F_{(1,\ 579)} = 7.123$, $\beta = -0.110$, $R^2 = 0.012$, $p < 0.01$. In step 2, exercise commitment significantly influenced exercise behavior, $F_{(2,\ 578)} = 82.842$, $\beta = 0.464$, $T = 12.516$, $p < 0.001$, $R^2 = 0.223$, whereas procrastination had a non-significant influence on the outcome, $\beta = -0.040$, $T = -1.084$, $p > 0.05$, with $\Delta F = 75.719$, and $\Delta R^2 = 0.211$. In step 3, after entering action control, the regression model was significant, $F_{(3,\ 577)} = 95.240$, $R^2 = 0.331$, $p < 0.001$. Procrastination had nonsignificant effects on exercise behavior, $\beta = 0.019$, $T = 0.541$, $p > 0.05$, whereas exercise commitment ($\beta = 0.252$, T = 6.161, $p < 0.001$) and action control ($\beta = 0.401$, T = 9.670, $p < 0.001$) significantly affected exercise behavior, with $\Delta F = 12.398$, and $\Delta R^2 = 0.108$. The results showed that exercise commitment and action control had a complete chain mediation role in the relationship between procrastination and exercise behavior.

The mediation effect was determined according to the 95% bias-corrected confidence interval through a bootstrap procedure with 5000 replications. Confidence intervals not including zero indicated significant indirect effects. As shown in Table 7, the total indirect effects of exercise commitment and action control reached −0.165%, 95% CI [−0.254, −0.026], which did not include zero, thus indicating significant indirect effects. The indirect effect comprised three indirect paths. The path of procrastination → exercise commitment → exercise behavior showed an indirect effect of −0.053%, 95% CI [−0.105, −0.022] indicating statistical significance. The path of procrastination → action control → exercise behavior showed an indirect effect of −0.064%, 95% CI [−0.135, −0.025] indicating significance. The path of procrastination → exercise commitment → action control → exercise behavior had an indirect effect of −0.047, 95% CI [−0.092, −0.019] indicating a significant chain mediation effect. The path of procrastination → exercise behavior showed a direct effect of 0.043%, 95% CI [−0.051, 0.134] indicating no significance.

The nonsignificant direct effect of procrastination on exercise behavior ($p > 0.05$) suggested a complete mediation effect via exercise commitment and action control. As shown in Table 7, the total effect of procrastination on exercise behavior (direct effect + indirect effects) was 0.208, the direct effect was 0.043, the total indirect effect was −0.165, and the mediated proportion (= indirect effect/total effect) of the three indirect paths was 25.48%, 30.77%, and 22.60%, respectively.

Subsequently, a chain mediation model was fit within the structural equation modeling framework (Fig. 2) to provide a comprehensive picture of the factors affecting exercise

TABLE 7

Path estimates of procrastination on exercise behavior testing the direct and indirect effects

Effects	Path	|Effect|	Proportion of total effect (%)	95% CI_{upper}	95% CI_{lower}
Direct effect	Procrastination → Exercise behavior	0.043	20.67%	0.134	−0.051
Indirect effect	Procrastination → Exercise commitment → Exercise behavior	0.053	25.48%	−0.022	−0.105
	Procrastination → Action control → Exercise behavior	0.064	30.77%	−0.025	−0.135
	Procrastination → Exercise commitment → Action control → Exercise behavior	0.047	22.60%	−0.019	−0.092
Total indirect effect		0.165	79.33%	−0.026	−0.254
Total effect		0.208	–	–	–

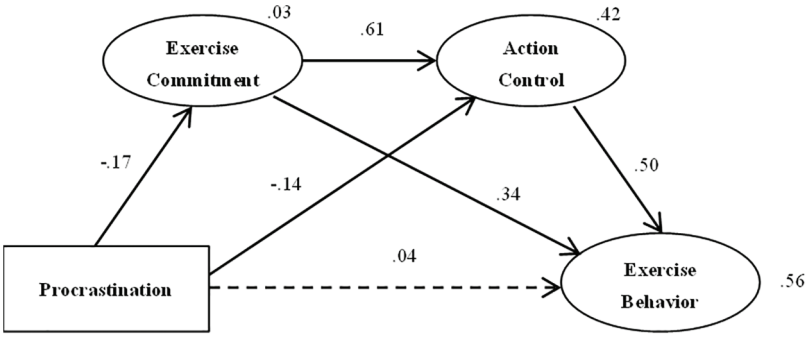

FIGURE 2. Chain mediation model

behavior. The model had a good fit, $x^2 = 214.184$, $df = 59$, $x^2/df = 3.630 < 5$, GFI = 0.948, NFI = 0.939, TLI = 0.941, IFI = 0.955, CFI = 0.955, and RMSEA = 0.067.

