



OPEN The relationship between physical activity and college students' sense of security: the chain-mediated role of self-esteem and psychological capital

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To explore the relationship between physical activity and college students' sense of security, as well as the mediating role of self-esteem and psychological capital between the two. This study used a cross-sectional design, and questionnaires were distributed to 593 college students (29.7% male and 70.3% female) selected from selected colleges and universities in the Liaoning region of China through a simple random sampling method. The questionnaires included the Physical Activity Scale, the Sense of Security Scale, the Self-Esteem Scale, and the Psychological Capital Scale. Data were analyzed using SPSS 26.0 and PROCESS 3.4 plug-ins and Bootstrap methods to test the chain-mediated effects of self-esteem and psychological capital. (1) there is a positive correlation between physical activity and college students' sense of security, and the direct prediction of sense of security is significant; (2) physical activity can positively predict self-esteem, self-esteem can positively predict psychological capital and sense of security, and psychological capital can positively predict sense of security; (3) self-esteem and psychological capital play a significant mediating role between physical activity and sense of security, and the three mediating effect paths: physical activity → self-esteem → sense of security, physical activity → psychological capital → sense of security and physical activity → self-esteem → psychological capital → sense of security. (1) Physical activity can significantly and positively predict college students' sense of security; (2) Self-esteem and psychological capital play mediating roles between physical activity and college students' sense of security, respectively, and also play chain mediating roles.

Keywords Physical activity, College students' sense of security, Self-esteem

Psychological capital

In 2020, General Secretary Xi Jinping delivered an important speech at a symposium of expert representatives in the field of education, culture, health and sports in Beijing, emphasizing the need to strengthen physical activity and constantly enhance the people's sense of security¹. At the same time, the Special Action Plan to Comprehensively Strengthen and Improve Student Mental Health Work in the New Era (2023–2025), issued by the Ministry of Education and other seventeen departments, emphasized the need to give play to the role of sports in relieving stress and regulating emotions, and to place mental health work in a prominent position². As an important new force driving China's development, the college student population's sense of security is of great significance to the promotion of mental health as well as the development of China as a whole³. When college students' sense of security is insufficient, it is very easy to cause psychological problems such as anxiety and depression, and even lead to physiological symptoms such as insomnia and loss of appetite⁴. This psychological state will further affect their academic performance, and studies have shown that college students with a low sense of security have worse grades and higher failure rates⁵. In addition, a lack of security can make college students lack self-confidence, affect their social skills, make them withdraw from interpersonal interactions, and

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make it difficult for them to establish intimate relationships⁶. Therefore, the study of college students' sense of security has triggered a great deal of attention from many scholars⁷. And physical activity, as a proven way of mental health intervention, has gained the consensus of the whole society. Studies have shown that long-term adherence to physical activity not only helps to cultivate the will quality of perseverance, but also enhances the ability of individuals to cope with life's setbacks, making them more confident in facing challenges and solving problems, which significantly improves the sense of security of Chinese nationals^{8,9}. However, combing through the existing studies, we found that there is a scarcity of research on the mechanism of the influence of physical activity on college students' sense of security, and the depth and breadth of the research need to be expanded. Therefore, this study focuses on the special group of college students and explores the mechanism of physical activity on college students' sense of security, in order to provide a theoretical basis and practical guidance for physical educators to formulate and implement effective physical education interventions to enhance college students' sense of security.

