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Analyzing the effects of physical exercise on procrastination among college students using a chain-of-intermediates model

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Procrastination is a key factor affecting college students' academic efficiency and physical and mental health. Factors such as digital culture, academic patterns, and economic pressures make students more prone to self-management difficulties, with procrastination becoming increasingly prominent. As an effective means of promoting physical and mental well-being, the relationship between physical exercise and procrastination warrants in-depth exploration. This study employs a cross-sectional survey design to examine the relationship between physical exercise and procrastination among college students, while testing the chained mediating effects of time management tendencies and mobile phone dependency. Methodologically, questionnaires were administered to 866 college students using the Physical Exercise Level Scale, General Procrastination Scale, Time Management Ttendencies Scale, and Mobile Phone Dependency Scale. Structural equation modeling analyzed variable relationships, while Bootstrap sampling verified the significance of mediating effects. Results revealed: ① Physical exercise was significantly negatively correlated with procrastination behavior; ② Physical exercise not only directly predicted procrastination behavior but also influenced it through the mediating effects of time management tendencies and mobile phone dependency; ③ Time management tendencies and mobile phone dependency exert a chain-mediating effect between physical exercise and procrastination. Findings indicate that physical exercise can indirectly alleviate procrastination among college students by enhancing time management tendencies and reducing mobile phone dependency. However, as this study employs a cross-sectional design, causal inferences should be interpreted with caution. Future research is recommended to adopt longitudinal or experimental designs to further validate causal mechanisms.

Keywords Physical exercise, Procrastination, Time management tendencies, Mobile phone dependence, Chain intermediation

In the contemporary higher education environment, college students face increasingly complex challenges stemming from academic pressures, social demands, and information overload. Particularly in today's digital landscape, students are constantly tempted by social media, instant messaging, and entertainment. Frequent interruptions and multitasking weaken their focus and willingness to initiate tasks, exacerbating tendencies toward avoidance and procrastination. The post-pandemic hybrid learning model, while offering flexibility, has also reduced external supervision and time structure, making students more susceptible to self-regulation difficulties. Additionally, mounting economic pressures have driven more students to take on part-time jobs or internships, crowding out study time and mental resources, leading to emotional exhaustion and procrastination. These factors collectively reinforce the psychological mechanisms of procrastination and embed it more deeply into students' daily practices, becoming a significant issue affecting both academic performance and mental health[1]. The World Health Organization explicitly states that regular physical exercise is a core element in promoting individual physical and mental well-being[2]. Extensive research indicates that physical exercise not only enhances college students' social and emotional competencies—such as discipline and teamwork[3]—but also elevates positive emotional states[4], thereby offering a potential pathway to mitigate procrastination[5]. Strong time management skills help students effectively plan tasks and reduce the likelihood of procrastination[6], while mobile phone dependency significantly increases procrastination risk by continuously occupying cognitive resources and distracting attention[7,8]. However, existing literature is largely confined to examining pairwise

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relationships among these variables, failing to systematically reveal their underlying mechanisms within an integrated framework. Notably, there is a lack of in-depth exploration of the chained pathway from "time management tendencies to mobile phone dependency," as well as empirical testing of how physical exercise influences procrastination behavior through this chained mechanism.

In fact, the inhibitory effect of time management tendencies on mobile phone dependency rests on a solid theoretical foundation. According to self-regulation theory, individuals with high time management tendencies are more adept at setting goals, monitoring progress, and adjusting behaviors. This enables them to effectively suppress the tendency toward instant gratification and reduce unnecessary mobile phone usage[9]. On the other hand, resource allocation theory also suggests that increased investment of limited mental resources in time planning naturally reduces the resources available for distracting activities like mobile phone entertainment[10]. Moreover, students with stronger time management abilities typically possess clearer prioritization awareness and goal orientation, allowing them to consciously avoid the time fragmentation and cognitive overload caused by mobile phones, thereby reducing dependency. Therefore, incorporating time management tendencies and mobile phone dependency into the same chain of mediating effects not only aligns with theoretical expectations but also offers a novel perspective for understanding how physical exercise alleviates procrastination through multiple psychological-behavioral mechanisms.

Addressing this research gap, this study proposes constructing a chained mediation model (physical exercise → time management tendencies → mobile phone dependency → procrastination behavior) to comprehensively examine the underlying mechanisms of these variables. This approach not only compensates for previous studies' tendency to focus on isolated relationships but also offers a more comprehensive and in-depth theoretical explanation for the formation and intervention of procrastination behavior from the perspectives of self-regulation and cognitive resource allocation. The findings hold significant practical value for designing and implementing comprehensive procrastination intervention programs in higher education settings.

