

# Can Physical Activity Improve Psychological Problems Predicted by Poor Sleep? A Cross-Sectional Study from a Large Sample

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**Abstract:** Sleep quality is recognized as an important factor for depression, but suitable physical activity and psychological resilience may relieve depression. However, it remains unknown whether physical activity (PA) and psychological resilience (PR) can reduce the effect of sleep quality on depression. Therefore, a cross-sectional data from Survey of Physical and Mental Health of College Students was used. The Pittsburgh Sleep Quality Index Survey (PSQI), DASS-21, The short International physical activity Questionnaire (IPAQ), CD-RISC-10 were used to collect data. Logistic regression and restricted cubic spline models were used to examine the association of sleep quality and depression. A total of 19184 College Students aged 19.8 years (SD=1.66) were finally included in this study. The results indicated a positive correlation result between sleep quality and depression. Our results also indicate that low sleep quality is a risk factor for depression, and PA, PR can moderate this relationship to some degree.

## 1 Introduction

The university period is a time when psychological health is more vulnerable compared to other age groups [1]. This situation has further deteriorated due to the COVID-19 pandemic [2]. A study has revealed that, during the pandemic, 73% reported mild to severe depression [3]. However, only 34% to 36% of students, in general, seek psychological counseling while in college [4]. Emotional issues, such as depression often associate with negative outcomes, such as poor academic performance and drop-outs [4]. Furthermore, depression has been linked with unstable relationships [5], suicidal thoughts [6] and attempts, as well as poorer work performance [7].

Given the prevalence of depression worldwide and its major impact, many studies attempted to find low cost method to improve this situation, such as sleep plays an important role in the physiological and psychological health of college students as it is known to be a recurring and reversible neural behavioral state [8] and one of the most crucial factors influencing their emotions [9]. Research indicates that increasing psychological resilience (PR) can enhance positive emotions and reduce negative emotion [10]. Evidence indicates that physical activity (PA) enhances the release of dopamine, which positively impacts emotions, and reduces the secretion of adrenaline and serotonin, neurotransmitters that could potentially contribute to negative emotional states.

To sum up, even though PR and PA exert crucial influences on negative emotions caused by sleep deprivation among university students, there is currently a lack of relevant researches exploring the relationship between them

[11]. Moreover, there is insufficient exploration of the effects of PA of various intensities on improvement of negative emotions.

This paper represents the first attempt to investigate the link between the four variables and examine how PA of different intensities can have an impact on improving negative emotions. The aim of this paper is to develop a mediating chain model that outlines how PR and PA work together to predict negative emotions in the context of poor sleep quality among college students, with the ultimate goal of providing practical means of improving their emotional well-being. The hypotheses of this paper are the following: (1) there is a negative correlation between PA and negative emotions, (2) PR can mitigate negative emotions that are caused by poor sleep, and (3) different intensities of PA have varying effects on the improvement of neg.

## 2 Methods

### 2.1 Participants

This study employed cluster sampling to select a sample population of healthy first-year students enrolled in three universities located in the eastern, western, and central regions of China. The survey was conducted from October 18 to December 20, 2021. Specially-assigned students provided guidance and answered relevant queries. A total of 19,184 valid responses with a pass rate of 89.5% were obtained after discarding 2,239 invalid questionnaires out of

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the 21,423 collected. Respondents included 52.2% females and 47.8% males, with an average age of 19.8 years (SD=1.66). Participants were required to complete an electronic questionnaire, comprising demographic variables, sleep, PA, emotions, and PR.

## 2.2 Procedure

The data was collected through the Questionnaire Star website to ensure participants' responses were exclusively used for survey research. To ensure accuracy and care in completing the online survey, two methods were employed. Firstly, the responsible teachers underwent uniform training on research purposes, content, and implementation procedures and then informed the participants of the study's attributes, benefits, usage and adverse effects. Secondly, the screening criteria comprised of IPAQ Lite Data Cleansing and Outlier Elimination Principles, as well as Lie Test Questions. Participants with missing activity frequency or time data not included in the analysis, or if the cumulative daily time of PA of the three intensities, i.e. short rolls, exceeded 960 minutes (16 hours) were not included. Furthermore, exclusion occurred if the subtraction value of two lie test questions exceeded an absolute value of 2, indicating incorrect survey completion.