Theoretical basis and hypothesis

Social learning theory states that individuals can achieve behavioural acquisition and cognitive change through observational learning, alternative reinforcement and self-regulation mechanisms, and the systematic analytical framework constructed by the theory with the core pillars of observational learning, alternative reinforcement and interactional determinism¹⁰ provides a scientific theoretical perspective for the analysis of the chain relationship between physical activity, self-esteem, psychological capital and sense of security. Firstly, when college students participate in physical activity, they will observe the outstanding performance of their peers or imitate the standard skills of coaches, and then obtain positive feedback from others, such as praise and affirmation, which generates alternative reinforcement, which helps to prompt college students to re-examine their selves and adjust their own behavioural patterns, so as to gradually improve their self-esteem level¹¹. Secondly, high self-esteem individuals tend to regard physical activity as a growth opportunity based on positive perceptions of their own value, accumulating elements of psychological capital such as self-efficacy and optimism in the continuous challenge of athletic goals¹². Finally, the self-regulation mechanism states that college students with high psychological capital can observe environmental challenges more acutely, make optimistic self-judgments, and formulate feasible strategies so as to confidently cope with challenges such as academic pressure and interpersonal conflicts, and to enhance their sense of psychological security¹³. Therefore, physical activity can activate the self-esteem enhancement path through observational learning and alternative reinforcement, promote the development of psychological capital with self-esteem as the intermediary, and ultimately promote the sense of security, forming the chain mechanism of 'Physical activity—self-esteem—psychological capital—sense of security', and the chain mechanism of 'Physical activity—self-esteem—psychological capital—sense of security'. The chain mechanism of 'physical activity-self-esteem-psychological capital-sense of security' reveals the internal logic of the synergistic transformation of individual cognition and psychological resources.

The relationship between physical activity and college students' sense of security

The sense of security is the premonition of possible risks or dangers to the body or the mind, as well as the individual's sense of powerlessness or strength in coping with difficulties, which is mainly manifested in the sense of certainty and controllability¹⁴. According to the theory of stress and coping, when the intensity of external stimuli exceeds the boundaries of the individual's coping resources and regulatory capacity, the individual is very easy to produce traumatic experiences, which in turn breeds anxiety¹⁵, in order to effectively alleviate anxiety, the individual tends to spontaneously activate the psychological defense mechanism, in order to seek a sense of security¹⁶. The lack of security will also directly reduce the level of psychological health of college students, which may also lead to the occurrence of mental illness¹⁷. The results of previous studies have shown that physical activity is not only a key way to improve negative emotions^{18,19} and enhance the sense of security^{20,21}, but also has a significant positive correlation with college students' sense of security, which has a direct predictive effect¹⁶. It can be seen that the prominent role of physical activity in the process of improving college students' sense of security. Accordingly, hypothesis 1 of this paper is proposed. H1: Physical activity has a significant positive predictive effect on college students' sense of security.

Mediating effects of self-esteem

Self-esteem refers to the emotional experience generated by the individual through the evaluation of the self, which contains the dimensions of self-worth and self-competence, belonging to the emotional component of the self-system²². Fear management theory states that self-esteem is mainly derived from the fear of death, and the self-esteem resources possessed by an individual can reduce and alleviate anxiety^{23,24}. When faced with negative events, self-esteem prompts individuals to adopt social behaviours to alleviate their internal anxiety and to regain a sense of value and meaning for themselves²⁵. The results of one study have shown that physical activity is significantly positively correlated with college students' self-esteem²⁶, and when individuals engage in self-motivated types of physical activity, the likelihood of an individual's overall self-esteem improving is even greater²⁷. Through an experimental intervention, it was demonstrated that students who were actively engaged in physical activity had higher levels of self-esteem²⁸. Therefore, physical exercise can not only make college students strong and healthy, but also plays an important role in the improvement of college students' self-esteem. Meanwhile, self-esteem has a significant positive predictive effect on college students' sense of security, which is positively correlated with college students' sense of security²⁹, and college students with low self-esteem are difficult to obtain a high sense of security due to a lack of self-confidence, whereas college students with high self-esteem, on the contrary, are more likely to obtain a high sense of security³⁰. Therefore, self-esteem has an indispensable role in the process of improving college students' sense of security. Accordingly, the research

hypothesis 2 of this paper is proposed. H2: Self-esteem plays a mediating role in the relationship between physical activity and college students' sense of security.

