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Potential categories and influences on college students' exercise motivation: a latent profile-based analysis

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Based on self-determination theory, this study aimed to explore the latent heterogeneous profile structures of exercise motivation among Chinese college students. Furthermore, it systematically examined the predictive effects of demographic variables and social relationship factors on different motivation categories, as well as the differences among these categories concerning perceived academic stress and physical education class engagement. Utilizing a convenience cluster sampling method, 1346 college students (54.75% male) from three universities in North, East, and South China were recruited as participants. Measurements were conducted using the exercise motivation scale, Perceived academic stress scale, and physical education class engagement scale. Latent profile analysis was employed to identify motivation latent profiles. Subsequently, multinomial logistic regression was used to test the predictive variables, and the BCH method was applied to compare differences in outcome variables across the identified profiles. Latent profile analysis identified five distinct motivation profiles: (1) Low-binding type (11.5%), characterized by the lowest levels across all motivation dimensions and autonomy; (2) Identified regulation type (30.2%), the largest profile, marked by prominent identified regulation and intrinsic motivation; (3) External regulation type (27.8%), dominated by controlled motivation; (4) High autonomy type (15.2%), exhibiting the highest levels of autonomous motivation; and (5) High-binding type (15.3%), maintaining relatively high levels across all motivation dimensions. Multinomial logistic regression revealed that gender and grade level did not significantly predict profile membership. In contrast, social relationship factors were key predictors. Students with exercise companions were more likely to belong to the Identified regulation type and High-binding type. Those in a romantic relationship had a significantly higher probability of belonging to the high autonomy type, high-binding type, and external regulation type. Regarding outcome variables, students in the high autonomy type reported the lowest levels of perceived academic stress, whereas those in the high-binding type reported the highest. Concerning PE class engagement, both the high autonomy and High-binding type demonstrated significantly higher levels compared to the other categories. Significant group heterogeneity exists in the exercise motivation of Chinese college students. The high-binding type may represent a unique motivational configuration within the specific Chinese cultural context. The findings indicate that, compared to static demographic characteristics, dynamic social relationship factors are pivotal in shaping college students' motivation patterns. Physical education in higher institutions should emphasize fostering supportive social environments to promote the internalization and integration of student motivation. Moreover, cultivating high autonomous motivation may not only benefit exercise behavior itself but could also serve as a potential psychological resource for helping students cope with academic stress and enhance classes engagement.

Keywords College students, Exercise motivation, Academic stress, Study engagement, Latent profile

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“Exercise is medicine” has become a consensus across various sectors. From the perspective of physiological health, exercise can enhance the functions of the cardiovascular and immune systems, reduce the risk of cardiovascular diseases, and improve bodily resistance, thereby decreasing the probability of illness^{1,2}. From the perspective of mental health, physical activity can elevate an individual’s sense of pleasure and well-being through the release of chemicals such as endorphins, consequently alleviating stress and anxiety, enhancing psychological resilience, and improving emotional states^{3,4}. College students, being outstanding members of the youth demographic and key contributors to future societal development, have their physical and mental health levels drawing significant attention. Substantial research demonstrates that physical inactivity negatively affects college students’ physiological functions, academic performance, and social adaptation, among other aspects⁵⁻⁷.

Exercise motivation is the internal psychological force that drives individuals to initiate, maintain, and adhere to physical activity, and it exerts a significant influence on college students’ persistence in exercise⁸. The Self-determination theory (SDT) provides a robust meta-theoretical framework for understanding exercise motivation⁹. This theory posits that motivation exists on a continuum from amotivation and extrinsic motivation (encompassing external regulation, introjected regulation, and identified regulation) to intrinsic motivation, reflecting varying degrees of behavioral self-determination¹⁰. More self-determined forms of motivation (e.g., intrinsic motivation, identified regulation) are strongly associated with more positive exercise behaviors and higher levels of physical and mental well-being¹¹. Furthermore, research indicates that the type of exercise motivation influences different aspects of exercise behavior. A significant positive correlation exists between intrinsic motivation and exercise frequency, intensity, and duration, whereas extrinsic motivation is correlated with exercise intensity¹². However, a crucial premise of SDT is that different motivation types can coexist within an individual, forming a complex “motivational soup”¹³. Existing studies on college students’ exercise motivation primarily employ a variable-centered approach. This approach typically assesses motivation levels by comparing subjects’ scale scores against cut-off values or theoretical medians^{13,14}. While such research has enhanced the understanding of exercise motivation levels among the college student population, this analytical method has the limitation of overlooking inter-individual heterogeneity. Individual differences in motivation are manifested not only in varying levels of motivation but also in the characteristics of their psychological structure. Exercise motivation is a multidimensional construct; different individuals may exhibit identical total scale scores yet possess entirely distinct patterns of dimension scores, implying different motivational profiles.

Compared to the variable-centered perspective, Latent Profile Analysis (LPA), as a person-oriented statistical method, can identify homogeneous subgroups with similar motivational structures based on scores from multiple motivational dimensions, thereby effectively revealing motivational heterogeneity¹⁵. In recent years, researchers have begun to apply LPA to explore exercise motivation. For instance, Lindwall et al.¹³ identified six motivational profiles in both college student and adult samples, including a “self-determined profile,” a “self-determined with high introjected regulation profile,” and a “low motivation profile,” among others. Furthermore, significant differences in basic psychological need satisfaction and actual exercise behavior were found across these profiles. In a study focusing on Chinese college students, Liu et al.¹⁶ identified four distinct profiles: “Low Motivation type,” “Healthy Appearance-oriented type,” “Healthy Fun-oriented type,” and “High Motivation type.” Their study was also the first to reveal that family social class is a significant external factor influencing profile membership.

Although the aforementioned studies confirm the value of LPA in revealing the heterogeneity of exercise motivation, there remains scope for expansion in current research. First, the number of LPA-based studies on college students’ exercise motivation is still limited, with most being concentrated in Western cultural contexts. Chinese college students are situated within the unique policy context of the “integration of sports and education,” and their academic pressure, patterns of sports participation, and social relationships may differ from those of Western samples¹⁶. This may lead to a distinct structure of their motivational profiles. Second, when examining the factors influencing motivational profiles, existing studies have often focused on single variables¹⁶. They have not systematically integrated key demographic variables (e.g., gender, grade, place of origin) with social relational factors (e.g., romantic relationship status, exercise companions) to collectively predict profile membership. Notably, a meta-analysis by Guerin et al.¹⁷ indicated that overall gender differences across the dimensions of self-determined motivation are minimal. This finding underscores the necessity of examining the gender variable within the context of more specific motivational combinations and particular socio-cultural settings to gain a more nuanced understanding. Furthermore, most existing research stops at profile identification or only examines the relationship with basic psychological needs and exercise behavior^{13,16}, paying less attention to the influence of latent motivational profiles as antecedent variables on education-related outcomes.