## 2.3 Ethics Statement

This research was approved by the Ethics Committee of Southwest University, Shanghai Jiao Tong University, and Zhengzhou University. All testing content and procedures are approved by school authorities and teachers.

## 3 Measures

### 3.1 Predictive Variable - Sleep Quality

The Pittsburgh Sleep Quality Index Survey (PSQI) was utilized to evaluate sleep quality and patterns in the past month by considering seven components: overall sleep quality, sleep duration, sleep latency, sleep efficiency, sleep disturbances, frequency of medication use for falling asleep, and daytime dysfunction [12]. Responses were rated using a Likert scale from 0 to 3, indicating "very good," "fairly good," "fairly bad," and "very bad," respectively. Based on a cut-off score of 5, the "short PSQI" was used to identify poor sleepers. Scores higher than 5 indicated poor sleep quality. The Shortening of the Pittsburgh Sleep Quality Index Survey's reliability was evaluated using Cronbach's alpha, resulting in a value of 0.745 [13].

### 3.2 Outcome Variable - Depression Anxiety Stress

The 21-item version of the Depression Anxiety Stress Scales (DASS-21) was developed to serve as a brief form of the 42-item self-report measure by Lovibond and Lovibond assessing depression, anxiety, and stress (DASS) [14]. Participants complete the DASS-21 as a self-report by rating how frequently and severely they have experienced

negative emotions over the preceding week. Responses utilize 4-point scales (0 = did not apply to me at all; 3 = applied to me very much, or most of the time). Cronbach's alpha was used to assess the reliability (internal consistency) of the DASS-21 Anxiety, Depression, Stress, and total scales, resulting in a value of  $\alpha=0.88$  (95% CI = 0.87–0.89) for the Depression scale, 0.82 (95% CI = 0.80–0.83) for the Anxiety scale, 0.90 (95% CI = 0.89–0.91) for the Stress scale, and 0.93 (95% CI = 0.93–0.94) for the total scale [15]. The final scores got from subscale were multiplied by two to enable normative comparisons.

## 3.3 Mediators

### 1) Psychological resilience

The Connor-Davidson Resilience Scale is a self-report measure consisting of 25 items designed to gauge one's ability to manage and cope with adversity [16]. The abbreviated version of the questionnaire, CD-RISC-10, contains 10 items evaluating factors such as "ability to adapt to change," "ability to deal with problems," "ability to find humor in problems," and "strengthening effects of stress." These retained items assess the respondent's capacity to cope with different life stressors, including change, illness, and failure, among others. Respondents rate each item on a scale ranging from 0 (not true at all) to 4 (true nearly all the time). To assess the CD-RISC's internal consistency, Cronbach's alpha was calculated, resulting in an alpha value of 0.85, indicating good reliability [17].

### 2) Physical activity

The short International physical activity Questionnaire (IPAQ) was used to summarize PA data, including light, moderate, and vigorous activities, as well as sitting time per week [18]. Participants answered seven self-report physical activity questions, and sitting time was measured separately from PA. The IPAQ data was used to estimate total PA per week by estimating MET energy expenditure for each activity and weighting the reported minutes accordingly. The Cronbach's alpha ( $\alpha=0.758$ ) assessed the internal consistency of IPAQ-SF. The reliability of IPAQ-SF was high, with all intraclass correlation coefficients favoring high internal consistency (Cronbach's alpha > 0.80,  $p < 0.05$ ) [19].

## 3.4 Covariates

Demographic variables were treated as risk factors for anxiety and depression and included as covariates in all analyses. The 8 covariates measured at the time of the questionnaire were: sex, age, only child status, body mass index, household registration, university, and parents' education level.

## 3.5 Statistical Analysis

Descriptive statistics including means and standard deviation (SD) were presented for continuous variables, while frequencies and percentages were presented for categorical variables. Pearson's correlation coefficient was used to

test the association between the research variables. All statistical analyses were conducted using the software Statistical Package for the Social Sciences (SPSS) version 25.0, and the level of significance was set at  $p < 0.05$ .

A mediation analysis was conducted to investigate whether PR and PA mediated the association between sleep quality and symptoms of depression. Model 6 of the PROCESS macro, utilizing SPSS® 25.0 (IBM Corporation, Armonk NY, USA) for Windows® operating system, was used to test the mediation models. The bootstrap method was employed to verify the indirect effect and generate bias-corrected confidence intervals utilized for 5000

samples [20]. Reported p-values were two-tailed, and a significance level of  $p < 0.05$  was used throughout the analysis.

