



## Research article

# Effect of physical exercise on negative emotions in Chinese university students: The mediating effect of self-efficacy

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## ABSTRACT

**Objective:** This study investigates the impact of physical activity on negative emotions among university students and examines the mediating influence of self-efficacy, aiming to furnish empirical insights and a theoretical framework to enhance and optimize the mental health of this population comprehensively.

**Methods:** Using the cluster random sampling method, 5341 university students were selected from three universities. The questionnaire included demographic information about university students, physical exercise behaviors, expressions of negative emotions such as depression and anxiety, and self-efficacy in physical exercise. The types of questionnaires included the Physical Activity Rating Scale (PARS-3), the General Self-Efficacy Scale (GSES), and the Depression Anxiety Stress Scales (DASS).

**Results:** 76.877 % of university students had low exercise. The detection rates of depression, anxiety and stress in negative mood were 77.041 %, 64.276 % and 47.931 %, respectively. There were significant differences in physical exercise and negative mood scores among university students of different genders and grades. University student. Negative emotions were significantly correlated with physical exercise and self-efficacy ( $P < 0.001$ ). According to the regression model, physical exercise can significantly predict negative emotions and self-efficacy. The mediating effect of self-efficacy is evident.

**Conclusion:** Physical exercise among university students typically comprises light workouts, associated with a high prevalence of anxiety symptoms. Self-efficacy acts as a mediator in the effects of physical exercise on negative emotions within this group.

## 1. Introduction

As they navigate the transition from adolescence to adulthood, university students are shaped by external influences including

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**Table 1**  
Distribution of research objects.

		Frequency	Percentage
Gender	Male	1713	32.1
	Female	3628	67.9
Grade	1	2477	46.4
	2	1762	33.0
	3	596	11.2
	4	506	9.5
Totle		5341	100.0

interpersonal relationships, academic stress, and campus life, alongside their own negative cognitions. In recent years, mental health issues among university students have become frequent, with common occurrences of self-isolation behaviors and declines in academic performance. Among these, anxiety induced by negative emotions accounts for a high proportion and poses significant harm. According to the “Report on the Mental Health of University Students in China,” only half of the students have no risk of anxiety (54.72%) [1]. Significant differences in mental health status exist among students of different genders, schools, household registrations, and academic stages.

Negative emotions refer to the adverse psychological impact caused by life events, leading to emotional fluctuations, which in turn cause disruptions in the body’s internal energy flow or endocrine disorders [2,3]. Depression, anxiety, and stress represent the predominant negative emotions experienced by university students [4]. Cognitive Behavioral Theory (CBT) suggests that university students face high pressure regarding academic performance and grades [5]. Suppose they adopt an “all-or-nothing” mindset to evaluate their academic achievements (e.g., believing that anything less than the best is a failure). In that case, it may lead to excessive anxiety and depression [6,7].

Furthermore, the increasing educational competition, uncertainty about future careers, and concerns about the job market may lead to catastrophic thinking among university students, exacerbating their anxiety and stress. Existing studies demonstrate that physical exercise facilitates the release of beneficial biochemicals in the body, including endorphins, which act as ‘natural painkillers’ and enhance mood [8]. Stress theory posits that prolonged stress can lead to chronic stress responses, whereas physical exercise helps regulate the levels of these biochemical substances, reducing the adverse effects of stress responses [9]. Based on the above perspectives, this study hypothesizes **H1: The level of physical exercise among university students can positively predict negative emotions.**

Physical exercise involves using various physical methods, combined with natural forces (sunlight, air, water) and hygiene measures, to develop the body, promote health, enhance physical fitness, and entertain the mind and body [10,11]. It is the main form of mass physical activity. Expectancy theory suggests that when individuals have confidence in their ability to complete a specific task, they are more likely to engage in and persist with that behavior [12]. Existing evidence shows that physical exercise enhances university students’ self-efficacy in sports and other areas of life, thereby positively influencing their psychological state and behavior patterns [13,14]. A systematic randomized controlled trial assessed the impact of consistent physical exercise on depressive symptoms in adults [15]. The results showed that the group participating in regular exercise significantly reduced depressive symptoms compared to the non-exercise control group. Other studies indicate that individuals who regularly engage in moderate-intensity exercise have a lower incidence of anxiety symptoms compared to those with lower activity levels.