Discussion

The results of this study indicated that procrastination significantly and negatively predicted physical exercise behavior. Exercise commitment and action control each showed full mediation effects between procrastination and exercise behavior. Exercise commitment and action control showed a full chain mediation effect. The above results supported our four hypotheses.

Procrastination and exercise behavior among college students

Procrastination tendency is prevalent among college students, and can interfere with their social behavior choices, and trigger individual behavioral discretion and inertia. Procrastination tendency has been found to inhibit participation in physical exercise behavior.

The results of this study indicated that procrastination had a significant negative effect on exercise behavior, and higher tendency to procrastinate was associated with less participation in physical exercise behaviors, in agreement with previous findings [2,5,6,8,55]. Procrastination interferes with the choice of individual behavior by decreasing the sense of responsibility, and additionally affects the execution and sustainability of exercise behavior. Greater tendency to procrastinate causes less self-regulation in exercise and more pronounced arbitrariness of exercise behavior [2,20,56]. The lack of organization, persistence, motivation, and control of exercisers in the goal-oriented exercise behavior leads to blocking and difficulty in forming positive and regular exercise behavior, thus leading to a decline in physical quality and health among contemporary college students [3,5,24]. After college students terminate high-pressure passive learning in high school and start their relatively relaxed and free college life, their primary learning and living style is self-learning, and they lack supervision by others. In this scenario, students are easily disturbed by other events and delay completion of set goals; moreover, the control of their willpower decreases, thus leading to procrastination. Most procrastinators have a strong will to exercise, not simply a lack of motivation to exercise; however, they fail to take action or show deviations in action, thus eventually leading to a gap between exercise intention and behavior. Exercise behavior among college students lacks standardization. Therefore, to mitigate the negative effects of procrastination on physical exercise, interventions targeting various aspects are necessary. In addition to the direct influence of procrastination on physical exercise, researchers should pay attention to the comprehensive influence of other variables, to promote college students' positive psychological tendency to participate in physical exercise, overcome procrastination, and develop good habits of physical exercise.

Mediating effect of exercise commitment

This study used serial hierarchical regression analysis to test the mediating effects of the variables and showed that

exercise commitment had a full mediation effect between procrastination and exercise behavior. Procrastination predicted exercise behavior both directly and indirectly mediated by exercise commitment. The results suggested that participation in physical exercise behaviors may be increased by interventions targeting procrastination tendency, and that promotion of physical exercise can also be achieved by interventions focusing on exercise commitment. Our findings support the previous exercise commitment model [57], in which individuals persist in a behavior primarily because they either want to or need to do so. Moreover, persistence out of want (determination) and need (obligation) are the very self-selections that counteract procrastination [58]. Given the idiosyncratic nature of procrastination, the self-regulatory nature of exercise commitment makes the goal-directedness of an intervention relatively clear and easy to manipulate. Wilson's study, using a model of exercise commitment, has reported results similar to those of the present study, and has demonstrated that only "wanting" commitment correlates with physical exercise behavior [59]. Thus, follow-up research is necessary.

This study indicated that higher exercise commitment constraints were associated with higher participation and total amounts of physical exercise behavior. Exercise commitment is a high-level intrinsic motivation and contractual attitude that promotes individuals to actively exercise [60]. Influenced by exercise enjoyment, autonomy, social constraints, participation opportunities, and personal investments, exercise commitment comprehensively stimulates individuals' desire and determination to participate in physical exercise; forms clear exercise intentions and goals; and leads to positive exercise experiences and achievement beliefs, and more positive and active performance in physical exercise [29,30]. In contrast, if individuals lack exercise commitment, they may not have strong will and determination to exercise, and may show negative behavioral tendencies, such as withdrawal and procrastination in the face of physical exercise activities [31]. The study concluded that exercise commitment, as a rational psychological decision, helps individuals maintain the stability and regularity of exercise behavior, regardless of the dominant environment or the presence of stressful situations. Thus, individuals are directly motivated to persistently participate in physical exercise. The results obtained herein are consistent with previous observations [27,32]. In conclusion, the finding that exercise procrastination among college students was improved by exercise commitment supported hypothesis H2.

Mediating effect of action control

The full mediating effect of action control significantly influenced the relationship between procrastination and exercise behavior. Our results suggested that, in addition to direct intervention in procrastination, action control can be directly targeted through interventions to achieve increased physical exercise behavior. Thus, in addition to direct interventions for procrastination, interventions can target action control to achieve increased physical exercise behavior. Action control theory suggests that individuals ensure that a behavior is performed by overcoming the interference of other behavioral tendencies or intentions when executing the target action, as characterized by actively controlling the attention and overcoming low motivational intentions that are directed toward the goal of decreasing procrastination in the behavior [61]. For example, students may actively participate in physical exercise by suppressing distraction from cellphone videos that lead to physical exercise procrastination.