## 4 Results

### 4.1 Descriptive Analyses

Table 1 presents the descriptive statistics of the total survey scores, including the mean and standard deviation values for each variable. According to Table 2, 30.8% experienced varying degrees of depression.

**Table 1.** Mean and standard deviation of the total scores of the all study variables.

Variable	Mean	Standard deviation
Vigorous PA	226.66	643.34
Moderate PA	159.88	365.16
Light PA	829.91	778.89
Sleep	5.73	2.89
Stress	8.92	8.1319
Anxiety	7.26	7.14
Depression	6.75	7.607
psychological resilience	34.33	8.09

**Table 2.** Participants' demographic characteristics (N = 19184)

Variable	Level	Number	%
Sleep	Very good	9603	50.10%
	Fairly good	8384	43.70%
	Fairly bad	1140	5.90%
	Very bad	57	0.30%
Total PA	High	1311	6.80%
	Moderate	11469	59.70%
	Low	6404	33.30%
Stress	Normal	15699	81.80%
	Mild	1468	7.70%
	Moderate	1146	6.00%
	Severe	639	3.3%
Anxiety	Extremely severe	232	1.2%
	Normal	11334	59.10%
	Mild	1587	8.30%
	Moderate	4071	21.20%
Depression	Severe	1012	5.30%
	Extremely severe	1180	6.2%
	Normal	13821	69.20%
	Mild	2114	11.0%
Depression	Moderate	2735	14.30%
	Severe	517	2.70%
	Extremely severe	537	2.8%

### 4.2 Correlation Between Study Variables

As showed in Table 3 the correlation coefficients of the control variables and the main research variables. The results showed a significant negative correlation between

depression and moderate and walking activity. There is a significant positive correlation between sleep quality and the following factors: BMI, moderate, and walking activity, sex and age, whether they were an only child, body mass index, household registration, university, and parents' education level. The relationship between variables supports subsequent hypothesis testing.

**Table 3.** Descriptive statistics and correlations between key study variables

N:19184	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.University	1													
2.Sex	-.106**	1												
3.BMI	.042**	-.203**	1											
4.Age	.189**	-.080**	.024**	1										
5.Household registration	.136**	0.004	-.033**	.029**	1									
6.Farther's education level	.038**	.016*	-.022**	.038**	.511**	1								
7.Mother's education level	.034**	0.007	-.031**	.041**	.523**	.704**	1							
8.whether you are an only child	.184**	.079**	-.051**	.026**	.449**	.400**	.425**	1						
9.Moderate activities	-.206**	-.144**	.049**	-.046**	-.104**	-.101**	-.102**	-.113**	1					
10.Walking activities	-.062**	.030**	-.017*	-.075**	0.01	.026**	.031**	0.001	.115**	1				
11.Sleep	.092**	.052**	-.023**	.095**	.046**	.037**	.043**	.046**	-.064**	-.015*	1			
12.Anxiety	-.016*	.018*	0.008	0.011	.043**	.051**	.057**	.043**	-.054**	-.039**	.457**	1		
13.Depression	.018*	-.016*	.018*	.049**	.040**	.051**	.050**	.037**	-.055**	-.065**	.444**	.818**	1	
14.Psychological Resilience	-.052**	-0.01	-0.012	-.041**	-.087**	-.096**	-.091**	-.071**	.118**	.113**	-.227**	-.333**	-.390**	1
M			22.552	19.777					159.876	829.911	5.728	7.261	6.7533	34.3347
SD			6.494	1.661					365.164	778.891	2.893	7.145	7.60735	8.09146

SD: standard deviation.

\*\*  $p < .01$ .

\*  $p < .05$ .

### 4.3 Mediation Effect

According to Ye & Wen suggestions on the test of intermediary effect [21], the model 6 in SPSS macro degree compiled by Hayes was used to complete the test of intermediary effect. The inspection results are shown in Table 4. First, controlling for demographic variables (gender and age, whether the only child, body mass index, registered residence, university, and parents' education level), the direct pathway of sleep quality on depression was examined. The results showed that the direct pathway of sleep quality on depression was significant before the inclusion of mediating variables ( $\beta = 0.5858$ ,  $t = 68.4561$ ,  $p < 0.01$ ). Therefore, hypothesis 1 holds.