Therefore, do other variables mediate the influence of physical exercise on negative emotions? Prior studies indicate that self-efficacy could be a critical mediating factor in how physical exercise affects emotional regulation among university students [16]. Self-efficacy is defined as individuals’ belief in their capability to execute specific tasks effectively within a particular context and their confidence in achieving success [17]. According to self-efficacy theory, higher self-efficacy can motivate individuals to exert more effort and persist in various activities until they reach their goals [16]. In contrast, individuals with low self-efficacy are more likely to experience doubt, worry, and other negative emotions when encountering failure and setbacks, typically settling for mediocre performance. When faced with seemingly impossible tasks, they tend to develop avoidance behaviors, whereas individuals with high self-efficacy do not exhibit significant harmful psychological defense mechanisms. Previous research suggests that the regulation of negative emotions stems from intrinsic motivation and enhanced self-efficacy [18]. According to Lazarus and Folkman’s stress and coping theory, how university students evaluate stress situations (as threats or challenges) directly influences their emotional responses [19]. High self-efficacy makes students more likely to positively assess their stress and setbacks when encountering difficulties in daily skills practice and theoretical knowledge learning, reducing the perception of threats and alleviating negative emotions. A systematic review indicates that different negative emotions (such as anger, depression, and anxiety) have varying effects on behavior [20]. Anger is directly related to subsequent prosocial and aggressive behaviors, while depressive and anxious states do not predict these behaviors. Furthermore, negative emotions directly influence prosocial and aggressive behaviors in adolescents, with emotional self-efficacy regulation partially mediating the connection between negative emotions and these behaviors [21]. In summary, this study proposes **Hypothesis H2: Self-efficacy mediates the impact of physical exercise on negative emotions in university students.**

In the current complex environment, it is imperative to simultaneously monitor and understand the mental health status and dynamic shifts among university students, examine factors influencing their mental wellness, and identify scientifically validated

**Table 2**  
Basic results of physical exercise and negative emotions in university students.

Index	Overall		Sex				Grade							
			Male (n = 1713)		Female (n = 3628)		1 (n = 2477)		2 (n = 1762)		3 (n = 596)		4 (n = 506)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
<b>Depression</b>														
Normal	1207	22.599	369	21.541	838	23.098	646	26.080	360	20.431	118	19.799	83	16.403
Mild	1748	32.728	469	27.379	1279	35.254	956	38.595	496	28.150	158	26.510	138	27.273
Moderate	1715	32.110	528	30.823	1187	32.718	693	27.977	641	36.379	203	34.060	178	35.178
Severe	458	8.575	208	12.142	250	6.891	142	5.733	167	9.478	80	13.423	69	13.636
Very serious	213	3.988	139	8.114	74	2.040	40	1.615	98	5.562	37	6.208	38	7.510
$\chi^2$			169.690				227.439							
<i>P</i>			<0.001				<0.001							
Cramer's V			0.178				0.119							
<b>Anxiety</b>														
Normal	1908	35.724	583	34.034	1325	36.521	987	39.847	585	33.201	185	31.040	151	29.842
Mild	1306	24.452	374	21.833	932	25.689	697	28.139	357	20.261	137	22.987	115	22.727
Moderate	1159	21.700	343	20.023	816	22.492	492	19.863	444	25.199	112	18.792	111	21.937
Severe	383	7.171	121	7.064	262	7.222	154	6.217	134	7.605	55	9.228	40	7.905
Very serious	585	10.953	292	17.046	293	8.076	147	5.935	242	13.734	107	17.953	89	17.589
$\chi^2$			97.878				191.086							
<i>P</i>			<0.001				<0.001							
Cramer's V			0.135				0.189							
<b>Stress</b>														
Normal	2781	52.069	806	47.052	1975	54.438	1478	59.669	840	47.673	252	42.282	211	41.700
Mild	1553	29.077	467	27.262	1086	29.934	683	27.574	546	30.988	165	27.685	159	31.423
Moderate	745	13.949	282	16.462	463	12.762	257	10.375	265	15.040	132	22.148	91	17.984
Severe	262	4.905	158	9.224	104	2.867	59	2.382	111	6.300	47	7.886	45	8.893
Very serious	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
$\chi^2$			122.328				186.064							
<i>P</i>			<0.001				<0.001							
Cramer's V			0.151				0.108							
<b>Physical exercise</b>														
Small	4106	76.877	979	57.151	3127	86.191	1931	77.957	1373	77.923	445	74.664	357	70.553
Moderate	736	13.780	354	20.665	382	10.529	362	14.614	214	12.145	76	12.752	84	16.601
Large	499	9.343	380	22.183	119	3.280	184	7.428	175	9.932	75	12.584	65	12.846
$\chi^2$			659.435				35.405							
<i>P</i>			<0.001				<0.001							
Cramer's V			0.351				0.081							