Mediating effects of psychological capital

Psychological capital is a positive psychological state shown by individuals in the process of growth, including the dimensions of self-efficacy, optimism, resilience and hope³¹. According to psychological capital theory, psychological capital has a positive impact on individual behavior and cognitive enhancement, and is an important resource for personal ability improvement³². Previous studies have shown that physical activity can positively predict the level of psychological capital of college students, and college students with high physical activity have high levels of psychological capital^{33,35}. Therefore, physical activity is important for the improvement of psychological capital. At the same time, there is a significant positive correlation between psychological capital and college students' sense of security, as a positive psychological state, it has a contributing effect on the formation and development of college students' sense of security, the higher the level of psychological capital of college students, the higher the level of sense of security, and vice versa, the lower it is³⁶. At the same time, psychological capital can play a buffering role in coping with stress and adversity, thus indirectly enhancing the level of individual's sense of security³⁷. It can be seen that psychological capital may be a mediating variable between physical activity and college students' sense of security, accordingly, hypothesis 3 of this research paper is proposed. H3: Psychological capital plays a mediating role in the relationship between physical activity and college students' sense of security.

Chain-mediated effects of self-esteem and psychological capital

Physical activity, self-esteem and psychological capital have significant positive effects on the improvement of college students' sense of security, respectively, and self-esteem and psychological capital play a simple mediating effect in the relationship between physical activity and college students' sense of security, respectively. Social learning theory suggests that individuals can promote the development of their own self-esteem and psychological capital by observing and imitating the positive behaviors and outcomes of others in physical activity situations^{13,38}, which can gain self-recognition and self-affirmation, prompting them to be optimistic, cheerful, and self-confident³⁹, and contributing to a higher sense of security. At the same time, there is a significant positive correlation between self-esteem and psychological capital dimensions, and self-esteem has a positive predictive effect on psychological capital, the higher the self-esteem, the higher the level of psychological capital, and more likely to obtain a sense of security^{40–44}. Therefore, self-esteem may affect the level of psychological capital, which is one of the key factors to improve psychological capital, and the higher the level of self-esteem of college students, the stronger the psychological capital may be. Based on this, the research hypothesis 4 of this paper is proposed. H4: Self-esteem and psychological capital may play a chain mediating role in the relationship between physical activity and college students' sense of security.

As a result, the research hypothesis model is constructed as shown in Fig. 1.

Methodology

Participants

This paper examines the relationship between physical activity and college students' sense of security and the mediating role of self-esteem and psychological capital. The four selected scales were synthesised into a comprehensive questionnaire using simple random sampling method. The sample size was determined based on the simple random sampling method. A medium effect size (effect size = 0.25), significance level ($\alpha = 0.05$) and statistical power (power = 0.80) were set according to Cohen's (1988) recommendations⁴⁵. The minimum sample size required for calculations through the G*Power software was 128 individuals. However, considering the complexity of the study and the need for multivariate analyses, we further expanded the sample size. A total of 623 questionnaires were distributed to 623 college students enrolled in universities in Liaoning Province through online distribution of questionnaires, and 623 questionnaires were recovered. Before the data were analysed, the data were tested for outliers, and extreme values with standard scores greater than 2 and less than -2 were deleted to reduce the impact of outliers on the analysis results, as suggested by Tabachnick and Fidell (2013)⁴⁶. In addition, the data were tested for normality and the results showed a normal distribution ($p > 0.05$), indicating that the next step of the analysis could be carried out. After excluding invalid data, a total of 593 valid questionnaires were obtained, with a validity rate of approximately 95.2%. Of these, 176 were male (valid

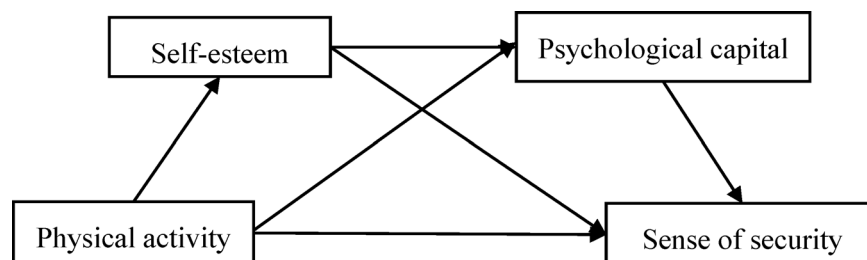


Fig. 1. Diagram of the hypothetical model.

percentage of 29.7%) and 417 were female (valid percentage of 70.3%). The demographic characteristics of the respondents are described in detail in Table 1.