Theoretical basis and assumptions

The impact of physical exercise on procrastination behavior among college students

According to the Theory of Planned Behavior, an individual's behavior is influenced by behavioral attitudes, subjective norms, and perceived behavioral control[11].Physical exercise is an activity aimed at enhancing physical fitness, promoting mental and physical health, and improving or maintaining bodily functions. These activities may include fitness training, recreational activities, health recovery, and mental and intellectual training[12]. Recent studies have shown that physical exercise helps improve an individual's physical, mental, and social adaptability, making it an effective method for maintaining overall health[13]. Procrastination is a very common personality trait and behavioral tendency in modern society[14]. Some scholars argue that procrastination is a behavioral tendency, and it is particularly prevalent among college students[15]. The relationship between procrastination and intervention strategies has long been a hot topic in the field of psychology, often linked to the degree of aversion toward the task at hand and fear of failure[16]. Procrastination is increasingly attracting attention from researchers across disciplines such as education and psychology, suggesting that the underlying psychological mechanisms governing these relationships warrant further exploration. A literature review revealed that physical exercise and procrastination, as outcome variables of the Theory of Planned Behavior, are both influenced by the factors of this theory, indicating that they are not isolated individual behaviors but may have an interactive relationship[17]. A study conducted an empirical investigation on 610 college students to explore the relationship between physical exercise and procrastination. The results indicated a significant negative correlation between the two, with positive physical exercise habits helping to alleviate procrastination among college students[18]. Previous studies have found that physical exercise is an effective intervention measure to alleviate procrastination among college students[19–21]. Physical exercise can enhance college students' self-control abilities, curb the emergence of negative emotions such as carelessness, and effectively reduce and alleviate the exacerbation of procrastination behavior[22]. Based on this, the research hypothesis H1 is proposed: physical exercise negatively predicts procrastination behavior.

Mediating effect of time management tendencies

Based on self-regulation theory, individuals' monitoring and regulation of their own cognition and behavior are key factors influencing behavioral outcomes[23]. Time management tendencies and procrastination have garnered significant attention in recent years. In this study, time management tendencies and procrastination are regarded as two distinct yet closely related constructs. Conceptually, time management tendencies represent a relatively stable, positive psychological trait and behavioral inclination. They reflect an individual's perception of time's value and their capacity to plan, monitor, and evaluate time usage. The core focus lies in "how to efficiently plan and utilize time." In contrast, procrastination is defined as a maladaptive behavioral outcome—the voluntary postponement of initiating or completing a task despite anticipating negative consequences. Its essence lies in "failure of self-regulation." Time management tendencies and procrastination behavior have been widely discussed topics in recent years. Time management tendencies refer to the psychological and behavioral characteristics individuals exhibit in their perception of the functions and value of time, as well as in their methods of utilizing time. These tendencies continuously influence an individual's efficiency and outcomes, and also impact their emotions, beliefs, and self-worth[24]. Effective time management can reduce the waste of time resources and achieve the highest efficiency in time utilization, particularly for college students who are at a critical stage in their lives. Research has found that physical exercise can significantly enhance college students' time management abilities. Regular physical exercise helps cultivate individuals' self-discipline, planning, and perseverance[25]. Physical exercise typically requires students to balance academics and sports, which necessitates efficient time management skills and the ability to allocate time reasonably. Empirical research results also indicate that time management is negatively correlated with procrastination behavior[26,27].

College students with high time management tendencies can more effectively plan their study and living time, set clear goals and deadlines, and proactively adopt strategies such as task decomposition and priority ranking to manage task progress, significantly reducing procrastination behavior caused by unclear goals, disorganized plans, or fear of difficulty[28]. As such, the lack of time management skills among college students inevitably leads to procrastination, a finding supported by existing research. Students with lower time management skills exhibit more procrastination, and enhancing adolescents' time management tendencies can effectively mitigate procrastination[29]. Based on the above analysis, this study proposes the hypothesis H2: Time management tendencies mediate the relationship between physical exercise and procrastination among college students.

Mediating effect of mobile phone dependence

According to the Cognitive-Energy Model, individuals possess limited self-regulatory resources. Excessive mobile phone use consumes substantial cognitive resources, leading to diminished self-control capacity[30]. Through a review of previous studies, it can be inferred that smartphone dependency mediates the relationship between physical exercise and procrastination. Smartphone dependency refers to an individual's strong psychological need for smartphones, excessive time and energy spent on them, and subsequent impairment of physical, cognitive, and social functions[31]. Scientific physical exercise methods can enhance students' exercise efficiency and interest in physical activity, effectively reducing varying degrees of smartphone dependency. Research indicates a significant negative correlation between physical exercise and smartphone dependency[32,33]. The smartphone addiction rate (MPAI) among Chinese university students is 23%[34]. Physical exercise can improve the central nervous system regulation capabilities of individuals with smartphone dependency, enabling them to shift their attention to other activities and experience the joy of movement. Regular participation in physical exercise can reduce smartphone dependency by enhancing self-control and efficiency[35,36]. Additionally, smartphone dependency can trigger procrastination and is an important contributing factor to procrastination[37]. College students who are overly engrossed in their smartphones find it difficult to focus on completing tasks efficiently, struggle to concentrate, and exhibit more distractible behavior[38]. Issues such as smartphone use and internet addiction can lead to the development of procrastination[39]. Smartphone dependency not only affects the acquisition of negative emotions but also influences individual behavior. Metacognitive theory suggests that the widespread dissemination of information on smartphones can easily lead to the failure of self-monitoring strategies, thereby exacerbating procrastination behavior among college students in their daily lives and studies[40]. Since smartphone dependency consumes significant time and energy and can lead to various physical and mental health issues, particularly difficulty concentrating on other tasks, we hypothesize that smartphone dependency may result in severe procrastination, negatively impacting college students' academic and personal lives. Based on the above analysis, this study proposes Hypothesis H3: Smartphone dependency mediates the relationship between physical exercise and procrastination among college students.