Based on this, the present study aims to utilize the LPA method to explore the latent profile structure of physical exercise motivation among Chinese college students. Subsequently, this study will conduct a bidirectional investigation: On one hand, treating the motivational profiles as the dependent variable, it will examine the predictive effects of demographic variables and social relational factors on profile membership. On the other hand, treating the motivational profiles as the independent variable, it will test whether significant differences exist among different motivational profiles in terms of academic stress and levels of physical education (PE) class engagement. This research framework can not only deepen the theoretical understanding of the overall patterns, antecedents, and consequences of Chinese college students’ exercise motivation but also provide precise empirical evidence for higher education institutions to develop targeted psychoeducational interventions. These interventions would aim to alleviate academic stress and enhance classroom engagement through the optimization of motivational qualities.

Research subjects and methods

Research subjects

This study utilized a convenience cluster sampling method, a form of non-probability sampling, to obtain the sample. First, based on the principles of research feasibility and sample diversity, three universities of different types and from different geographical regions were selected via convenience sampling: Capital Normal University (teacher education type, North China), Fuzhou University (comprehensive type, East China), and Guangdong University of Science and Technology (application-oriented type, South China). Subsequently, cluster sampling was conducted within each university. The "natural teaching class" was used as the sampling unit. As senior students (fourth-year) typically do not have compulsory PE courses, the study population was limited to full-time undergraduate students in their first to third years. To enhance sample representativeness, "academic year" was used as a stratification dimension. Within each university, six teaching classes were non-randomly selected from each of the first-year, second-year, and third-year cohorts (totaling 18 classes per university) as survey targets. Finally, group testing was administered by class through coordination with the respective course instructors.

During data collection, the following measures were implemented to maximize data authenticity and reduce common method bias: Data were collected from May 14 to June 3, 2025, through group administration by class, where instructors distributed links to the Wenjuanxing platform. As whole-class administration might lead to passive consent due to the presence of peers or teachers, a "Participant Information Sheet" was presented on the first page of the electronic questionnaire. This sheet detailed the research purpose, estimated completion time (4–6 min), data anonymization procedures, the right to withdraw at any time, and the assurance that data would be used solely for academic purposes. Participants were required to actively click the option "I have read and agree" before proceeding to the questionnaire items, thereby ensuring voluntary informed consent. To ensure the completeness of collected data, all items in the Wenjuanxing platform were set as "mandatory," meaning participants had to respond to every item before final submission. Consequently, the successfully retrieved questionnaires contained no missing values on the scale items.

To rigorously ensure data quality, the following procedures were implemented. First, strict exclusion criteria were established: (1) completion time deemed too short (less than 120 s, which is below half of the minimum estimated time); (2) patterned responses (e.g., straight-line or zigzag patterns).

According to this protocol, 1558 questionnaires were initially collected. After excluding invalid responses based on the criteria, 1346 valid questionnaires were retained, resulting in an effective response rate of 86.40%. The valid sample consisted of 737 males (54.75%) and 609 females (45.25%); 654 freshmen (48.59%), 318 sophomores (23.63%), and 374 juniors (27.79%); 620 students with place of origin in rural areas (46.06%), 321 from towns (23.85%), and 405 from cities (30.09%). The distribution of the valid sample is presented in (Table 1).

Research tools

Exercise motivation scale

The exercise motivation of college students was measured using four subscales, totaling 14 items, from the Chinese-translated Behavioral Regulation in Exercise Questionnaire-2 (C-BREQ-2) revised by Liu et al.¹⁸. The selected subscales included: External Regulation (4 items, e.g., "I exercise because others suggest I should"), Introjected Regulation (3 items, e.g., "I would feel guilty if I didn't exercise"), Identified Regulation (3 items, e.g., "I value the benefits of exercise"), and Intrinsic Regulation (4 items, e.g., "I find exercise pleasurable"). Items were rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Reliability analysis indicated that the overall scale's Cronbach's α was 0.854, with subscale α coefficients of 0.766, 0.829, 0.837, and 0.919, respectively. Confirmatory factor analysis yielded $\chi^2/df = 4.775$, RMSEA = 0.053, TLI = 0.968, and CFI = 0.981, indicating good model fit¹⁹. Following the procedure outlined by Gagné et al.²⁰, a Relative Autonomy Index (RAI) was calculated as: RAI = (2 \times Intrinsic Regulation) + Identified Regulation – Introjected Regulation – (2 \times External Regulation). A higher RAI score indicates a higher level of autonomous exercise motivation.

Variable		Numbers	Proportions (%)
Gender	Male	737	54.75
	Female	609	45.25
Grade	Freshman	654	48.59
	Sophomore	318	23.63
	Junior	374	27.79
Place of residence	Rural area	620	46.06
	Town area	321	23.85
	City area	405	30.09
Romantic relationship status	Yes	251	18.65
	No	1095	81.35
Exercise partner	Yes	534	39.67
	No	812	60.33

Table 1. Characteristics of valid sample distribution.

Perceived academic stress scale

The Academic Stress Scale developed by Solberg et al.²¹, comprising 7 items, was used to assess perceived academic stress levels among college students. Example items include "I feel difficulties in fulfilling school responsibilities" and "I feel stressed when dealing with schoolwork." The scale was first translated and back-translated to ensure semantic accuracy. Two experts in exercise psychology evaluated the content validity of the items, confirming their applicability within the Chinese college student context. Items were rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), with higher total scores indicating greater perceived academic stress. In this study, the scale's unidimensional structure and small number of items resulted in low degrees of freedom for the CFA model, leading to inflated fit indices ($\chi^2/df = 11.975$, RMSEA = 0.090, TLI = 0.950, CFI = 0.967). Consequently, convergent validity was further examined. Results showed that, except for the first item with a factor loading of 0.577, the standardized factor loadings for the remaining items ranged from 0.650 to 0.843, generally meeting or exceeding the recommended threshold of 0.70. The scale demonstrated a composite reliability (CR) of 0.890 and an average variance extracted (AVE) of 0.539, both exceeding the critical values^{22,23}. The scale's Cronbach's α coefficient was 0.920, indicating good reliability and convergent validity in this study.