intervention techniques and strategies for managing negative emotions. As sports psychology advances, bolstering individual self-efficacy has become crucial for promoting personal health development. The university phase marks a critical period for psychological growth in students, and integrating mental health initiatives into university education is essential. Investigating ways to enhance self-efficacy carries significant implications for the psychological health education of university students. Accordingly, this study examines whether the influence of physical exercise on mental health is mediated by self-efficacy, acting as a crucial intermediary. Hence, this research seeks to explore the connections and underlying mechanisms between physical exercise, self-efficacy, and negative emotions in Chinese university students, thereby providing a reference and theoretical foundation for systematically enhancing and comprehensively optimizing their mental health.

## 2. Research methods

### 2.1. Subjects

This study utilized a cross-sectional research design. Employing a stratified random sampling methodology, a survey was conducted in October 2022 among university students at Shangqiu University, Henan Province, Yangzhou University, Jiangsu Province, and Nantong University, Jiangsu Province. A proportionate number of classes within each institution were randomly selected as sampling units. More specifically, courses at each university were assigned random numbers, and certain classes were subsequently chosen for inclusion in the survey via a random number generator. All students in the selected classes participated in the study. The distribution of the study participants is detailed in Table 1.

The minimum sample size required for the study was determined using formula (A), with the Type I error rate ( $\alpha$ ) established at 0.05, the allowable error ( $\delta$ ) set at 0.01, and the sample proportion ( $p$ ) fixed at 0.05. Based on the most recent data from the official websites of the universities for the year 2022, the total undergraduate population across the three universities was identified as 104,530, thereby defining the total population ( $N$ ) as 104,530. Consequently, the calculated minimum sample size necessary for this research was found to be  $n = 1794$ . The formula used for calculating the minimum sample size is depicted in the figure presented below [22].

**Table 3**  
Analysis of the Correlation analysis.

		PARS-3	Depression	Anxiety	Stress	DASS
PARS-3						
Depression	r	-0.162				
	p	<0.001				
Anxiety	r	-0.163	0.832			
	p	<0.001	<0.001			
Stress	r	-0.127	0.809	0.827		
	p	0.047	<0.001	<0.001		
DASS						
	r	-0.172	0.929	0.927	0.890	
	p	<0.001	<0.001	<0.001	<0.001	
GSES						
	r	0.296	-0.197	-0.171	-0.114	-0.163
	p	<0.001	<0.001	<0.001	0.292	<0.001

$$n = \frac{\frac{Z_{\alpha}^2 * \sigma^2}{\delta^2}}{1 + \frac{Z_{\alpha}^2 * \sigma^2}{\delta^2} / N} \quad (A)$$

## 2.2. Tools

### 2.2.1. Physical Activity Rating Scale (PARS-3)

PARS-3 was developed by Japanese scholar Koo Hashimoto and later revised by Liang [23]. This scale evaluates physical exercise by measuring three dimensions: the intensity, frequency, and duration of each exercise session. It applies these metrics to assess participants' engagement in physical activities. During the actual survey process, each item in the questionnaire is divided into five levels, with scores ranging from 1 to 5. The raw scores derived from the survey responses are calculated using Equation (B).

$$\text{Physical exercise volume score} = \text{intensity} \times (\text{time} - 1) \times \text{frequency} \quad (B)$$

PARS-3 has a complete physical exercise level norm for Chinese college students [23]. The outcomes derived from the PARS-3 offer an evaluation of the participants' volumes of physical exercise, which serves to illustrate, to a certain degree, the current state of physical engagement amongst university students at a given moment. Furthermore, the findings obtained through the PARS-3 provide an assessment of the participants' quantities of physical activity, demonstrating a test-retest reliability coefficient of 0.82 [24].