Chain mediating effects of time management tendencies and mobile phone dependence

This pathway integrates self-control theory with finite self-control theory[41].Previous studies have found that time management tendencies can negatively predict mobile phone dependence[42]. Time management tendencies, as an individual's ability to plan, monitor, and evaluate time resources, are a core manifestation of effective self-regulation[43]. Time management tendencies and their various dimensions are closely negatively correlated with smartphone addiction among college students; the lower an individual's time management tendencies, the higher the likelihood of smartphone addiction[44]. College students with high time management tendencies are better able to effectively utilize time resources, not only avoiding distractions, procrastination, and inefficiency but also facilitating academic performance improvement and goal achievement[45]. Mobile phone dependency refers to an individual's strong tendency toward mobile phone use and the onset of noticeable physiological and psychological discomfort when unable to access a mobile phone[46]. Existing research indicates that frequent mobile phone use can have numerous negative effects. On one hand, mobile phone dependency can impair college students' perception of time[47], leading them to underestimate the passage of time and resulting in reduced time monitoring ability. On the other hand, when students are engrossed in mobile phone entertainment, social media, or information browsing, it not only occupies a significant amount of time that should be allocated to academic tasks but also leads to fragmented attention, difficulty in initiating tasks, and reduced time management ability, causing students to become addicted and fall into procrastination[48]. Based on the above analysis, this study proposes Hypothesis H4: Time management tendencies and mobile phone dependency play a chain-mediated role in physical exercise and college students' procrastination behavior.

In summary, physical exercise not only directly enhances college students' self-control over their physical and mental well-being to reduce procrastination but may also reduce smartphone dependency by enhancing time management tendencies, thereby improving time management abilities. Ultimately, by alleviating smartphone dependency, it reduces procrastination behavior, thereby exerting its deeper intervention effects. Therefore, we propose hypothesis H5: Time management tendencies and smartphone dependency play a chain-mediated role between physical exercise and college students' procrastination behavior.

Thus, the research hypothesis model is constructed as shown in Fig. 1.

Research subjects and methods

Research subjects

This paper examines the effects of physical activity on college students' procrastination behavior and the mediating role of time management tendencies and cell phone dependence. Separating the measurement time during the study was programmed to control to reduce the subjects' guessing of the measurement purpose. In order to reduce the interference of common method bias, reduce the memory effect of the subjects, and avoid systematic bias due to memory association, the questionnaires in this study were distributed in two times with a

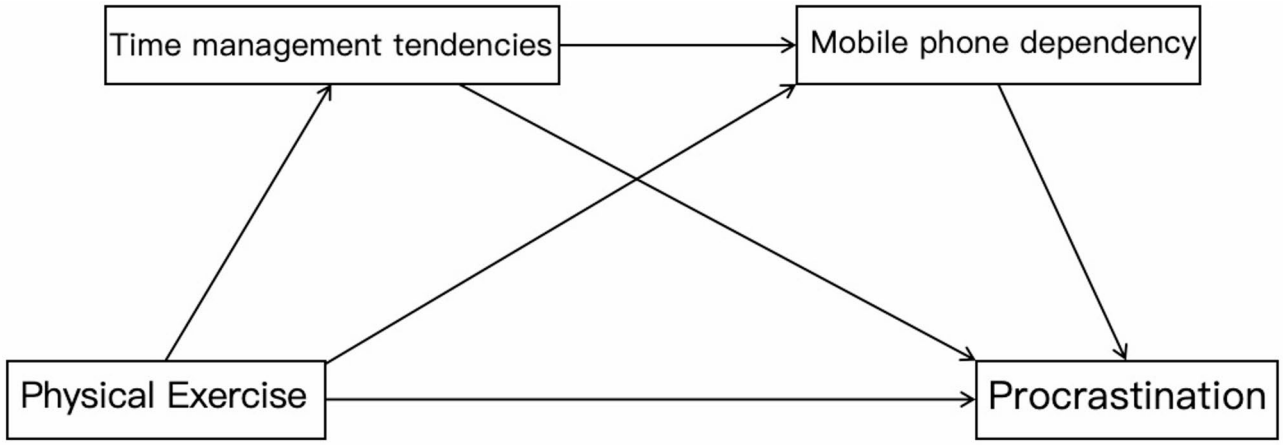

Fig. 1. Hypothesis model of the effect of physical exercise on procrastination behavior.

2-week interval. A survey was conducted in July 2025 across 16 universities in Heilongjiang, Jilin, and Liaoning provinces, covering multiple disciplines and majors. A stratified random sampling method was employed, with undergraduate students selected by gender and grade level to ensure sample representativeness. A total of 903 questionnaires were returned, of which 37 students were excluded due to incomplete test information, yielding 866 valid subjects and a questionnaire validity rate of 95.90%. The design of this study followed the guidelines and regulations of the Declaration of Helsinki and approved by Ethics Committee of Liaoning Normal University (LL2025167), and all participants signed an informed consent form and were paid for their participation. The demographics of the participants are detailed in the Supplementary Table.