The role of PR and PA in mediating the chain between the relationship between sleep quality and depression was then examined. The results showed in Table 4, analysis of

the main variables relationship indicated that the direct effect of sleep quality on depression remained significant after the inclusion of mediating variables ( $\beta = 0.5471$ ,  $t = 64.5863$ ,  $p < 0.01$ ) and the remaining direct pathways all reached significant levels and could act on depression through two indirect pathways: (1) sleep quality  $\rightarrow$  PR  $\rightarrow$  depression; (2) sleep quality  $\rightarrow$  PR  $\rightarrow$  PA  $\rightarrow$  depression; Hypothesis 2 was tested by the significant direct paths of sleep quality on PR ( $\beta = -0.4420$ ,  $t = -22.1253$ ,  $p < 0.01$ ) and PR on depression ( $\beta = -0.0868$ ,  $t = -28.5701$ ,  $p < 0.01$ ); the insignificant direct paths of sleep quality on PA ( $\beta = 1.9656$ ,  $t = 1.0414$ ,  $p = 0.2977$ ) and the direct pathway of PA to depression was insignificant ( $\beta = -0.0002$ ,  $t = -6.4579$ ,  $p = 0.0000$ ), hypothesis 3 was tested; the direct pathway of PR to PA was significant ( $\beta = 9.1979$ ,  $t = 13.1049$ ,  $p < 0.01$ ), indicating that a chain mediator of PR and PA existed and hypothesis 4 was tested.

**Table 4.** Analysis of regression relationship among variables

Effect	Item	Effect	SE	t	p	LLCI	ULCI
Direct effect	SQ $\rightarrow$ DE	0.5471	0.0085	64.5863	0.0000	0.5305	0.5637
	SQ $\rightarrow$ PR	-0.4420	0.0200	-22.1253	0.0000	-0.4811	-0.4028
	SQ $\rightarrow$ PA	2.0471	1.9656	1.0414	0.2977	-1.8057	5.8998
Indirect effect	PR $\rightarrow$ PA	9.1979	0.7019	13.1049	0.0000	7.8222	10.5736
	PR $\rightarrow$ DE	-0.0868	0.0030	-28.5701	0.0000	-0.0928	0.0808
	PA $\rightarrow$ DE	-0.0002	0.0000	-6.4579	0.0000	-0.0003	0.0001
Total effect	SQ $\rightarrow$ DE	0.5858	0.0086	68.4561	0.0000	0.5691	0.6026

The deviation correction percentile Bootstrap method (repeated sampling 5,000 times) was used for inspection. It can be seen from Table 5 that the 95% confidence interval result of the intermediary effect Bootstrap: the confidence interval of sleep quality  $\rightarrow$  PR  $\rightarrow$  depression

(0.0328 0.0443), and the intermediary effect amount is 0.0384 ; confidence interval of sleep quality  $\rightarrow$  PA  $\rightarrow$  depression (-0.0013 0.0004), and intermediary effect amount -0.0004 ; The confidence interval of sleep quality  $\rightarrow$  PR  $\rightarrow$  PA  $\rightarrow$  depression (0.0005 0.0011), the

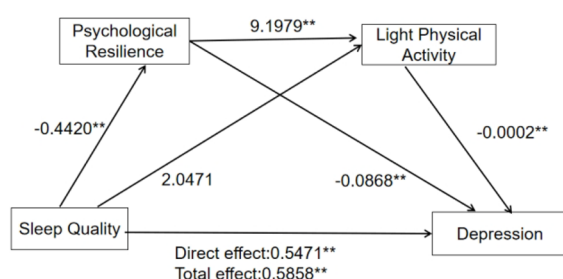
amount of intermediary effect is 0.0008, and the confidence interval does not include 0, indicating that the intermediary effect is significant. The mediating effect of PR

and PA between sleep quality and depression is shown in Figure 1.