Physical education class engagement scale

The Students' Individual Self-Report Engagement (Student Questionnaire) developed by Jang et al.²⁴, containing 4 items, was used. Each item was prefaced with "In this physical education class," and measured behavioral engagement (e.g., "I paid attention in class"), cognitive engagement (e.g., "I tried hard to learn"), and emotional engagement (e.g., "I enjoyed this PE class"). The scale was first translated and back-translated to ensure semantic accuracy. Two experts in exercise psychology evaluated the content validity of the items, confirming their applicability within the Chinese college student context. Given the small number of items and relatively simple structure, the fit indices from the confirmatory factor analysis ($\chi^2/df = 6.046$, RMR = 0.006, TLI = 0.994, CFI = 0.998) should be interpreted with caution. Convergent validity was further examined. Results showed that all standardized factor loadings ranged from 0.716 to 0.940, all exceeding the recommended threshold of 0.70. The scale demonstrated a CR of 0.927 and an AVE of 0.764, both substantially exceeding the critical values^{22,23}. The scale's Cronbach's α coefficient was 0.774, indicating excellent reliability and convergent validity in this study.

Data analysis

First, Excel 2015 and SPSS 26.0 were used for data management, reliability analysis, common method bias testing, and descriptive statistics for all variables. Amos 26.0 was employed to conduct confirmatory factor analyses for each scale to examine their structural validity.

Second, Mplus 8.3 was used to perform LPA to examine the latent class structure of college students' exercise motivation. Prior to modeling, key statistical assumptions for LPA were checked to ensure validity. Following Nylund et al.²⁵, models were estimated starting from a 2-class baseline model, progressively increasing the number of classes for parameter estimation and model comparison. Model fit was evaluated using multiple criteria: lower values of the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Adjusted Bayesian Information Criterion (aBIC) indicated better fit; an Entropy value closer to 1 indicated higher classification accuracy, with Entropy ≥ 0.8 suggesting classification accuracy exceeds 90%²⁶; furthermore, significant p-values ($p < 0.05$) for the Lo-Mendell-Rubin (LMR) and Bootstrap Likelihood Ratio Test (BLRT) indicated that the k-class model fit significantly better than the (k-1)-class model²⁷. The final model selection was based not only on these fit indices but also ensured that each latent class possessed sufficient theoretical meaning, distinct profile characteristics, an acceptable sample size proportion ($> 5\%$)²⁵, and high average posterior probabilities (> 0.8)²⁸, thereby guaranteeing the reliability, stability, and interpretability of the latent classes.

Finally, post-hoc LPA methods were employed to explore relationships between latent classes and predictor/outcome variables. First, the R3STEP method was used to examine the predictive effects of demographic and social relational factors on exercise motivation latent class membership. Prior to this analysis, multicollinearity among all predictor variables was diagnosed; variance inflation factors were all below 5, indicating no severe multicollinearity issues, thus satisfying the model's application prerequisites. Second, the BCH method was used to compare differences in perceived academic stress and PE class engagement across different motivational latent classes. This method does not require specific distributional assumptions for the outcome variables and provides robust results for mean difference comparisons²⁹. As the BCH method does not provide class-specific variances for outcome variables, Cohen's d effect sizes were calculated using the overall standard deviation of each variable in the total sample as the denominator. Given that 10 pairwise comparisons were conducted, the Bonferroni correction was applied, setting the adjusted significance level at $p < 0.005$.

Ethics statement

This study involves research methodology and research procedures that follow the Declaration of Helsinki. The ethical review of this study was approved by the Ethics Committee of the leading institution, Capital University of Physical Education and Sports (Approval No. 2025A0102). We confirm that all methods were performed in accordance with the relevant guidelines and regulations. Prior to implementation, the research team submitted the study protocol, informed consent form, questionnaire content, and the ethical approval document from Capital University of Physical Education and Sports to the sports departments of Capital Normal University, Fuzhou University, and Guangdong University of Science and Technology, obtaining their official permission and support for student questionnaire administration. All participating institutions acknowledged the ethical review conclusion provided by Capital University of Physical Education and Sports. Data collection was completed with the informed consent and collaboration of all participating institutions. All participants agreed to participate in this research voluntarily; they provided informed consent when they completed the survey and

Model	χ^2/df	RMR	GFI	RFI	IFI
One-factor model	48.240	0.202	0.466	0.296	0.360
Three-factor model	16.641	0.124	0.722	0.757	0.790
Theoretical model	4.834	0.052	0.930	0.929	0.951
Bifactor model	5.174	0.078	0.928	0.925	0.949

Table 2. Confirmatory factor analysis and model comparison. One-factor model: all items loading on a single common factor; three-factor model: the four sub-dimensions of exercise motivation collapsed into one factor, along with perceived academic stress and PE class engagement as the other two factors; theoretical model: with separate factors for external regulation, introjected regulation, identified regulation, intrinsic motivation, perceived academic stress, and PE class engagement; bifactor model: based on the theoretical model but adding a latent method factor on which all items also loaded.

	M	SD	1	2	3	4	5	6
1. Ext R	9.08	3.35	–					
2. Int R	7.28	0.96	0.345**	–				
3. Ide R	11.02	0.68	0.001	0.498**	–			
4. Int M	13.99	3.86	–0.037	0.417**	0.685**	–		
5. RAI	13.57	11.80	–0.679**	–0.061*	0.549**	0.726**	–	
6. Aca S	21.50	5.57	0.181**	0.063*	–0.053	–0.095**	–0.193**	–
7. Cla E	16.02	3.22	0.025	0.116**	0.269**	0.285**	0.204**	–0.049

Table 3. Descriptive statistics and correlation coefficients of study variables. *Ext R* external regulation, *Int R* introjected regulation, *Ide R* identified regulation, *Int M* intrinsic motivation, *RAI* relative autonomy index, *Aca S* academic stress, *Cla E* class engagement. * $p < .05$, ** $p < .01$.

were able to withdraw from the study freely at any time. In addition, our data were anonymized to ensure the privacy of all participants.

Results

Common method bias testing

As the data in this study were derived from participant self-reports, common method bias was a potential concern. Firstly, Harman's single-factor test was employed to assess common method bias. An unrotated principal component factor analysis including all items was conducted. The results revealed 9 factors with eigenvalues greater than 1, and the first factor accounted for 26.801% of the variance, which is below the critical threshold of 40%³⁰.