Research tools

Physical activity rating scale (PARS-3)

The Physical Activity Rating Scale revised by Liang Deqing et al.[49] was used. This scale aims to assess participants' physical activity intensity, duration, and frequency over the past month. Each indicator is scored using a 5-point Likert scale. Physical activity levels are measured across three dimensions: intensity, duration, and frequency. Exercise intensity is categorized into five levels: Low-intensity, prolonged exercise (e.g., jogging, tai chi, with slight heart rate increase), moderate-intensity endurance exercise (e.g., jogging, cycling, with increased heart rate and perspiration), high-intensity exercise with rapid breathing and significant sweating (e.g., vigorous running, basketball), and high-intensity, short-duration exercise with rapid breathing and heavy sweating (e.g., competitions, intensive training). Duration of each exercise session is categorized into 5 levels: under 10 min, 11–20 min, 21–30 min, 31–59 min, over 60 min. Exercise frequency refers to the number of weekly physical activity sessions, divided into 5 levels: less than once per month, 1–2 times per month, 1–2 times per week, 3–5 times per week, approximately once per day.The total score is calculated as follows: physical activity score = intensity score × (duration score – 1) × frequency score. Higher scores indicate greater levels of physical activity participation. In this study, the internal consistency (Cronbach's α coefficient) of the scale was 0.896, indicating good reliability and validity.Descriptive statistical analysis indicates that the physical exercise score for the study sample was (24.030 ± 26.545) points, with a minimum value of 0 and a maximum value of 100.

General procrastination scale (GPS)

The General Procrastination Scale developed by Lay, also known as the Lay Procrastination Scale, uses a 5-point Likert scale ranging from "strongly disagree" to "strongly agree." This scale is unidimensional and consists of 20 items. The total score is calculated by summing the scores of all items, with higher total scores indicating more severe procrastination behavior and a higher degree of procrastination[50]. Lay's General Procrastination Behavior Scale primarily measures an individual's procrastination behavior in daily life, such as "When it's time to get up, I get up immediately." Therefore, this scale is currently one of the most widely used measurement questionnaires. In this study, the internal consistency Cronbach's α coefficient of this scale was 0.981, indicating good reliability and validity.

Time management tendencies scale

This study utilized the Time Management Tendencies Scale developed by Huang Xiting and Zhang Zhijie[51]. This scale has been widely used by researchers both domestically and internationally, and has demonstrated good reliability and validity. There are a total of 44 items, covering three dimensions: time value perception, time efficacy perception, and time monitoring perception. Additionally, in this scale, except for items 9, 17, 27, 30, and 41, all other items are positive-scoring items. Each item in the scale uses a 5-point Likert scale, where 1 indicates "not at all agree" and 5 indicates "completely agree." Lower scores indicate lower time management levels, while higher scores indicate higher time management tendencies among the study participants. In this study, the internal consistency Cronbach's α coefficient for the scale was 0.988, indicating good reliability and validity.

College students' mobile phone dependency tendency scale
The scale used in this study was developed by Xiong Jie, Zhou Zongkui, and others. It consists of 16 items and uses a 5-point rating scale ranging from "strongly disagree" to "strongly agree"[52]. It includes four dimensions: withdrawal symptoms, prominent behavior, social comfort, and mood changes. Scores are assigned as follows: 1 point for "completely disagree," 2 points for "somewhat disagree," 3 points for "neutral," 4 points for "somewhat agree," and 5 points for "completely agree." This is a 5-point Likert scale scoring method. The maximum score is 80 points, and the minimum score is 16 points. Higher scores indicate a stronger tendency toward mobile phone dependence, while lower scores indicate a weaker tendency toward addiction. A score below 47 indicates normal mobile phone use, while a score of 48 or above indicates mobile phone dependence, with higher scores indicating more severe dependence. In this study, the internal consistency Cronbach's α coefficient of the scale was 0.977, indicating good reliability and validity.

Statistical methods
This study utilized SPSS 29.0 statistical software for data analysis. First, Cronbach's alpha test was employed to assess reliability, and Harman's one-factor test was used to examine common method bias following data collection. Subsequently, after importing the data into SPSS, descriptive statistics were applied for demographic analysis. Pearson's correlation coefficient was utilized to analyze the correlations between physical exercise, procrastination behavior, time management tendencies, and mobile phone dependency. Multivariate regression analysis was conducted using Model 6 in the PROCESS macro program, and the significance level of the mediating effect was evaluated using the Bootstrap test to analyze the study. In this study, the standardized beta coefficient (β) indicates the change in the dependent variable when the independent variable changes by one standard deviation; R^2 represents the proportion of variance in the dependent variable explained by the model.

Results and analysis
Common method bias test
Due to factors such as the measurement environment, questionnaire instructions, and context, questionnaire surveys may be subject to common method bias[53]. A one-factor Harman test was conducted on the measurement data. Using SPSS 29.0, an unrotated principal component analysis was performed on physical exercise, academic self-efficacy, future orientation, and psychological resilience. The results showed that there were four factors with eigenvalues greater than 1, with the first factor explaining 39.862% of the variance, which is below the critical value of 40%. This indicates that there is no common method bias in the data of this study. Although Harman's test indicated that the results were within an acceptable range, additional measures were implemented, such as anonymous surveys and randomizing the order of questions, to minimize common method bias.