Tools

Physical activity rating scale

The Physical Activity Rating Scale (PARS), which was revised by Liang Deqing et al.⁴⁷ in 1994, was used to examine the physical activity behaviour of university students, which includes a total of physical activity duration (e.g., how many minutes at a time do you perform physical activities at the above intensity?), frequency of activity (e.g., how many times a month do you perform the above physical activities?) and intensity of activity (e.g., what is the intensity of your physical activity?)3 indicators. Each indicator is scored on a 5-point scale, physical activity = intensity × duration × frequency, and the total score is classified into three levels, including small activity ≤ 19, medium activity 20–42, and large activity ≥ 43, and the level classification is used as an indicator for assessing physical activity. The clombach alpha coefficient for this scale in this study was 0.71.

Sense of security scale

The scale is based on the Sense of Security Scale developed by Congzhong and An Lijuan⁴⁸ in 2004, which consists of a total of 16 items, including Sense of Interpersonal Security (e.g., I feel that life is always full of uncertainty and unpredictability.) and certainty of control (e.g., I often worry that I will lose control of my thoughts or feelings.) Two dimensions, each including eight items, each item is scored on a 5-point scale from 1 (very much in line) to 5 (very much out of line), and the total score is the sum of the scores of the items, with higher scores indicating higher levels of security. The alpha coefficient of Clonbach for this scale in this study was 0.93.

Self-esteem scale

A 10-item self-esteem scale developed by Rosenberg⁴⁹ in 1965 was used, with a 4-point scale consisting of positively scored questions (e.g., I feel that I am a valuable person, at least on the same level as others.) and reverse scoring questions (e.g., I feel worthless from time to time.) The sum of the scores of each item is the total score, and self-esteem is proportional to the score, with low self-esteem ≤ 25, moderate self-esteem 26–32, and high self-esteem ≥ 33. The Clonbach’s alpha coefficient for this scale in this study was 0.91.

Psychological capital scale

The scale was adopted from the psychological capital scale developed by Zhang Gao et al.⁵⁰ in 2010, with 26 questions on a 7-point scale (1 = not at all, 7 = fully), including four categories: hope (e.g., ‘I feel that the future is full of hope’), self-efficacy (e.g., ‘I rarely care about the unpleasantness of life’), optimism (e.g., ‘I feel that there are still the majority of good people in society’), and resilience (e.g., ‘I am happy to take on difficult and challenging work’). (e.g., ‘I think there are still a majority of good people in society’) and resilience (e.g., ‘I am happy to take on difficult and challenging work’). The resilience and self-efficacy dimensions have seven questions each, and the optimism and hope dimensions have six questions each. The sum of the scores of the 26 questions is the total score, and the higher the score, the higher the level of psychological capital. The scale was tested to have good reliability, and the alpha coefficient of Clonbach for this scale in this study was 0.92.

Statistical methods

The data obtained from the survey were analyzed and processed using the statistical software SPSS 26.0, which mainly includes screening out invalid data, reliability analysis, common method bias test, Pearson correlation analysis and regression analysis, etc. Based on the results of the study, the mediation effect test was carried out through the process macro program prepared by Hayes.

Results

Common method bias test

Due to the influence of the measurement environment and other factors, the data obtained from the questionnaire may have the problem of common method bias⁵¹. The data obtained were subjected to Harman’s one-way test and analyzed using SPSS 26.0 for physical activity, security, self-esteem, and psychological capital, and the results

	Form	Number of people	Percentage (%)
Distinguishing between the sexes	Male	176	29.7
	Female	417	70.3
Grade	Freshman year	276	46.5
	Sophomore	191	32.2
	Junior	86	14.5
	Senior	40	6.7
Professional category	Science and technology	222	37.4
	Humanities and social sciences	256	43.2
	Arts and sports	115	19.4
Only child	Yes	311	52.4
	No	282	47.6
Add up the total		593	100

Table 1. Description of demographic characteristics of survey respondents.

showed that the total number of factors with an eigenroot greater than 1 was eight, and the first factor explained 32.29% of the variation, which was less than the 40% critical value, suggesting that there was no common methodological bias in this study.