Secondly, confirmatory factor analysis was used for model comparison. The model fit indices (Table 2) indicated poor fit for both the single-factor and three-factor models. The theoretical model demonstrated acceptable fit. Furthermore, after adding a latent method factor representing common method bias to the theoretical model, the fit indices of the two-factor model showed slight degradation rather than improvement. Synthesizing these results, it was concluded that the impact of common method bias on the study findings was acceptable.

Descriptive statistics and correlation analysis

The results (Table 3) indicated that RAI of exercise motivation was significantly correlated with its four dimensions. Additionally, RAI was significantly correlated with both perceived academic stress and PE class engagement.

Latent profile analysis

Using the one-category baseline model as a reference, models with increasing numbers of latent categories were fitted sequentially, ranging from 1 to 6 category (Table 4). Model selection followed the principle of combining statistical indicators with theoretical meaningfulness. As the number of classes increased, the AIC, BIC, and aBIC values decreased consistently, and the Entropy values for all models were above 0.8, indicating good classification accuracy. For the 5-category model, the BLRT was significant ($p < 0.001$), although the LMR test result was not statistically significant ($p > 0.05$), suggesting potentially limited improvement in fit compared to the 4-category model. However, relevant literature³¹ notes that BIC is generally considered a more robust model selection indicator than LRT in most cross-sectional studies. In this study, the BIC value for the 5-category model decreased significantly compared to the 4-category model, indicating that the informational gain from adding a category outweighed the cost of increased model complexity. Secondly, the motivational profiles derived from the 5-category model possessed clearer and richer practical significance within the self-determination theory framework. Specifically, the 5-category model successfully distinguished the "High Autonomy type" from the "High-binding type," potentially capturing important differences in motivational quality and behavioral

Model	AIC	BIC	aBIC	Entropy	LMR(<i>p</i>)	BLRT(<i>p</i>)
1	66871.307	67027.454	66932.157	–	–	–
2	62291.311	62530.737	62384.614	0.889	<0.001	<0.001
3	60322.624	60645.328	60448.381	0.906	<0.01	<0.001
4	58949.609	59355.591	59107.818	0.908	<0.05	<0.001
5	57716.765	58206.025	57907.428	0.900	0.332	<0.001
6	56899.174	57471.712	57122.289	0.907	0.140	<0.001

Table 4. Comparison of model metrics for different categories.

Model	Category probability (%)	Average posterior probabilities(%)				
		1	2	3	4	5
1	–	0.950	0.008	0.042	0.000	0.000
2	50.1/49.9	0.009	0.935	0.030	0.009	0.016
3	14.5/53.9/31.6	0.017	0.036	0.934	0.000	0.013
4	8.7/49.0/24.1/18.2	0.000	0.041	0.000	0.937	0.022
5	11.5/30.2/27.8/15.2/15.3	0.000	0.036	0.024	0.009	0.930
6	15.2/4.9/26.4/26.0/12.6/14.9	–	–	–	–	–

Table 5. Category probability and average posterior probabilities.

manifestations between these student groups, a nuance the 4-category model failed to reveal, thus enhancing its theoretical value and practical applicability. Finally, while the fit indices for the 6-category model continued to improve, the decrease in BIC plateaued compared to the 5-category model. Furthermore, Table 5 shows that the smallest class in the 6-category model comprised only 4.9% of the total sample, falling below the 5% threshold and potentially risking unstable estimates²⁵. Regarding classification quality, the average posterior probabilities for all latent classes in the 5- category model exceeded 0.90, far surpassing the common standard of 0.80, indicating highly accurate classification of individuals, clear boundaries between categories, and excellent internal validity. In summary, despite the non-significant LMR test for the 5-category model, it demonstrated superior advantages in terms of significant BIC improvement, theoretical clarity, and profile distinctiveness. This choice better balanced statistical indicators with theoretical substance and was therefore selected as the final model for subsequent analysis.

Figure 1 displays the score profiles of the five identified college student exercise motivation latent classes across the four motivational dimensions (External Regulation, Introjected Regulation, Identified Regulation, Intrinsic Motivation) and the Relative Autonomy Index (RAI). This multi-line chart plots motivational dimensions on the x-axis and scores on the y-axis, where higher scores indicate stronger motivation in that dimension. Class 1 exhibited low scores on all four motivational dimensions and the lowest RAI value, thus being named the Low-binding type. This class comprised 154 individuals (11.5% of the total sample), making it the smallest group. Class 2 showed moderate scores on Identified Regulation and Intrinsic Motivation, alongside moderate external and introjected regulation, but a relatively high RAI, and was named the Identified regulation type. This was the largest class, with 407 individuals (30.2%). Class 3 demonstrated high scores on external and introjected regulation but lower scores on Identified and Intrinsic Motivation, with an RAI value only higher than the Low-binding type, hence named the External regulation type. This class included 374 individuals (27.8%). Class 4 showed low scores on external and introjected regulation but the highest scores on identified and intrinsic Motivation, resulting in the highest RAI value, and was named the High autonomy type. This class contained 205 individuals (15.2%). Class 5 exhibited high scores on all four motivational dimensions, with a moderate RAI value, and was named the High-binding type. This class consisted of 206 individuals (15.3%).

Demographic characteristics of college students' exercise motivation potential category

To understand the influence of demographic variables and social relational factors on college students' exercise motivation, a multinomial logistic regression was conducted based on the identified latent categories of exercise motivation. Gender (Boy = 0, Girl = 1), grade (Freshman = 0, Sophomore = 1, Junior = 1), place of origin (Rural = 0, Town = 1, City = 1), current romantic relationship status (No = 0, Yes = 1), and presence of exercise partner (No = 0, Yes = 1) were included as independent variables, with the five latent classes of physical exercise motivation as the dependent variable.

Prior to analysis, multicollinearity among the independent variables was examined. The results (Table 6) showed that the tolerance for all independent variables ranged from 0.932 to 0.978 (all > 0.1), and the Variance Inflation Factor (VIF) values ranged from 1.022 to 1.073 (all < 5), indicating no significant multicollinearity issues, thus satisfying the prerequisite assumptions for regression analysis.

In the regression analysis, the C1 group (Low-binding type) was set as the reference category. Odds Ratios (OR) were derived to show the effects of various demographic and social relational factors across the different latent classes of college students' physical exercise motivation.