Statistics and correlation analysis of the current status of college students' physical exercise, procrastination behavior, time management tendency, and cell phone dependence
Demographics
Descriptive statistical analysis shows (Table 1) that there are 866 college students in the sample, of which 478 are male students, accounting for 55.2%, and 388 are female students, accounting for 44.8%. This indicates that there are more male than female college students participating in the survey. In terms of grade distribution, there were 202 freshmen students, accounting for 23.2%, 227 sophomores, accounting for 26.2%, 211 juniors, accounting for 24.4%, and 226 seniors, accounting for 26.1%.

Independent samples T-test
An independent samples t-test was conducted to analyze differences between male and female college students in physical exercise, procrastination behavior, time management tendencies, and mobile phone dependency. Results showed (Table 2) that males engaged in significantly more physical exercise than females ($t = 8.326$, $p < 0.001$); males scored significantly lower on procrastination behavior than females ($t = -5.231$, $p < 0.001$); male students scored significantly lower than female students on mobile phone dependency ($t = -4.558$, $p < 0.001$); no significant gender difference was found in time management tendencies ($t = 0.326$, $p = 0.745$).

ANOVA One-way analysis
ANOVA analysis revealed (Table 3) significant differences in time management tendencies across grade levels ($F = 2.671$, $p < 0.05$). Post-hoc tests (LSD method) indicated (Table 4) that sophomore students scored significantly higher on time management tendencies than freshmen ($p < 0.05$) and seniors ($p < 0.05$). No significant differences were found in physical exercise, procrastination, or mobile phone dependency across different grade levels.

Causality	Form	Quantities	Percentage
Gender	Male student	478	55.2%
	Female student	388	44.8%
Grade	First-year university student	202	23.3%
	Second-year university student	227	26.3%
	Third-year university student	211	24.4%
	Fourth-year university student	226	26.1%

Table 1. Demographic characteristics of participants.

Relevant variable	Gender	*N*	M ± SD	t	*p*
Physical exercise	Male	478	31.908 ± 29.953	8.326	<0.001
	Female	388	17.111 ± 22.301		
Procrastination	Male	478	2.812 ± 1.112	-5.231	<0.001
	Female	388	3.214 ± 1.136		
Time management tendencies	Male	478	3.078 ± 1.051	0.326	0.745
	Female	388	3.055 ± 1.075		
Mobile phone dependence	Male	478	2.838 ± 1.102	-4.558	<0.001
	Female	388	3.194 ± 1.175		

Table 2. Comparison of differences in various variables among students of different sexes. *: $p<0.05$, **: $p<0.001$.

Relevant variable	Grade	M ± SD	F	*P*
Physical exercise	1(202)	24.030 ± 26.545	0.310	0.818
	2(227)	24.797 ± 26.845		
	3(211)	26.469 ± 29.200		
	4(226)	25.766 ± 28.522		
Procrastination	1(202)	2.982 ± 1.097	0.756	0.519
	2(227)	2.908 ± 1.143		
	3(211)	3.015 ± 1.156		
	4(226)	3.064 ± 1.160		
Time management tendencies	1(202)	2.996 ± 1.052	2.671	*P*<0.05
	2(227)	3.210 ± 1.077		
	3(211)	3.108 ± 1.062		
	4(226)	2.953 ± 1.041		
Mobile phone dependence	1(202)	2.986 ± 1.123	0.398	0.755
	2(227)	2.945 ± 1.120		
	3(211)	2.996 ± 1.164		
	4(226)	3.061 ± 1.187		

Table 3. Comparison of differences in various variables among students of different grades.

Grade (I)	Grade (J)	Mean difference (I-J)	Standard error	Significance (*P*)
1	2	−0.214	0.102	0.036*
	3	−0.112	0.104	0.283
	4	0.043	0.102	0.677
2	3	0.102	0.101	0.310
	4	0.257	0.099	0.010*
3	4	0.155	0.101	0.127

Table 4. Post-hoc multiple comparisons of time management tendencies among students of different grades (LSD method). *$p<0.05$, **$p<0.01$.

Pearson correlation analysis

Through Pearson correlation analysis of physical activity, college students' procrastination behavior, time management tendency and cell phone dependence data (Table 5), Physical exercise showed significant negative correlations with procrastination (r = -0.485, $p<0.01$) and mobile phone dependency (r = -0.538, $p<0.01$), while exhibiting a significant positive correlation with time management tendencies ($r=0.152$, $p<0.01$). Time management tendencies showed significant negative correlations with both procrastination behavior (r = -0.328, $p<0.01$) and mobile phone dependency (r = -0.181, $p<0.01$). Mobile phone dependency exhibited a significant positive correlation with procrastination behavior ($r=0.421$, $p<0.01$).