### 2.2.2. General Self-Efficacy Scale Schwarzer (GSES)

GSES was compiled by Schwarzer et al. [25]. The Chinese adaptation of the GSES was translated and modified by Wang. Its reliability and validity were rigorously evaluated, demonstrating that the GSES possesses robust reliability for use among Chinese populations. For Chinese university students, the scale showed an internal consistency, with a Cronbach's alpha ( $\alpha$ ) of 0.87. Additionally, the test-retest reliability coefficient was  $r = 0.83$  ( $p < 0.001$ ), and the split-half reliability score stood at  $r = 0.82$  ( $n = 401$ ,  $p < 0.001$ ) [26]. GSES consists of ten questions and utilizes a 4-point Likert scale for responses, with scores ranging from 1 to 4 points each. The cumulative total of these scores represents the overall level of an individual's self-efficacy; thus, a higher total score indicates greater self-efficacy. The GSES is appropriate for individuals aged 12 years and older.

### 2.2.3. Depression Anxiety and stress Scale (DASS)

DASS adheres to the three-dimensional model formulated by Clark and Watson. In this study, the test of negative emotions was tested using the Depression Anxiety and Stress Chinese Simplified Scale (DASS-C) compiled by Lovibond., revised by Antony, and translated by Wen [27,28]. DASS-C is equipped with a complete evaluation norm for Chinese college students. DASS-C demonstrates high reliability and validity among Chinese university students. Specifically, the overall Cronbach's  $\alpha$  coefficient for DASS-C is 0.912 and its test-retest reliability score is 0.751. Additionally, the average correlation coefficient among items stands at 0.338. The Pearson correlation coefficients between the scores on the three subscales and the total score of the DASS-C21 scale range from 0.895 to 0.910, while the inter-subscale correlation coefficients vary from 0.708 to 0.741 ( $p < 0.01$ ) [28].

## 2.3. Statistical analysis

Statistical analysis was conducted using SPSS 25.0 software, following these steps: (1) Descriptive data analysis assessed the current state of negative emotions and physical exercise behaviors among university students. The Chi-square test examined differences in these variables across different genders and academic years, using Cramer's V coefficient to measure effect size. (2) Correlation analysis determined the relationships between self-efficacy, negative mood (including depression, anxiety, and stress), and physical exercise behavior. (3) Linear regression analysis tested the mediating role of self-efficacy in the relationship between physical exercise behavior and negative emotions, with standardization (Z-score) of the three variables prior to assessing the mediation effect.

**Table 4**  
Analysis of the Mediation effects.

Equation	Independent variable	Dependent variable	Model Summary		ANOVA		Coefficient		
			R <sup>2</sup>	Adjusted R <sup>2</sup>	F	p	$\beta$	t	p
Depression									
(1)	Physical exercise	Depression	0.001	0.001	4.417	0.036	-0.029	-2.102	0.036
(2)	Physical exercise	Self-efficacy	0.097	0.097	527.277	<0.001	0.311	23.922	<0.001
(3)	Physical exercise, self-efficacy	Depression	0.002	0.002	5.565	0.004	-0.04	-2.804	0.005
							0.037	2.59	0.010
Anxiety									
(4)	Physical exercise	Anxiety	0.001	0.001	6.333	0.012	-0.034	-2.517	0.012
(5)	Physical exercise, self-efficacy	Anxiety	0.004	0.003	10.291	<0.001	-0.051	-3.569	<0.001
							0.054	3.773	<0.001
DASS									
(6)	Physical exercise	DASS	0.001	0.001	4.658	0.031	-0.030	-2.158	0.031
(7)	Physical exercise, self-efficacy	DASS	0.003	0.002	6.74	0.001	-0.043	-2.976	0.003
							0.043	2.969	0.003

### 3. Results

The Harman one-way test was employed to assess common method bias, analyzing all items related to physical exercise, negative emotions, and self-efficacy through unrotated exploratory factor analysis. The results indicated that the maximum variance explained by a single factor was 33.04 %, which is below the critical threshold of 40 %. Consequently, this study does not exhibit common method bias.

#### 3.1. Descriptive analysis

The results of Table 2 showed that the assessment of depression in the negative mood of university students was normally 22.599 % of the total sample, and moderate and above accounted for about 44.673 % of the total sample. Normal university students in the anxiety test accounted for only 35.724 % of the total sample, about 64.276 % of the tested university survival symptoms of anxiety, and severe anxiety (about 7.171 %) and very severe anxiety (about 10.953 %) university students are more. The stress test of university students showed that 52.069 % of university students were normal and did not have very stressful university students.