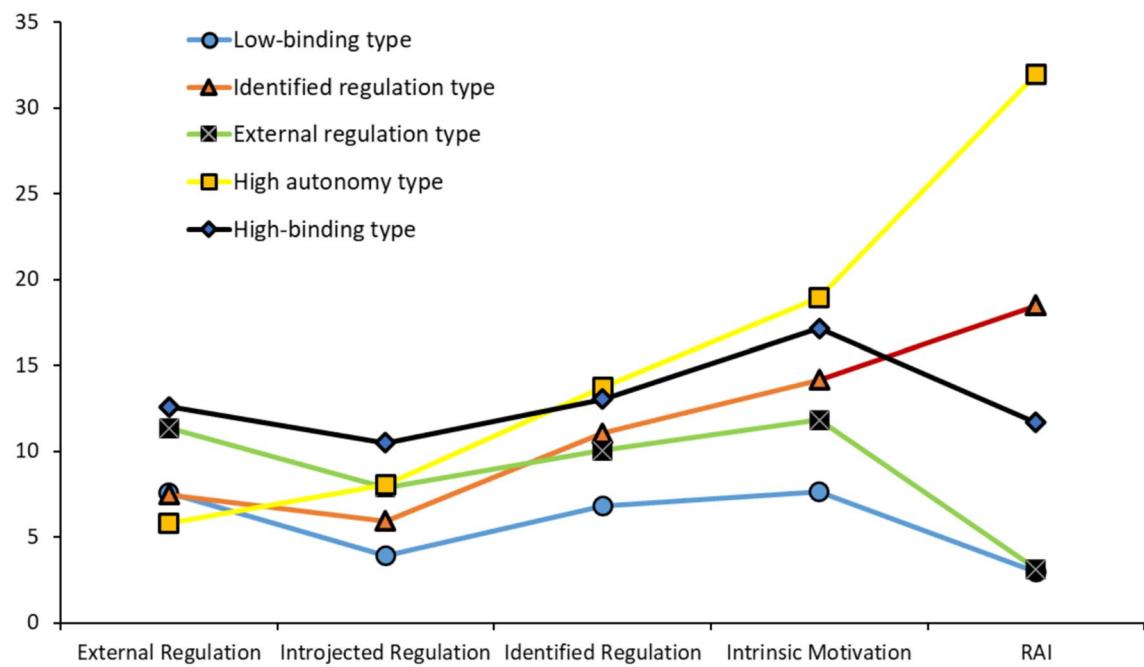


Fig. 1. Five potential categories of exercise motivation among college students.

	Unstandardized coefficients		standardized coefficients <i>Beta</i>	t	p	Collinearity statistics	
	B	SE				VIF	Tolerance
Constant	2.129	0.209		10.178	0.000		
Gender	0.271	0.066	0.113	4.108	0.000	0.978	1.022
Grade	-0.011	0.040	-0.008	-0.285	0.775	0.932	1.073
Place of origin	0.053	0.039	0.038	1.359	0.174	0.958	1.044
Current romantic relationship status	-0.051	0.085	-0.016	-0.593	0.554	0.956	1.046
Exercise partner	-0.013	0.068	-0.005	-0.197	0.844	0.968	1.033
R ²	0.015						
Adjusted R ²	0.011						
F	4.052**						

Table 6. Multicollinearity among the independent variables. ** $p < .01$.

The results (Table 7) indicated that gender and grade did not significantly differentiate the distribution of students across the latent motivation categories. Compared to students from rural areas, those from urban areas had a significantly higher probability of belonging to the High-binding type; however, there was no significant difference between students from rural areas and those from towns. Students in a romantic relationship had a significantly higher probability of belonging to the External regulation type, High autonomy type, and High-binding type. Notably, romantic relationship status had the strongest positive effect on belonging to the High autonomy type. Students with exercise partner were more likely to belong to the Identified regulation type and High-binding type, while their probability of belonging to the External regulation type and High autonomy type was significantly lower compared to the Low-binding type.

Differences in perceived academic stress and PE class engagement among potential categories

The analysis (Table 8) revealed clear differences in perceived academic stress among students from different latent categories. Students in the High-binding type reported the highest levels of perceived academic stress, significantly higher than all other categories except the Low-binding type, Identified regulation type, and High autonomy type ($p < 0.005$). This was followed by the External regulation type, which reported significantly higher stress than the High autonomy type ($p < 0.005$) but significantly lower stress than the High-binding type ($p < 0.005$). Students in the High autonomy type reported the lowest levels of academic stress, followed by the Identified regulation type, with no significant difference between these two categories ($p > 0.005$).

Regarding PE class engagement, students in the High autonomy type demonstrated the highest level, followed by those in the High-binding type. The engagement levels of students in both these categories were

Predictor variable	C1 vs. C2		C1 vs. C3		C1 vs. C4		C1 vs. C5	
	b(S.E.)	OR	b(S.E.)	OR	b(S.E.)	OR	b(S.E.)	OR
Gender (Boy = 0)								
Girl = 1	0.088 (0.362)	1.092	-0.130 (0.349)	0.878	0.166 (0.396)	1.181	0.126 (0.408)	1.135
Grade (Freshman = 0)								
Sophomore = 1	0.062 (0.349)	1.064	-0.230 (0.336)	0.794	-0.802 (0.431)	0.448	-0.411 (0.418)	0.663
Junior = 1	0.068 (0.366)	1.070	0.425 (0.343)	1.530	0.034 (0.428)	1.034	0.129 (0.413)	1.138
Place of origin (rural areas = 0)								
town areas = 1	0.219 (0.336)	1.245	-0.064 (0.329)	0.938	0.266 (0.388)	1.304	0.026 (0.380)	1.027
city areas = 1	0.594 (0.488)	1.812	0.715 (0.431)	2.045	-0.302 (0.584)	0.739	1.032* (0.502)	2.806
Current romantic relationship status (not in a relationship = 0)								
In a relationship = 1	0.260 (0.345)	1.297	0.932** (0.322)	2.541	1.382*** (0.380)	3.982	0.993** (0.362)	2.700
Exercise partner (No = 0)								
Yes = 1	0.646*** (0.175)	1.907	-0.333* (0.165)	0.717	-1.235*** (0.233)	0.291	0.661** (0.199)	1.937