Mediation effect test

As shown in Table 6, Model 6 from the SPSS PROCESS macro developed by Hayes was employed to examine chained mediating effects. After controlling for gender and grade level, the results are presented in Table 6. Results indicate: In the time management tendency (M1) model, the standardized regression coefficient for

Relevant variable	M ± SD	Physical exercise	Procrastination	Time management tendencies	Mobile phone dependence
Physical exercise	24.030 ± 26.545	1			
Procrastination	2.992 ± 1.136	− 0.485**	1		
Time management tendencies	3.067 ± 1.062	0.152**	− 0.328**	1	
Mobile phone dependence	3.008 ± 1.147	− 0.538**	0.421**	− 0.181**	1

Table 5. Correlation analysis of physical activity, procrastination behavior, time management tendency and cell phone dependence. Pearson correlation coefficient. $^{**}p < 0.01$.

Equation of regression		Overall fit index			Significance of regression coefficient		
Result variable	Variable of prediction	R	R2	F	β	t	p
Time management tendencies	Gender	0.158	0.025	7.397	0.031	0.893	0.372
	Grade				-0.032	-0.960	0.337
	Physical exercise				0.161***	4.622	0.000
Mobile phone dependence	Gender	0.549	0.301	92.749	0.016	0.543	0.588
	Grade				0.039	1.379	0.168
	Physical exercise				-0.520***	-17.363	0.000
	Time management tendencies				-0.100***	-3.475	0.000
Procrastination	Gender	0.575	0.331	85.069	0.056	1.926	0.054
	Grade				0.034	1.214	0.225
	Physical exercise				-0.332***	-9.760	0.000
	Time management tendencies				-0.241***	-8.480	0.000
	Mobile phone dependence				0.190***	5.682	0.000
Procrastination	Gender	0.490	0.240	90.632	0.050	1.646	0.100
	Grade				0.050	1.676	0.094
	Physical exercise				-0.473***	-15.342	0.000

Table 6. Regression analysis of the relationship of variables in the model. $^{*}p<0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

physical exercise on time management tendency was β = 0.161 ($p < 0.001$), indicating that each one-standard-deviation increase in physical exercise leads to a 0.161-standard-deviation increase in time management tendency. Physical exercise significantly and positively predicted mobile phone dependency (β = -0.520, $p < 0.001$). In the mobile phone dependency (M2) model, physical exercise had a standardized regression coefficient of β = -0.520 ($p < 0.001$) for mobile phone dependency, while time management tendency had a standardized regression coefficient of β = -0.100 ($p < 0.001$). Physical exercise and time management tendencies together explained 30.1% of the variance in peer relationships (R^2 = 0.301); In the procrastination behavior (Y) model, the standardized regression coefficient for physical exercise on procrastination behavior was β = -0.332 ($p < 0.001$), and the standardized regression coefficient for time management tendency on procrastination behavior was β = -0.241 ($p < 0.001$). and the standardized regression coefficient for mobile phone dependency on procrastination behavior was β = 0.190 ($p < 0.001$). Together, these three variables explained 33.1% of the variance (R^2 = 0.331). When incorporating both time management tendencies and mobile phone dependency into the structural equation, physical exercise exerted a significant negative predictive effect on college students' procrastination behavior (β = -0.473, $p < 0.001$).

Bootstrap mediation effect analysis results

This study focuses on the issue of physical exercise affecting college students' procrastination behavior, and constructs and validates the chain mediation model of college students' physical exercise and procrastination behavior by introducing the two variables of time management tendency and cell phone dependence. The results of the study show (Table 7): the total effect value of physical exercise on procrastination behavior is -0.0194, the direct effect value is -0.0136, the total indirect effect value is -0.0058, and the mediating effects of time management tendency, cell phone dependence and the interaction between the two reach the statistical significance level. The results showed that the chain mediation model of the research hypothesis was valid and all four hypotheses were tested.

The model indicates that physical exercise predicts procrastination behavior, with time management tendencies and mobile phone dependency serving as indirect mediators (through three pathways). The total indirect effect of physical exercise on procrastination behavior is -0.0058, and the Bootstrap 95% confidence interval does not include zero (LLCL=-0.0075, UCL = -0.0040), accounting for 29.90% of the total effect.Among them, the first mediating effect path: physical exercise → cell phone management tendency → procrastination behavior (path 1), with an indirect effect value of -0.0016, accounting for 8.25% of the total effect; the second path: physical exercise → cell phone dependence → procrastination behavior (path 2), with an indirect effect

Effect	Impact pathway	Effect value	BOOT SE	LLCL	ULCL	Proportion
Total effect		-0.0194	0.0013	-0.0219	-0.0169	100%
Direct effect	Direct path	-0.0136	0.0014	-0.0164	-0.0109	70.10%
Total indirect effect		-0.0058	0.0009	-0.0075	-0.0040	29.90%
Indirect effect	Ind1	-0.0016	0.0004	-0.0024	-0.0009	8.25%
	Ind2	-0.0040	0.0008	-0.0057	-0.0025	20.62%
	Ind3	-0.0013	0.0001	-0.0002	-0.0001	6.7%

Table 7. Results of bootstrap mediated effects analysis. Ind1: Physical Exercise → Time Management Tendencies → Procrastination Behavior. Ind2: Physical Exercise → Mobile Phone Dependence → Procrastination Behavior. Ind3: Physical Exercise → Time Management Tendencies → Mobile Phone Dependence → Procrastination Behavior.