The study revealed that 76.877 % of university students engaged in light physical exercise, 13.78 % participated in moderate exercise, and 9.343 % engaged in intense physical activity. Analyzing gender differences, it was found that the prevalence of depression and anxiety among male university students was significantly higher than that among females ( $P < 0.001$ , Cramer's  $V = 0.178$ ). Specifically, the incidence of severe anxiety was notably greater in male students compared to female students ( $P < 0.001$ , Cramer's  $V = 0.135$ ). Differences were also observed in stress levels between males and females ( $P < 0.001$ , Cramer's  $V = 0.151$ ), indicating a more pronounced negative emotional state in male university students. Additionally, significant disparities were evident in physical exercise behaviors between genders ( $P < 0.001$ , Cramer's  $V = 0.351$ ), with males participating more frequently in moderate and intense exercises compared to females.

#### 3.2. Correlation analysis

Table 3 shows a significant negative correlation between university students' physical exercise volume and negative emotions ( $P < 0.001$ ), with a correlation coefficient of  $-0.172$ . The correlation coefficients between physical exercise volume and the depression, anxiety, and stress dimensions under negative emotions range from  $-0.163$  to  $-0.127$ . University students' physical exercise volume significantly correlates with general self-efficacy, with a correlation coefficient of  $0.296$  ( $P < 0.001$ ). Negative emotions of university students exhibit a significant negative correlation with general self-efficacy, with a correlation coefficient of  $-0.163$  ( $P < 0.001$ ). The depression and anxiety dimensions under negative emotions demonstrate significant negative correlations with general self-efficacy, with correlation coefficients of  $-0.197$  and  $-0.171$ , respectively ( $P < 0.001$ ). The stress dimension does not show a significant relationship with general self-efficacy ( $P = 0.292$ ).

#### 3.3. Mediation effect test

Table 4 shows that the variance test in the regression analysis indicated that all P values were below 0.05, demonstrating the validity of the regression model. According to the results from equation (1), physical exercise behavior was a significant predictor of depressed mood ( $F = 4.417$ ,  $P = 0.036$ ). The findings from equation (2) showed that physical exercise behavior also significantly predicted self-efficacy among university students ( $F = 527.277$ ,  $P < 0.001$ ). Notably, physical exercise accounted for 2.9 % of the variance in depressed mood as per equation (1), and this increased to 4 % when self-efficacy was included as a variable in equation (3). Furthermore, the regression coefficient for self-efficacy on aerobic fitness decreased from 0.311 in equation (2) to 0.037 in equation (3), indicating that self-efficacy partially mediates the relationship between physical exercise and depression. This analytical approach

is equally applicable to the analyses involving anxiety and the overall DASS score.

#### 4. Discussion

The issue of mental health challenges among Chinese university students presents a significant concern for university administrators and academics engaged in student psychology research. This study provides empirical evidence of the impact of physical exercise on negative emotions in university students and incorporates the mediating variable of self-efficacy. By investigating the influence factors, this research aims to deeply examine the state of negative emotions among Chinese university students. The findings will offer theoretical insights that could inform future strategies to address mental health issues within this population.

##### 4.1. Analysis of the current state of physical exercise among university students

The results of this study indicate that the current level of physical exercise among university students is relatively low. Specifically, 76.877 % of students engage in light physical exercise, 13.78 % engage in moderate physical exercise, and 9.343 % engage in high-intensity physical exercise. When comparing different demographic variables, there are significant differences in exercise behaviors between male and female students. Males participate in moderate and high-intensity exercise more frequently than females ( $P < 0.001$ , Cramer's  $V = 0.351$ ), consistent with previous research. Depressive states are pretty prevalent among university students, with notable gender differences. While 22.599 % of students were assessed as having normal levels of depression, 44.673 % of students exhibited moderate to severe depressive symptoms, and only 52.069 % of students had normal levels of stress. Demographic variables suggest that the occurrence of depressive states may be associated with multiple factors, including biological differences, social role expectations, stress coping mechanisms, and the social acceptability of emotional expression [29,30]. Biological factors may contribute to the emotional differences between genders [31]. Research indicates that males and females differ in neurotransmitter levels, hormone levels, and brain structure and function, which may affect emotional regulation and stress-coping abilities [32]. Additionally, social role expectations may play a role in these gender differences [33].