Table 7. Multiple logistic regression analysis of demographic variables on the five potential categories of exercise motivation. C1 low-binding type, C2 identified regulation type, C3 external regulation type, C4 high autonomy type, C5 high-binding type; OR odd ratios. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Variable	Comparison	χ^2	p	Cohen's d	95% CI	Variable	Comparison	χ^2	p	Cohen's d	95% CI
Aca S	C1 vs C2	3.963	.047	0.21	-0.04, 0.46	Cla E	C1 vs C2	16.292	<.005*	-0.46	-0.71, -0.21
	C1 vs C3	0.081	0.776	-0.003	-0.28, 0.22		C1 vs C3	3.933	.047	-0.23	-0.48, 0.02
	C1 vs C4	13.661	<.005*	0.48	0.23, 0.73		C1 vs C4	53.984	<.005*	-0.93	-1.21, -0.65
	C1 vs C5	1.496	.221	-0.15	-0.40, 0.10		C1 vs C5	54.073	<.005*	-0.88	-1.15, -0.61
	C2 vs C3	12.771	<.005*	-0.24	-0.39, -0.09		C2 vs C3	10.066	<.005*	0.23	0.08, 0.38
	C2 vs C4	6.532	.011	0.27	0.06, 0.48		C2 vs C4	26.716	<.005*	-0.47	-0.66, -0.28
	C2 vs C5	13.852	<.005*	-0.36	-0.54, -0.18		C2 vs C5	26.963	<.005*	-0.42	-0.60, -0.24
	C3 vs C4	26.111	<.005*	0.51	0.32, 0.70		C3 vs C4	61.401	<.005*	-0.70	-0.89, -0.51
	C3 vs C5	1.682	.195	-0.12	-0.31, 0.07		C3 vs C5	64.236	<.005*	-0.65	-0.83, -0.47
	C4 vs C5	26.018	<.005*	-0.63	-0.86, -0.40		C4 vs C5	0.224	.636	0.05	-0.15, 0.25

Table 8. Comparison of the five potential categories of exercise motivation in terms of perceived academic stress and class engagement-. (1) Aca S: Academic Stress; Cla E: Class Engagement. (2) C1: Low-binding type, C2: Identified regulation type, C3: External regulation type, C4: High autonomy type, C5: High-binding type. (3) Means across latent profiles were compared using the BCH method in Mplus. (4) All pairwise comparisons were conducted with Wald χ^2 tests with 1 degree of freedom. (5) Given the multiple pairwise comparisons ($n = 10$), a Bonferroni-corrected significance level of * $p < 0.005$ is suggested. (6) Cohen's d was calculated using the overall standard deviation of each variable in the total sample as the denominator. The overall standard deviation was 5.566 for academic stress and 3.224 for PE class engagement. (7) Cohen's d interpretation: $|d| \approx 0.2$ (small), 0.5 (medium), and 0.8 (large)³².

significantly higher than those in the other three classes ($p < 0.005$). It is noteworthy that there was no significant difference in engagement between the High autonomy type and the High-binding type ($p > 0.005$). Students in the Identified regulation type showed significantly higher engagement than those in the External regulation type ($p < 0.005$). Students in the Low-binding type had significantly lower PE class engagement than those in the Identified regulation type, High autonomy type, and High-binding type ($p < 0.005$), but no significant difference was found compared to the External regulation type ($p > 0.005$).

Discussion

Latent profile analysis of college students' exercise motivation

Based on SDT, this study identified five distinct exercise motivation profiles among Chinese college students using LPA: the "Low-binding type," "Identified regulation type," "External regulation type," "High autonomy type," and "High-binding type." These findings demonstrate both consistencies with and unique characteristics distinct from previous research, reflecting the influence of the specific Chinese cultural and educational context.

Previous studies have revealed heterogeneity in exercise motivation across different cultures and populations. For instance, Matsumoto and Takenaka¹⁴ identified four profiles among Japanese adult exercisers, including "self-determined motivation profile," "moderate motivation profile," "nonself-determined motivation profile," and "amotivation profile." Lindwall et al.¹³, utilizing two Western adult samples, consistently identified six latent profiles, which included "low motivation profile," "self-determined profile," "self-determined with high introjected regulation profile," "self-determined with low introjected regulation profile," "external and identified regulation profile," and "external and amotivation profile." Notably, a pure "amotivation profile" was not identified within our sample. This result aligns with the findings of Liu et al.¹⁶ in their study of Chinese college students, who also did not report a significant "amotivation" group (comprising only 0.82% of their sample). A potential explanation for this phenomenon lies in the widespread implementation of the "sports-education integration" policy in Chinese universities, which incorporates PE courses and extracurricular exercise as compulsory requirements¹⁶. This policy likely reduces the possibility of students completely disengaging from exercise contexts, thereby diminishing the overall manifestation of pure amotivation.

Regarding the specific profile structures, the present findings show both parallels and distinctions compared to existing literature. The most prevalent profile in this study was the "Identified regulation type" (30.2%), characterized by moderately high levels of identified regulation and intrinsic motivation, resulting in a high RAI value. This finding partially echoes the most frequent profiles, specifically the "high motivation type" (50.37%) and "healthy fun type" (37.36%), reported by Liu et al.¹⁶, suggesting a common tendency among Chinese college students to associate exercise with internalized values such as health and enjoyment. In contrast, the "low motivation profile" was the most frequent in the studies by Lindwall et al.¹³ (17.8% in Sample A and 27.4% in Sample B). This discrepancy may reflect differences in the overall quality of exercise motivation among college students across different cultural and educational backgrounds. The policy orientation of "sports-education integration" in China might facilitate students' recognition of the value of physical exercise¹⁶.

Particularly noteworthy is the identification of the "High-binding type" profile in this study. This category exhibited high scores across all motivational dimensions, coupled with a moderate RAI value. This specific profile is relatively uncommon in previous SDT-based motivation profile research. Lindwall et al.¹³ reported a somewhat similar "external and identified regulation profile," but it was characterized by more prominent external motivation features. The emergence of the "High-binding type" in our study might indicate that a subset of Chinese college students are simultaneously driven by a high degree of internalized exercise value and significant influence from external demands or social comparisons. This could be related to the characteristic, within the collectivist Chinese cultural context, where individual behaviors are often shaped by both personal interests and social expectations. Furthermore, although the "Low-binding type" constituted the smallest proportion (11.5%) in this study, it demonstrated the lowest motivational quality and the highest risk for exercise behavior discontinuation, marking it as a key target group for intervention. Liu et al.¹⁶ also noted that students from lower family social classes were more likely to belong to profiles with lower motivation levels, underscoring the necessity for targeted interventions for this demographic.