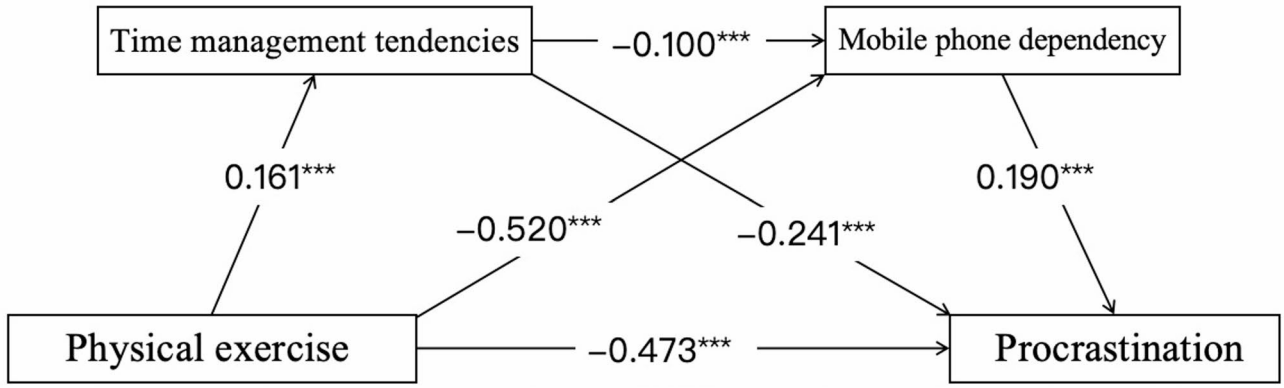

Fig. 2. Pathways of the effect of physical activity on procrastination behavior.

value of -0.0040, accounting for 20.62% of the total effect; and the third chain mediating effect path: physical exercise → time management tendency → cell phone dependence → procrastination behavior (path 3), with an indirect effect value of -0.0013, accounting for 6.7% of the total effect, The 95% confidence intervals for all three paths do not include zero.Suggesting that the research hypothesis H4 is valid.

According to the above research results, the chain mediation model is shown in Fig. 2.

Discussion

This study systematically examined the effects of physical exercise on procrastination among college students and its underlying mechanisms by constructing a chained mediation model, with a focus on verifying the mediating roles of time management tendencies and mobile phone dependency. The findings not only support the direct negative predictive effect of physical exercise on procrastination but also reveal the significance of the chained mediation pathway "time management tendencies → mobile phone dependency." This provides empirical evidence for understanding how physical exercise reduces procrastination through multiple psychological and behavioral mechanisms.

Physical exercise has a significant negative impact on college students' procrastination behavior

This study reaffirms the significant negative relationship between physical exercise and procrastination among college students, consistent with the findings of most existing research[54,55]. It demonstrates that physical exercise, as a positive behavioral intervention, can effectively enhance students' behavioral initiation and task persistence abilities. From a self-regulation theory perspective, physical exercise enhances executive function and emotional regulation by improving physical fitness, promoting endorphin secretion, and elevating mood states, thereby reducing procrastination stemming from emotional avoidance or insufficient motivation[56,57]. Furthermore, the self-discipline and goal-directed behavior cultivated through regular physical exercise can transfer to academic domains, strengthening individuals' proactive engagement with learning tasks[58]. Further Suppressing Procrastination Tendencies.

The mediating effect of time management tendencies between physical exercise and procrastination behavior among college students

This study found that time management tendencies mediate the relationship between physical exercise and procrastination. Physical exercise enhances students' self-regulation abilities by improving their time planning, monitoring, and sense of efficacy[59,60], thereby reducing procrastination caused by poor time management[61,62].

Students who regularly engage in physical exercise are more likely to set clear goals and plans, allocate time reasonably between study and daily life, and thus effectively decrease the frequency of procrastination. This finding empirically confirms that time management tendencies are not procrastination itself but rather a crucial psychological resource for countering it. The planning, goal-setting, and self-monitoring abilities strengthened through physical exercise can directly translate into more efficient task execution, thereby reducing procrastination stemming from disorganized planning or avoidance of difficulties. Consequently, time management tendencies mediate the relationship between physical exercise and procrastination.

The mediating effect of smartphone dependency on the relationship between physical exercise and procrastination among college students

This study further demonstrates through mediation analysis that physical exercise can indirectly improve procrastination by reducing mobile phone dependency. Mobile phone dependency is a significant factor contributing to procrastination among college students, consistent with previous research[63,64]. Physical exercise significantly reduces students' mobile phone dependency by diverting attention, enhancing psychological capital, and strengthening self-control[65]. Reducing mobile phone usage minimizes distractions and time wastage, thereby indirectly alleviating procrastination stemming from phone addiction. These findings support the study's conclusions. Consequently, mobile phone dependency mediates the relationship between physical exercise and procrastination.