We observed a marked negative correlation between action control and procrastination, in partial agreement with previous studies [19,62]. College students with greater tendency to procrastinate had lower individual action control ability and self-regulation and monitoring levels and were more susceptible to the temptation of interference from other factors in physical exercise, thus resulting in delay or abandonment of the expected exercise goals. Improving action control helps individuals better implement self-monitoring, regulation, and make efforts in exercise behavior, thus overcoming the interference of other behavioral tendencies or intentions. Establishing persistent, stable, regular, and orderly exercise behavior thus decreases the negative effects of exercise procrastination.

Action control, the most proximal factor predicting actual exercise behavior, significantly predicted exercise behavior, and consequently may aid in maintaining behavioral intentions that are difficult to execute and in overcoming action difficulties (e.g., procrastination, burnout). The results from our study are consistent with those in previous studies [37,39,40]. Action control resists interference from distracting stimuli in the internal and environment and promotes the execution and maintenance of volitional actions during the conversion of goal intentions into action intentions and the initiation of actual behavior [45,49]. Individuals with higher action control tend to use more action control strategies to facilitate the initiation, execution, and implementation of exercise intentions. During this goal-oriented regulation process, individuals can effectively monitor and regulate the execution of exercise behaviors, and decrease delays or forgetfulness regarding desired exercise goals, thereby contributing to the development of good exercise habits. In conclusion, college students' exercise procrastination can be ameliorated through interventions focused on action control; the above findings supported hypothesis H3.

Chain mediation effect of exercise commitment and action control

Exercise commitment and action control each fully mediated the effects of procrastination on physical exercise behavior. Serial hierarchical regression showed that the chain mediation effect of exercise commitment-action control was also significant, with exercise commitment fully mediating physical exercise behavior through a chain reaction with action control. The results suggested that when procrastination occurred, higher self-regulation of exercise commitment was associated with greater ability to overcome the disruption of procrastination, and both exercise commitment and action control promoted an increase in physical exercise behavior through a chain reaction.

Although no research has directly addressed the effects of exercise commitment and control of action, similar research has shown [63] that individuals' identification with exercise has been found to be positively associated with action control, and individuals' identification with exercise is consistent with exercise commitment in the sense of wanting to participate, thus indicating that individuals' attitude and motivation toward behaviors together create control and constraints on procrastination to achieve the target behavior.

We observed a significant positive correlation between exercise commitment and action control: stronger binding force of exercise commitment was associated with higher action control. Individuals with stronger determination to participate in physical exercise had higher levels of action control in using strategies to prompt the execution of exercise goals, as well as stronger ability to resist the interference of procrastination. Exercise commitment is an antecedent motivational factor that promotes exercise behavior. As a psychological link between participants' cognition and behavior, commitment is a strategy of adherence, willingness, and determination based on exercise consciousness [27]. Exercise commitment provides a strong motivation for individuals to engage in exercise activities. The "behavioral instructions" contained in action control motivate individuals to restart their exercise motivation and intention in the volitional stage. Individuals with clear exercise intention set a standard for the exercise goal, content, and method; monitor and evaluate their exercise behavior according to the set standard; and make corresponding adjustments to reduce the difference between intention and behavior, and ultimately achieve exercise goals [39,40].

Many theories have been proposed regarding physical exercise prediction and intervention, such as the theory of planned behavior and self-determination theory, etc. [4,37]. These theories involve the effects of individual's attitude, emotions, motivation, and other factors on physical exercise, all of which are inextricably associated with exercise commitment. The positive effect of exercise commitment on exercise behavior has been supported by several studies [29,31], but many additional factors may interfere with the relationship between commitment and behavioral goal attainment. Exercise commitment explains only the motivational aspects before intention generation, without regard to the post-intention-pre-action transformation process, i.e., a gap may exist between the onset of exercise commitment and the actual execution of physical exercise, thus suggesting that other variables may link exercise commitment and physical exercise behavior [64] and generate forces that work in concert against procrastination.

Action control helps individuals monitor and evaluate actual exercise behavior according to the committed exercise goal, by regulating the maintenance of behavioral intentions and exercise contracts that are difficult to execute; resisting interference from additional inducements; enhancing the link between exercise commitment and behavior; and decreasing the tendency to procrastinate, thus promoting physical exercise regularity and persistence [37,43,44]. Therefore, the distance between commitment and behavior can be shortened, and exercise procrastination among college students can be mitigated by increasing the level of action control. Individuals with strong tendency toward exercise procrastination could constrain themselves to make decisions to avoid procrastination through the ability of motivational internal drive (exercise commitment) and volitional decision-making (action control). Therefore, we concluded that exercise commitment and action control are key stages that influence the initiation and maintenance of exercise behavior, and thus decrease the tendency to procrastinate by enhancing the strength of motivation to volition and may provide an effective strategy to promote physical exercise in college. Our results are consistent with those from several previous studies [4,47,49] and support hypothesis H4.