**Table 5.** Mediating effect and effect size.

Path	Effect	The proportion of mediations in the total effect	BC 95 % bootstrap CI	
			LL CI	UL CI
SQ→ PR→ DE	0.0384	0.0384/0.5858 =6.56%	0.0328	0.0443
SQ→ PA→ DE	-0.0004	-0.0004/0.5858 =-0.07%	-0.0013	0.0004
SQ→ PR→ PA→DE	0.0008	0.0008 /0.5858 =0.14%	0.0005	0.0011

N = 19184; SQ, sleep quality; PR, psychological resilience; PA, physical activity; DE, depression



**Fig. 1.** Serial-multiple mediation of psychological resilience, and light PA in the relationship between sleep and depression with non-standardized beta values, stand error and *p*-value.

## 5 Discussion

As the first large-scale cross-sectional study (n=19184) to investigate whether PA and PR buffer negative mood predicted by poor sleep in college students, we found that sleep, PR, and PA were all significantly associated with negative mood in college students. We find that the combination of light PA and PR improved depression predicted by poor sleep quality among college students, highlighting the important role of light PA and individual PR in improving negative mood in college students with poor sleep.

This study found that the sleep quality of college students predicts negative emotions such as stress, anxiety, and depression. This result suggests that the poorer the quality of sleep, the worse the mood of college students, which is consistent with the results of existing research. The strong correlation between sleep and mood may be due to its effects on brain mechanisms. Studies have shown that sleep deprivation disrupts brain functions associated with reward and approach, such as excessive arousal, and has been shown to disrupt the function of corticolimbic circuits, including the prefrontal cortex (PFC), amygdala, striatum, and anterior cingulate cortex (ACC) in young adults (18-32 years), impairing emotional responses and regulation [22]. Therefore, there is a positive correlation between the sleep quality and the emotions of college students.

The paper found that PA among college students was significantly and negatively associated with negative mood predicted by sleep quality. This is consistent with existing research that individuals aged 18 years and older who engage in PA report higher levels of PR and positive

mood and lower levels of depression [23]. The physiological mechanisms by which PA improves mood include blunting/optimizing neuroendocrine stress (HPA and SNS) responses [24], reducing inflammation [25] [26] and increasing growth factor expression and neuroplasticity [27]. Therefore, PA can improve physical and mood-related brain function, allowing individuals to better deal with a variety of negative emotions.

Our results also show that PR can improve negative emotions in college students, possibly because brain areas associated with PR and brain areas responsible for emotions have overlapping regions [28]. The brain areas associated with PR which include the distress (fear and stress) network, the reward network, and the default mode network [29], and the hippocampus [30] are involved in emotion management. Therefore, PR can regulate mood. So college students with greater PR are likely to have better mood.

The present study found an interesting result that differs from previous research, which generally concludes that relative increases in cardiorespiratory fitness and habitual PA are dose-dependently associated with greater emotion level and lower depressive symptoms [31]. However, this study reveals that only the combination of light PA and PR improves negative mood, whereas moderate PA combined with PR does not improve negative mood. An explanation for the effectiveness of the combination of the two may be that although there is current evidence of acute positive effects of light PA on cognitive performance, there is no evidence of acute improvement in mood with light PA [32]. These findings suggest that light PA alone is insufficient to regulate negative emotions, which is consistent with our study.

This study has several advantages, including representative sampling, standardized data processing, and consistent and reliable findings. However, some limitations need to be addressed in future research. Firstly, our samples consisted of freshmen from three universities, and the sampling technique used was convenience sampling rather than random sampling. Secondly, the variables in the study were measured using self-assessment scales, which may not capture all aspects of the studied constructs. Thirdly, the assessment of depression was based on self-reporting rather than formal diagnostic tools, which may have led to biases. In future research, objective and systematic evaluation tools such as structured diagnostic interviews can be used to improve the objectivity of depres-

sion assessment, and electronic devices can be worn to objectively measure PA. Finally, the study adopted a cross-sectional design, and future research should use longitudinal design, experimental paradigms, and physiological measurements to study causal relationships.

The mental health of students is a global issue<sup>[33]</sup>. The new social and intellectual challenges faced by college students can often lead to emotional stress, resulting in an increased risk of depression, anxiety, and stress<sup>[34]</sup>. The primary research finding of this article is the first large-scale study to demonstrate that negative emotions, which are associated with poor sleep, can be regulated and improved through a combination of light PA and PR. University administrators are advised to take note of these findings and intervene early by providing appropriate support services.

## 6 Conclusion

The main conclusion of this article is that: light physical activity and psychological resilience can play a chain mediated role between sleep quality and depression.

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