The chain mediation effect of time management tendencies and mobile phone dependence on the relationship between physical exercise and procrastination behavior among college students

In examining the relationship between physical exercise and procrastination, this study further reveals that time management tendencies and mobile phone dependency form a chained mediating pathway between physical exercise and procrastination. Physical exercise first enhances students' time management abilities[66], then reduces mobile phone dependency by strengthening time monitoring and planning[67]. This enables students to more effectively identify, plan for, and resist the ubiquitous distraction of mobile phones, ultimately decreasing procrastination[68]. This pathway reveals that physical exercise systematically suppresses procrastination by empowering students' self-management capabilities, helping them effectively resist mobile phone distractions and improve task execution efficiency.

Theoretical implications and practical implications

In terms of theoretical significance, this study expands existing knowledge on procrastination theory by verifying the dual and chained mediating effects of time management tendencies and mobile phone dependency on the relationship between physical exercise and procrastination. First, it clarifies that physical exercise can reduce procrastination by enhancing self-regulation abilities, specifically through strengthening time management tendencies. This finding extends the value of physical exercise beyond physical health to the cognitive domain of behavioral regulation, supporting and deepening the view that time management serves as a critical resource in combating procrastination. Regular physical exercise requires and cultivates individuals' abilities to plan, monitor, and adjust their behavior. These skills are transferable to academic settings, enabling students to better manage tasks and deadlines. Second, this study confirms that smartphone dependency constitutes another significant mediating pathway through which physical exercise reduces procrastination. This result underscores the necessity of examining the mechanisms underlying procrastination in the digital age. The ubiquity of smartphones has become a critical environmental factor influencing student learning behaviors. This study demonstrates that physical exercise effectively reduces smartphone dependency by providing alternative rewards and occupying attention, thereby mitigating procrastination caused by digital distractions. Most crucially, it reveals a chained mediating pathway: "time management tendencies → smartphone dependency." This indicates that time management skills not only directly promote task execution but also help students more effectively control phone usage, thereby indirectly alleviating procrastination. This finding innovatively integrates traditional self-regulation theory with digital behavior research, offering a more systematic and contemporary theoretical explanation for how physical exercise promotes self-regulation within complex information environments.

Regarding practical implications, the study provides actionable insights for universities designing comprehensive intervention programs to mitigate student procrastination. First, regular physical exercise should be integrated into daily management and mental health promotion systems for college students. Institutions can help students establish consistent exercise habits by offering diverse physical education courses, encouraging the development of sports clubs, and providing convenient fitness facilities, thereby directly enhancing their action-taking ability and emotional regulation skills. Second, time management training components should be embedded in physical exercise promotion. For instance, guiding students to create exercise and study schedules during physical education classes or group activities enhances their awareness of time monitoring and planning, transferring the self-discipline cultivated through exercise to academic domains. Third, behavioral intervention techniques should be employed to help students reduce mobile phone dependency. Educational administrators can launch themed behavioral challenges such as "Exercise Instead of Screen Time," reinforcing students' awareness that physical exercise serves as a positive alternative to phone usage, thereby reducing digital addiction and procrastination. Fourth, differentiated intervention strategies are recommended. For students with high phone dependency, encourage participation in group sports; for those with weak time management skills, emphasize establishing structured schedules through regular exercise. Multi-level intervention designs achieve comprehensive improvement from behavioral to cognitive levels.

Conclusions

First, physical exercise, time management tendencies, and mobile phone dependency are significantly correlated with procrastination behavior among college students. Second, physical exercise can significantly negatively predict procrastination behavior among college students and is an important intervention variable for improving procrastination issues among college students. Third, time management tendencies and smartphone dependency not only play a simple mediating role in the process by which physical exercise influences college students' procrastination behavior but can also indirectly influence college students' procrastination behavior through the chained pathway of "time management tendencies → smartphone dependency." This chained mediating effect is of critical importance for understanding how physical exercise improves procrastination behavior.

Research limitations and future directions

This study examined the relationship between physical exercise and procrastination among college students. The constructed mediation model revealed the underlying mechanism through which physical exercise influences procrastination. It offers new perspectives and insights, holding significant theoretical and practical implications for reducing procrastination among college students. Several limitations remain: First, cross-sectional data limit causal inference; future studies may employ longitudinal tracking or experimental intervention designs to further validate the chained mediation pathway. Second, all variables were measured via self-report scales, potentially introducing common method bias; future research could incorporate objective data (e.g., mobile phone usage logs, fitness tracker data) for multi-method validation. Additionally, the sample was restricted to universities in Northeast China. Future research should broaden the sampling scope to enhance the generalizability of findings.

Data availability

The original contributions presented in the study are included in the article and its supplementary information files. Further inquiries can be directed to the corresponding author.

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Author contributions
FYF was responsible for the data analysis and writing of the original draft preparation. JY was responsible for data analysis and methodology. FYF was responsible for the conceptualization, writing, reviewing and editing the draft. JY was responsible for the conceptualization, writing, reviewing and editing the draft, and funding acquisition. All authors have read and approved the final manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

Ethical approval
The design of this study followed the guidelines and regulations of the Declaration of Helsinki and approved by Ethics Committee of Liaoning Normal University (LL2025167), and all participants signed an informed consent form and were paid for their participation.

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