In summary, greater procrastination tendency among college students is associated with less autonomy for exercise execution. The lack of positive participation motivation and psychological satisfaction in exercise, and the decrease in self-monitoring and regulation ability in exercise, lead to negative delay or withdrawal tendency in exercise. Therefore, procrastination tendency negatively influences college students' exercise behavior. If positive participation motivation and responsibility regarding physical exercise, and high self-control behavioral volition are maintained, students' exercise commitment and action control will inhibit procrastination tendencies and promote positive, stable, and more persistent exercise behavior.

College students should improve their awareness of autonomous exercise and positive beliefs; improve their volitional control to resist the current short-term temptations; conduct self-monitoring and regulation of exercise behavior; and make reasonable exercise plans and put them into action when participating in physical exercise. Maintaining self-discipline and persistence in physical exercise can decrease exercise delay and make exercise practice part of college students' self-determined activity, thereby eliminating the distance between knowledge and action. Therefore, developing good physical exercise habits improves college students' sports cognitive literacy.

Simultaneously, healthy personality traits, improving psychological quality and resilience, developing a strong character, and gaining correct exercise awareness and leisure exercise habits are also necessary. Students must understand the negative emotions and lagging hazards due to procrastination, and consciously fight against the tendency to procrastinate, to improve their self-control and behavior management ability. Moreover, students should improve their self-discipline; establish operable exercise goals; formulate reasonable exercise plans with high feasibility and low difficulty in a short time; and use tools such as fitness management applications or alarm clocks to set up exercise assistance guidance and reminder functions. In addition, students should self-monitor their physical exercise, resist interference from external temptation factors, conduct strict management of goals, and execute the list items. Increased peer support, supervision, and encouragement in the form of friendship contributes to decreasing procrastination in exercise.

Universities should improve sports monitoring and evaluation systems by incorporating physical health and

physical education course assessments into the evaluation of scholarships and graduation grades. Universities may also take measures such as increasing the diversity and enjoyment of physical education courses, enriching campus group sports activities, promoting the fun of unity and cooperation, cultivating students' proficiency in sports skills and interests, and creating a positive exercise atmosphere. In addition, universities could set campus exercise criteria for each semester/week (*e.g.*, exercise frequency and volume), and improve reward and supervision mechanisms to encourage students to actively participate in physical exercise. Obtaining positive psychological benefits and positive experiences in the exercise process is conducive to developing psychological attachment and self-discipline habits to participate in physical exercise.

Research limitations

First, the outcome variable (PARS-3) was based solely on retrospective self-reports. Although this study was unable to achieve physical exercise because of the large sample size, thus resulting in the outcome variable being based solely on retrospective self-reports, our findings suggested that in the future, a subset of participants might be sampled to establish their scale scores as a function of accelerometer measurements, to correct for the errors introduced by the PARS-3. Second, the study was only cross-sectional. Future studies should be conducted to explore and validate the findings through longitudinal tracking, to more comprehensively reveal the causal relationships among variables. Third, the study assessed only general procrastination. To date, most studies have assessed the effects of general procrastination on physical exercise, without distinguishing among forms of procrastination. Future studies should tailor the measurement instruments to physical exercise procrastination, to provide support for research on physical exercise procrastination. Fourth, Although the current study considered procrastination as irrational and negative, procrastination also has positive aspects. Future research is suggested to further explore these dual aspects of procrastination. Lastly, only mediating effects were explored. However, many factors affect physical exercise, such as injury, anxiety, and time factors. This study explored only the mediating variables closely associated with procrastination. Future research should focus on more moderating or mediating variables; consider how to assess and overcome exercise procrastination from multiple perspectives; and strive for cross-validation in the same study, to provide a practical basis for comprehensively revealing the influence of college students' normal behavioral tendencies on exercise behavior.

Conclusion

Procrastination, exercise commitment, and action control were found to be the antecedent variables of exercise behavior, which exerted direct and significant effects on exercise behavior. In the relationship between procrastination and physical activity behavior among college students, exercise commitment and action control each had full mediation effects. Moreover, exercise commitment-action control showed a significant chain mediation effect, with the total indirect effect accounting for 79.33% of the total effect. This study revealed the associations among the four variables at the structural level and verified that procrastination predicted exercise behavior both directly and indirectly through exercise commitment and action control. Our findings not only advance research in the field of procrastination but also provide new perspectives and ideas for the field of exercise procrastination, including practical insights that may aid in the development of exercise behavior motivation strategies among college students.

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Availability of Data and Materials: The data for the present study are available from the corresponding author upon reasonable request.

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