Combining other research results, both physiological and psychological perspectives reveal that physical exercise significantly alleviates negative emotions in university students. Physical exercise promotes neuroplasticity, ameliorates abnormal brain changes associated with depression, reduces pro-inflammatory cytokines like IL-6, and improves the immune system [34]. Different intensities of physical exercise effectively increase melatonin levels, thus physiologically mitigating depressive symptoms [35]. Psychologically, long-term physical exercise can enhance self-evaluation, self-awareness, and exercise adherence, increase positive emotions, and consequently positively impact the alleviation of depressive symptoms [36]. Based on the above findings, university health centers should improve on-campus fitness facilities, organize a variety of sports activities, and flexibly use big data technologies, such as exercise check-ins and WeChat step counting, to increase students' motivation to participate in physical exercise [37]. This effectively alleviates the negative emotional states of university students.

##### 4.2. University students have a high incidence of anxiety

The findings of this study reveal a high prevalence of anxiety among university students, a phenomenon that warrants significant attention from academia and society at large. Research data indicates that only 35.724 % of the surveyed students fall within the normal range, implying that approximately 64.276 % of the sampled university students exhibit symptoms of anxiety. This alarming proportion highlights the severe mental health challenges faced by contemporary university student populations. Notably, the study also found that a considerable percentage of students experience severe anxiety (about 7.171 %) and very severe anxiety (about 10.953 %), further emphasizing the urgency and severity of the issue. The causes of this situation may be multifaceted, but academic pressure is likely to be one of the primary factors [38]. The higher education environment's competitive nature and high academic expectations may create an atmosphere conducive to anxiety [39]. Continuous academic workload, exam stress, and research project requirements may lead to the accumulation of chronic stress, manifesting as anxiety symptoms [40]. In recent years, employment pressure has also emerged as a significant factor contributing to high anxiety levels [41]. As job market competition intensifies, students generally feel apprehensive about their career prospects after graduation. This uncertainty about the future may significantly exacerbate anxiety levels, particularly as students approach graduation [42]. This conjecture aligns with the distribution of anxiety across different year levels in this study, where the proportion of students experiencing severe anxiety among juniors (27.181 %) and seniors (25.494 %) is notably higher than that of freshmen (12.152 %) and sophomores (21.339 %).

Of particular note is the significant gender difference in anxiety prevalence found in this study. Male university students showed significantly higher rates of depression and anxiety compared to their female counterparts ( $P < 0.001$ , Cramer's  $V = 0.178$ ). This finding contrasts with some previous studies reporting higher anxiety rates among females [43]. These research findings are closely related to China's specific socio-cultural environment. Traditional role expectations for men in Chinese society, such as achieving career success and bearing family economic responsibilities, may place additional psychological burdens on male university students [44]. Simultaneously, deeply ingrained traditional notions may inhibit their willingness to express emotions and seek help, potentially exacerbating anxiety symptoms [45]. Furthermore, as a generation raised under the one-child policy, many male university students may be subject to high expectations from their families, further increasing their psychological pressure [46]. The combined effect of these factors may explain the gender differences observed in this study.

### 4.3. Correlation of physical exercise, self-efficacy, and negative emotions in university students

The results of this study indicate that there is a significant negative correlation between physical exercise and negative emotions among university students. Specifically, the correlation coefficient between physical exercise levels and the total DASS score is  $-0.172$ , indicating a significant association between increased physical activity and overall reduced psychological stress. These findings are consistent with previous literature, suggesting that physical exercise can effectively reduce symptoms of depression and anxiety, possibly through improved physical health and positive biochemical changes (such as increased levels of endorphins and serotonin) [47,48]. Specifically, the correlation coefficients between physical exercise and depression, anxiety, and stress among university students are  $-0.162$ ,  $-0.163$ , and  $-0.127$ , respectively, indicating a stable negative correlation between increased levels of physical exercise and reduced negative emotional states. These data highlight the potential value of physical exercise as a non-pharmacological intervention in preventing and alleviating psychological stress.