In summary, through LPA, this study reveals five unique combination patterns of exercise motivation among Chinese college students. These findings not only validate the core SDT hypothesis regarding the multidimensional coexistence of motivations¹³ but also highlight the localized characteristics of motivation profile structures within a specific policy and cultural context. This establishes a crucial typological foundation for subsequent in-depth investigation into their influencing factors and behavioral consequences.

Influence of demographic variables on latent categories of college students' exercise motivation

The findings of this study indicated that, compared to male students, female college students showed a greater probability of belonging to the High autonomy type, High-binding type, and Identified regulation type, although these differences were not statistically significant. This result aligns with the findings of Purc-Stephenson et al.³³, who also reported no significant gender differences in autonomous exercise motivation. Furthermore, the meta-analytic results of Guérin et al.¹⁷ demonstrated no significant mean-level differences in autonomous motivation between males and females. The present results not only provide supporting evidence from a Chinese college student sample for the Self-Determination Theory assumption regarding the gender universality of motivational regulation but also extend beyond the traditional variable-centered paradigm. By employing LPA, the study reveals a more complex, non-linear relationship between gender and motivation. The findings suggest that gender differences may not manifest simply as differences in motivation levels, but are subtly reflected in the differing probabilities of belonging to specific motivational profiles. Specifically, female college students demonstrated a tendency towards profiles dominated by higher-quality motivation. This conclusion, while confirming the basic finding of no significant gender differences in motivation levels, preliminarily suggests that gender might function by influencing the probability of belonging to particular motivational patterns.

This study found no significant differences in the distribution of exercise motivation latent categories among freshman, sophomore, and junior students. SDT posits that an individual's autonomous motivation is driven by the satisfaction of basic psychological needs, namely autonomy, competence, and relatedness¹⁰. For instance, Rodrigues et al. found that a supportive environment facilitates the satisfaction of these basic psychological needs, thereby enhancing autonomous motivation and subsequently improving future exercise adherence³⁴. Additionally, research indicates that self-efficacy is a key variable predicting exercise behavior and motivation, with students high in self-efficacy being more likely to set and persist with exercise goals³⁵. Crucially, the satisfaction of basic psychological needs and the enhancement of self-efficacy are not necessarily functions of increasing academic grade level^{36,37}. While progression to higher grades accompanies increased age and maturing cognition, it does not automatically lead to a development of more autonomous exercise motivation among college students.

No significant differences in exercise motivation latent categories were found between students from rural areas and those from towns. However, students from urban areas had a significantly higher probability of belonging to the High-binding type compared to their rural counterparts, with no significant differences observed for other classes. This pattern suggests that place of origin exerts minimal influence on the autonomous exercise motivation of college students. This finding is corroborated by Zhang et al.³⁸, whose research similarly found no statistically significant differences in exercise behaviors, such as exercise time, frequency, intensity, and persistence, between students with urban and rural household registration. The High-binding type is characterized by relatively high scores across all four motivational regulations, resulting in a moderate level of overall exercise autonomy. Students from urban areas typically have access to better sports facilities and resources, which provides more exercise opportunities and choices, potentially enhancing their exercise autonomy³⁹. In contrast, the exercise environment in rural or town areas often limits local adolescents' exposure to diverse sports activities and can hinder their ability to develop autonomous exercise habits⁴⁰. Concurrently, relevant research points out that, compared to rural students, urban students, who often possess higher family cultural capital and more complex social networks, face greater social desirability expectations and social pressure^{41,42}. This may simultaneously reinforce their exercise participation driven by a need to meet external expectations or avoid social anxiety, resulting in the High-binding type state, which reflects a combination of both resource advantages and social pressures.

Influence of social relational factors on latent categories of college students' exercise motivation

Romantic relationships serve as a key factor in identity formation during adolescence, influencing not only emotional states but also psychological and behavioral development⁴³. This study reveals multiple pathways through which romantic relationship status affects exercise motivation. Being in a romantic relationship significantly increased the probability of college students belonging to the External regulation type, High autonomy type, and High binding type, with its strongest predictive effect observed for the High autonomy type. This complex pattern indicates that romantic relationships, as a unique form of intimate connection, exert a dual influence on motivation, yet the overall trend is towards promoting more autonomous forms of exercise motivation. First, the strongest predictive power of romantic relationships was for the High autonomy type. Research indicates that romantic relationships, as intimate bonds, can provide individuals with a stable support system⁴⁴ and facilitate the satisfaction of basic psychological needs, thereby creating an ideal environment for the internalization and development of autonomous exercise motivation. Second, the positive association between romantic relationships and the External regulation type reveals a potentially controlling aspect. A partner with controlling tendencies may exert pressure or coercion regarding exercise participation, which can undermine autonomy and lead to reactance and the externalization of motivation⁴⁵. However, given that the strongest coefficient was for the High autonomy type, it can be inferred that the supportive effects of romantic relationships likely dominate in most circumstances.

This study found that the presence of exercise partners had a significant and differential predictive effect on college students' exercise motivation categories. Specifically, students with exercise partners were more likely to belong to the Identified regulation type and the High binding type, while demonstrating lower probabilities of belonging to the External regulation type and the High autonomy type. This complex pattern illuminates the unique role of exercise partners in facilitating both the internalization and diversification of individual motivation. Firstly, consistent with SDT, social support can promote the internalization of motivation^{10,46}. Exercise partners aid this process by fostering a sense of belonging and shared competence, helping individuals transform external reasons for exercise into personally endorsed values. This culminates in the High binding type motivational state, which represents an integrated form of motivation internalization. Corroborating research confirms that the presence of peers significantly enhances individuals' exercise motivation and participation levels⁴⁷. Second, and notably, having exercise partners was associated with a reduced probability of belonging to the High Autonomy Type. This finding is interpreted not as a negative effect of exercise partners, but rather as an indication of their role in promoting a more diversified motivational profile. Specifically, shared experiences with exercise partners, such as communication, sharing, and mutual encouragement, constitute a form of social interaction that generates enjoyment and satisfaction, forming a positive emotional experience⁴⁸. This experience, which might appear as an external motivation driven by the pursuit of positive affect, does not necessarily diminish autonomy. Instead, by satisfying the basic need for relatedness, it can transform the motivational structure from pure intrinsic enjoyment to a combination of intrinsic enjoyment and social connection, collectively constituting a more diverse and comprehensive motivational system.