A correlation analysis of physical activity, self-esteem, psychological capital and sense of security among college students

Through Person correlation analysis of gender, grade, major category, whether they are only child, physical activity, sense of security, self-esteem and psychological capital of college students, it was found that major category and whether they are only child are not correlated with gender, grade, physical activity, sense of security, self-esteem and psychological capital, whereas there is a significant positive correlation between gender and grade and physical activity, sense of security, self-esteem and psychological capital. There was a significant positive correlation between physical activity and sense of security, self-esteem and psychological capital, and a significant positive correlation between self-esteem and psychological capital and sense of security (Table 2).

Mediation effect test

Using physical activity as the independent variable, sense of security as the dependent variable, and self-esteem and psychological capital as the mediating variables, the chain mediating effects of self-esteem and psychological capital between physical activity and sense of security were tested using SPSS 26.0 and PROCESS 3.4 plug-ins under controlling for the variables of gender, grade, major category, and whether or not they are only child, and the results are shown in Table 3. The specific steps are as follows: in the first step, using the sense of security as the dependent variable, gender, grade, major category and whether or not they are only children were entered to control for the possible effects of these variables on the sense of security of college students. In the second step, a regression model was built by inputting physical activity to derive the total effect of physical activity on the sense of security, and it was found that physical activity could positively and significantly predict the sense of security ($\beta = 0.271, P < 0.001$), indicating that the research hypothesis H1 was valid. In the third step, self-esteem and psychological capital variables were added to the model to test whether they were mediating variables between physical activity and sense of security and whether there was a chain mediating effect. It was found that physical activity could significantly and positively predict the feeling of security ($\beta = 0.117, P < 0.001$), self-esteem could positively predict the feeling of security ($\beta = 0.543, P < 0.001$), and psychological capital could positively predict the feeling of security ($\beta = 0.299, P < 0.001$). It was also found in the test that physical activity was able to significantly positively predict self-esteem ($\beta = 0.114, P < 0.001$) and psychological capital ($\beta = 0.251, P < 0.001$), and self-esteem was able to positively predict psychological capital ($\beta = 0.483, P < 0.001$).

Using Bootstrap test to repeat the sampling 5000 times, the mediating effects of self-esteem and psychological capital between physical activity and sense of security and confidence intervals were examined separately (Table 4), and the results showed that the total effect value of physical activity on sense of security was 0.271, and the 95% confidence intervals of the mediating effects of self-esteem and psychological capital did not contain 0 (LLCL = 0.192, ULCL = 0.350), indicating that the total effect of physical activity on the feeling of security and the mediating effect of the two variables are significant. The value of the direct effect of physical activity on the sense of security is 0.117 (direct path), Bootstrap 95% confidence interval does not contain 0 (LLCL = 0.048, ULCL = 0.186), indicating that there is a significant direct effect of physical activity on the sense of security, and the value of the effect accounts for 43.17% of the total effect value.

It can be seen from the model that physical activity predicts the sense of security and that self-esteem and psychological capital play an indirect mediating role in it (there are three paths), with a total indirect effect value of 0.153, Bootstrap 95% confidence interval does not contain 0 (LLCL = 0.107, ULCL = 0.205), accounting for 56.46% of the total effect. Among them, the first mediating path: physical activity → self-esteem → sense of security (Path 1), the indirect effect value is 0.062, accounting for 22.88% of the total effect, It shows that the mediating effect is significant and the research hypothesis H2 is verified; the second path: physical activity → psychological capital → sense of security (Path 2), the indirect effect value is 0.075, accounting for 27.68% of the total effect, It shows that the mediating effect is significant and the research hypothesis H3 is tested; and the third chained mediating path: physical activity → self-esteem → psychological capital → sense of security (Path 3), with an indirect effect value of 0.016, accounting for 5.90% of the total effect, suggesting that research hypothesis H4 is valid.