Additionally, the correlation coefficient between physical exercise levels and self-efficacy is  $0.296$ , indicating that physical exercise helps relieve negative emotions and significantly enhances individuals' self-efficacy. This enhancement may be due to improvements in body image, health status, and mastery over exercise skills brought about by physical exercise, thereby increasing individuals' confidence in handling various life challenges. According to the correlation coefficient between self-efficacy and DASS scores, the enhancement of self-efficacy is associated with reductions in depression, anxiety, and stress. However, the relationship between self-efficacy and stress is not statistically significant, suggesting that the alleviating effect of self-efficacy on stress is less pronounced than its effects on depression and anxiety in this sample or possibly due to sample-specific characteristics or measurement differences.

### 4.4. The mediating effect of self-efficacy between physical exercise and negative emotions is significant

In modern higher education, student mental health has become an essential concern for educators and policymakers. The results of this study are realistic, and the effect of physical exercise on university students' negative emotions is significant in major public health emergencies. Specifically, physical exercise significantly reduces negative emotions among university students and enhances psychological resilience and well-being by enhancing self-efficacy [49]. Self-efficacy is the psychological state in which individuals trust their ability to achieve goals, directly influencing their motivation and behavior when facing challenges. Studies have shown that regular physical activity can help students build successful experiences, thereby enhancing their self-efficacy in academic and other life domains [50]. The positive psychological effects of physical exercise are not limited to strengthening self-efficacy. Physical exercise indirectly promotes higher educational and social achievements by improving emotional states and reducing stress responses [51]. Research indicates that through team sports and organized physical activities, students' cooperation and communication skills in interpersonal interactions are honed, which are critical factors in reducing negative emotions and promoting positive social interactions [52]. The successful experiences that university students gain in physical activities can be translated into confidence in coping with daily life difficulties and challenges.

Furthermore, this confidence reduces the expression of negative emotions when facing academic pressure and personal issues, lowering the detection rate of these emotions. Enhancing self-efficacy allows students to more optimistically assess their abilities, improving their overall psychological state and emotional health [53,54]. From the perspective of the dose-response relationship of physical exercise, although it is known that physical exercise positively affects self-efficacy and mental health, the specific dose-response relationship requires further research. This includes determining how long, how frequently, and at what intensity students should engage in physical exercise to achieve optimal mental health benefits [55]. Future research can use controlled trials and longitudinal studies to explore the specific effects of different types and intensities of physical activity on enhancing self-efficacy and emotional regulation.

### 4.5. Limitation

Firstly, the reliance on self-reported data for measuring physical activity in this research could introduce recall bias. Future studies could enhance measurement objectivity by utilizing wearable devices for objective tracking. Secondly, the study's cross-sectional design does not offer a longitudinal perspective across different time frames, resulting in a lack of robust historical data. Future research could adopt a longitudinal study design to more accurately and definitively establish causal relationships between variables. Lastly, the use of the PARS-3 and DASS scales, which are considered outdated, might lead to some inaccuracies in result interpretation. Moreover, the absence of established evaluation norms for university students within the GSES (General Self-Efficacy Scale) diminishes the extent of self-efficacy analysis conducted in this research.

## 5. Conclusion

University students' physical exercise is mostly of low intensity, yet the detection rate of anxiety symptoms is relatively high. Studies have shown that self-efficacy plays a crucial mediating role in the impact of physical exercise on negative emotions among university students. Specifically, physical exercise can effectively enhance university students' self-efficacy, thereby boosting their confidence and alleviating and suppressing the expression of negative emotions. Therefore, actively increasing university students' participation in daily physical exercise benefits physical health and promotes mental health.

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## Institutional review board statement

The Study protocol for this study received approval from the ethics committee at Nantong University, documented under approval number 2022 (70). Prior to commencing formal investigations and testing, researchers obtained informed consent from all participants involved in the study.

## Informed consent statement

Informed consent was obtained from all subjects involved in the study.

## Data availability statement

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

## CRediT authorship contribution statement

**Guo-You Qin:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Shan-Shan Han:** Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **Yang-Sheng Zhang:** Writing – original draft, Software, Project administration. **Yu-Peng Ye:** Writing – review & editing, Writing – original draft, Project administration, Data curation. **Chuan-Yi Xu:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This study was conducted independently and did not receive specific grants from funding agencies in the public, commercial, or not-for-profit sectors.

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