Relationship between latent categories of university students' exercise motivation and outcome variables

A significant hierarchical structure in perceived academic stress was observed among college students of different motivational types. Overall, types dominated by controlled motivation (the High-binding type and External regulation type) reported higher levels of academic stress, whereas types characterized by autonomous motivation (the High autonomy type and Identified regulation type) exhibited relatively lower stress levels. Previous research has established that physical exercise can effectively alleviate academic stress, with students who exercise regularly reporting significantly lower perceived stress levels than their non-exercising peers⁴⁹. The findings of this study further reveal that students with high exercise autonomy perceived significantly less academic stress than those with low autonomy. Students experiencing high academic stress often reduce their exercise time due to concerns about completing academic tasks, leading to decreased exercise motivation⁵⁰. For instance, during high-stress periods such as final examinations, students' physical activity levels typically decrease markedly in the short term, while sedentary behavior increases correspondingly⁵¹. Although academic

stress may generally hinder participation in physical activity, certain specific stressors, such as concerns about PE grades, might motivate students to engage in exercise through external motivation with the aim of improving their performance. This also explains why students in the High-binding type maintain a relatively high level of exercise autonomy.

Furthermore, the study found that the highest level of PE class engagement was demonstrated by the High autonomy type, followed by the High-binding type, while the Low-binding type showed the lowest engagement. Cognitive function serves as a crucial foundation for learning engagement, encompassing abilities such as attention, executive function, and problem-solving. Relevant studies indicate that exercise can enhance activity in the prefrontal and parietal cortices, thereby improving attention and inhibitory control⁵². College students with higher exercise autonomy typically engage in exercise more frequently and for longer durations, and often demonstrate greater cognitive flexibility and task persistence. Additionally, students with high cognitive engagement are more adept at integrating new knowledge into their existing cognitive frameworks, which enhances their sense of classroom participation. This, in turn, strengthens individual interest and learning motivation, forming a positive feedback loop of "motivation-cognition-affective engagement." Moreover, exercise motivation interacts with factors such as achievement emotions in PE and social support, collectively influencing the level of engagement in PE classes. Research has found a positive correlation between positive achievement emotions in PE and exercise motivation, forming a chain mediation effect that promotes college students' participation in physical activity⁵³. Consequently, students with high exercise autonomy generally exhibit better engagement in PE classes.

Conclusion

Firstly, this study identified five distinct latent profiles of exercise motivation among Chinese college students, demonstrating distinct group heterogeneity. This finding not only confirms the core hypothesis of the "motivational soup" within SDT but also reveals the localized characteristics of motivational structures among Chinese college students, shaped by the unique policy context of "sports-education integration" and the cultural background. It is particularly noteworthy that the most prevalent Identified regulation type and the unique High-binding type collectively indicate that the current student population generally internalizes the health value of exercise. Moreover, a subset of students successfully integrates external requirements with internal enjoyment, forming complex motivational configurations. However, the persistence of the Low-binding type group, characterized by the lowest motivational quality, highlights a key at-risk population requiring targeted attention in future PE psychological interventions within higher education.

Secondly, regarding factors influencing profile membership, this study underscores the prominent role of social contextual factors over static demographic characteristics. Gender and academic grade were found to have no significant predictive power for motivational profile membership, whereas dynamic social relational factors played a crucial role. Specifically, exercise companions acted as a "catalyst" for motivational internalization and integration. Students with exercise companions were more likely to belong to the higher-quality Identified regulation type and High-binding type, suggesting that peer support facilitates the transformation of external motivation into internal motivation by fulfilling needs for belonging and competence. Romantic relationship status exhibited a "dual-effect" on motivational development, yet the net effect was positive. Students in romantic relationships showed the highest probability of belonging to the High autonomy type, indicating that high-quality intimate relationships can enhance internal motivation by providing social support.

Finally, different motivational profiles exhibited clear gradient differences in key educational outcome variables, highlighting the added value of optimizing the quality of college students' exercise motivation. This study found that concerning academic stress, students in the autonomously motivated High autonomy type reported the lowest levels of perceived academic stress. In contrast, students in the High-binding type, characterized by a mix of controlled and autonomous motivation, perceived the highest stress levels. This suggests that fostering pure autonomous motivation may serve not only as a pathway to improving exercise adherence but also as an effective psychological resource for helping students cope with academic challenges. Regarding classroom engagement, both the High autonomy type and High-binding type students demonstrated the highest levels of PE class engagement. This indicates that, despite differing stress experiences, high levels of motivation serve as a powerful driver for active engagement in PE classes.

Research limitations and future prospects

- (1) The data for this study were collected solely through self-report scales, which presents a methodological limitation. Due to the inherent characteristics of self-report instruments, participants' responses may have been influenced by social desirability bias, potentially affecting the objective reflection of their true exercise motivation. Future research could employ a multi-method assessment system combining self-report and other-report measures. For instance, in addition to self-administered scales, roommates or PE teachers familiar with students' exercise behaviors could be invited to provide evaluations. Such a multi-perspective approach would enable a more comprehensive analysis of college students' exercise motivation, thereby enhancing data accuracy and reliability while providing a more complete understanding of the nature and characteristics of exercise motivation.
- (2) Certain limitations exist in the sample acquisition process. Although university geographic distribution and institutional type were considered during sampling to enhance diversity, the use of convenience cluster sampling means the sample is not a true probability sample. This may somewhat limit the generalizability of the findings to the broader national population of college students. However, the current sample demonstrates reasonable distribution across key demographic variables such as gender and academic grade. Future

studies could adopt more rigorous random sampling methods, such as stratified random sampling of universities nationwide, to further verify the universality of this study's conclusions.

(3) As a cross-sectional investigation, this study can only describe and analyze latent categories of college students' exercise motivation at a specific time point. It cannot explore the dynamic processes of how exercise motivation transitions between latent categories as individuals age or over time. Although differences in perceived academic stress and PE class engagement were identified across different motivational latent categories, these differences represent only static, immediate states without tracking subsequent developments. Future research should implement longitudinal designs to follow students from different motivational latent categories over extended periods, regularly collecting data on perceived academic stress and PE class engagement. This approach would facilitate in-depth investigation into the trends and interactive mechanisms of these factors among college student populations with different exercise motivation profiles.

Date availability

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

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Author contributions

PW and XG designed the study and written the original manuscript. ZL and PW revised the manuscript. XY, YS and CL collected and analyzed the data. All authors contributed to the article and approved the submitted version.

Declarations

Competing interests

The authors declare no competing interests.

Ethics statement

The studies involving humans were approved by the Capital University of Physical Education and Sports (Approval 2025A0102). The participants provided their written informed consent to participate in this study.

Additional information

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