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

	1	2	3	4	5	6	7	8
Genders (1)	1							
Grade (2)	0.499**	1						
Professional category (3)	− 0.079	− 0.032	1					
Only child (4)	0.064	0.042	− 0.056	1				
Physical activity (5)	0.296**	0.576**	− 0.025	0.038	1			
Sense of security (6)	0.148**	0.146**	0.010	0.030	0.302**	1		
Self-esteem (7)	0.135**	0.108**	− 0.055	0.069	0.206**	0.486**	1	
Psychological capital (8)	0.104*	0.090*	− 0.027	− 0.029	0.280**	0.479**	0.335**	1

Table 2. Correlation analysis of physical activity, self-esteem, psychological capital and sense of security among university students. * indicates $P < 0.05$, ** indicates $P < 0.01$, the correlation is significant.

Regression equation		Overall fit index				Significance of coefficients	
outcome variable	predictor variable	R	R ²	ΔR ²	F	β	t
Sense of security	Physical activity	0.316	0.100	0.009	13.060	0.271	6.781***
	Gender					0.160	2.134
	Year					− 0.073	− 1.693
	Professional category					0.025	0.619
	Whether the only child					0.025	0.417
Self-esteem	Physical activity	0.236	0.056	0.014	6.961	0.114	4.347***
	Gender					0.104	2.121
	Year					− 0.036	− 1.259
	Professional category					− 0.027	− 1.020
	Whether the only child					0.053	1.360
Psychological capital	Physical activity	0.413	0.170	0.114	20.107	0.251	5.988***
	Self-esteem					0.483	7.441***
	Gender					0.082	1.060
	Year					− 0.109	− 2.420
	Professional category					− 0.008	− 0.192
	Whether the only child					− 0.094	− 1.522
Sense of security	Physical activity	0.607	0.369	0.199	48.965	0.117	3.346***
	Self-esteem					0.543	9.843***
	Psychological capital					0.299	8.930***
	Gender					0.064	1.006
	Year					− 0.016	− 0.445
	Professional category					0.046	1.357
	Whether the only child					0.016	0.326

Table 3. Regression model of mediating effects of self-esteem and psychological capital. ** indicates $P < 0.01$, *** indicates $P < 0.001$.

Effect	Trails	Efficiency value	Standard error	LLCL	ULCL	Efficiency ratio
Total effect		0.271	0.040	0.192	0.350	100%
Direct effect	Direct path	0.117	0.035	0.048	0.186	43.17%
Total indirect effect		0.153	0.024	0.107	0.205	56.46%
	Path 1	0.062	0.016	0.032	0.097	22.88%
Indirect effect	Path 2	0.075	0.021	0.037	0.119	27.68%
	Path 3	0.016	0.005	0.007	0.027	5.90%

Table 4. Mediating effects of self-esteem and psychological capital.

Discussion

Physical activity has a significant positive effect on college students' sense of security

The results of the study show that there is a correlation between physical activity and sense of security, and physical activity can significantly and positively predict college students' sense of security, which is consistent with the results of existing studies^{14–21}. On the one hand, when an individual feels that external stimuli are beyond his or her control, he or she will feel anxious and traumatised, and in order to alleviate this status quo he or she will take certain defensive measures to seek a sense of security, while physical activity has a different degree of improvement on the sense of security, which can narrow the sense of distance in interpersonal interactions, weaken the feeling of inner uneasiness, and from which he or she will feel a sense of belonging and love, and thus obtain a sense of security¹⁴. On the other hand, physical activity is an auxiliary treatment for anxiety, psychological fear, depression and interpersonal communication, which has a certain promotional effect and positively improves the development of physical health and subjective experience, and also positively promotes the enhancement of the sense of security^{14–21}. In addition, physical activity can be an important path to enhance college students' sense of security by strengthening their emotional regulation and social adaptation, fostering positive interpersonal relationships, and promoting the development of physical and mental health⁵². Therefore, colleges and universities should call for policy support (setting up special funds, training teachers in psychological counselling skills, etc.) to promote the integration of physical education and psychological counselling to enhance college students' sense of security.

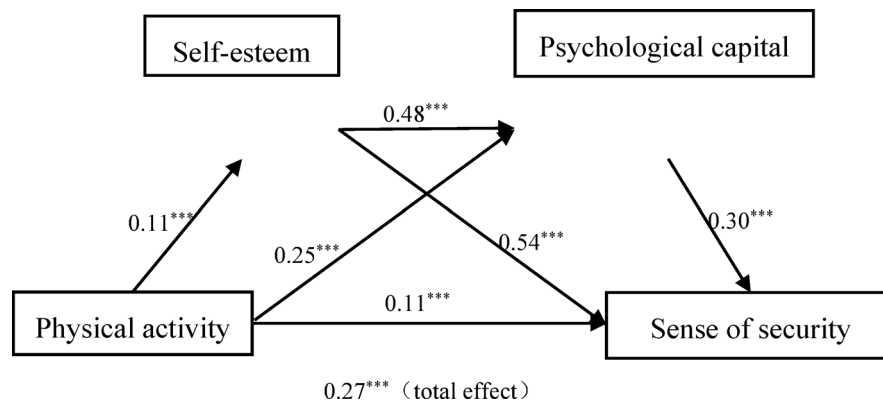


Fig. 2. Chain-mediated effects model of self-esteem and psychological capital.

The mediating effect of self-esteem between physical activity and college students' sense of security

The study shows that self-esteem plays a partially mediating role in physical activity and college students' sense of security (the relative mediating effect is 22.88%), indicating that physical activity not only directly affects college students' sense of security, but also positively influences college students' sense of security indirectly through self-esteem, which verifies this paper's hypothesis 2. On the one hand, physical activity can significantly and positively predict the level of self-esteem, and the former Through meta-analysis of more than 100 studies on the relationship between physical activity and self-esteem, it was concluded that physical activity can improve both overall self-esteem and physical self-esteem, and the more active an individual is in physical activity, the higher the level of self-esteem, which is consistent with the results of many studies^{22–28}. On the other hand, self-esteem has a significant positive predictive effect on college students' sense of security. In general, when facing the external environment, individuals with low self-esteem may ignore the care and help from others, underestimate the external support, and have difficulty in obtaining a high degree of security; whereas individuals with high self-esteem are more likely to feel the care and encouragement from others, and are able to obtain a greater sense of security^{29,30}. Through this mechanism of action, it not only helps to shape college students' character of self-confidence and perseverance and enhance their ability to cope with challenges, but also provides new ideas for activity intervention research and promotes in-depth cognition of the relationship between physical activity and psychological development⁵³. Therefore, educators should design a tiered physical education curriculum based on students' self-esteem levels and construct a dual-track intervention model of “activity + psychology” to achieve the educational goal of synergistic activity and psychological interventions.

The mediating effect of psychological capital between physical activity and college students' sense of security

Physical activity can positively predict college students' psychological capital, and psychological capital plays a significant mediating effect between physical activity and college students' sense of security, which is basically consistent with existing studies^{33–37}. On the one hand, psychological capital, as a positive personality trait, not only helps individuals to better face the variables in life, but also improves the individual's ability to resist stress and setbacks, and enhances personal perseverance and self-efficacy. In the process of participating in physical exercise, the brain produces endorphins, which can relieve the pressure of study and life, obtain a higher sense of physical and mental pleasure, enhance the sense of self-efficacy, and promote the further deepening of social relationships. At the same time, the collective sports programme makes the social relationship between students closer, and the acceptance and support of students make the individual experience a higher level of psychological capital, which can help the students to develop their physical and mental health synchronously. At the same time, it also enhances the level of tough will and emotional control, thus increasing the level of psychological capital of college students^{33,35}. On the other hand, psychological capital is a specific embodiment of security, when facing setbacks and difficulties, it can not only help college students maintain a healthy psychological state in the face of life variables, but also strengthen personal determination and perseverance, promote the self-growth and comprehensive development of college students, thus improving the level of college students' sense of security^{36,37}. It can be seen that physical activity builds a dual-action path for college students' sense of security by enhancing psychological capital, so that they can cope with challenges and pressures with a more resilient will, a more stable state of mind, and a more positive attitude⁵⁴. Based on this, colleges and universities should offer 'psychological capital-oriented' sports courses and develop personalised APPs that integrate physical activity and psychological capital cultivation to promote the enhancement of college students' psychological capital.

Chain-mediated effects of self-esteem and psychological capital on the relationship between physical activity and college students' sense of security

This study examined the effects of physical activity, self-esteem and psychological capital on college students' sense of security, and the results showed that the total effect value was $\beta = 0.271$. Among them, there were simple correlations between physical activity, self-esteem and psychological capital and sense of security respectively,

which could directly predict the effect value of sense of security $\beta=0.117$, i.e., the total indirect effect value of $\beta=0.153$, which indicated that the mediating effect had a greater explanatory power than the direct effect size, in which the third chain path accounted for 5.90% of the total effect (physical activity $\rightarrow$ self-esteem $\rightarrow$ psychological capital $\rightarrow$ sense of security), proving the existence of this chain mediator. Physical activity can not only significantly and positively predict college students' sense of security through the separate mediation of self-esteem and psychological capital, but also jointly affect college students' sense of security through the chain mediation of self-esteem and psychological capital, which also proves the value and significance of the two mediating variables for college students' sense of security. On the one hand, physical activity not only improves the level of self-esteem of college students, but also improves the level of psychological capital of college students, which has a good promotion effect on both self-esteem and psychological capital³⁸. On the other hand, self-esteem has a significant positive predictive effect on psychological capital, and an individual with higher self-esteem will have a somewhat stronger psychological capital, show more endurance and resilience when facing difficulties, hold a more optimistic attitude, and see hope more easily, thus more likely to obtain a sense of security^{40–44}. Therefore, by analysing the influence mechanism of physical activity and college students' sense of security, it can provide a scientific basis for enhancing college students' sense of security, help college students eliminate negative emotions and cultivate an optimistic mindset, so that they can deal with all kinds of challenges more comfortably in their studies and interpersonal interactions⁵⁵.

Limitations and future perspectives

This study explores the relationship between physical activity and college students' sense of security. The construction of the chain mediation model reveals the internal mechanism of the influence of physical activity on college students' sense of security, and provides new perspectives and new ideas, which is of great theoretical and practical significance for improving college students' sense of security. However, there are some limitations in this study: firstly, this study only explored the mediating effect of self-esteem and psychological capital between physical activity and college students' sense of security, and there may be other variables affecting college students' sense of security, which can be explored and demonstrated by adding stress and social support in the future; secondly, this paper belongs to a cross-sectional study and takes college students as the investigating group, which may limit the efficacy of the causal inference, and the sample gender ratio is not proportionate to the sample. Moreover, the gender ratio of the sample in this study is imbalanced (70.3% female), although the main effect of the model remains robust after gender is used as a control variable in the regression test, stratified sampling should be strictly followed to keep the gender balanced in future studies to further test the generalisability of the theoretical model in different gender groups; finally, experimental studies and other methods can be used to explore the relationship between physical activity and college students' sense of security and the variables. of the relationship between physical activity and college students' sense of security and the variables.

Conclusion

The positive predictive effect of physical activity on the sense of security was significant. When mediating variables were put in, both the direct and indirect effects of physical activity on college students' sense of security were significant, including the effect with self-esteem and psychological capital as independent mediators and the effect with self-esteem and psychological capital as chain mediators.

Data availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. If anyone would like to request data from this study, please contact the corresponding author, Shi Lei, 110064114@qq.com.

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Author contributions

H-B Z designed the study, collected and analyzed the data, and wrote the manuscript. Y.Q translate and polish. S.L is responsible for paper revision, supervision and funding acquisition. All authors have read and approved the final manuscript. All authors confirm that the manuscript has been submitted solely to this journal and is not published, in press, or submitted elsewhere (including preprint servers). And all the research meets the ethical guidelines, including adherence to the legal requirements of the study country. All authors have seen the manuscript and approved to submit to your journal.

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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 (LL2024208), and all participants signed an informed consent form and were paid for their participation.

Informed consent

Written informed consent was obtained from all the participants and their parents (or legal guardian) prior to this study.

Additional information

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