

Correlation Analysis Between Sleep Quality and Mental Health Among College Students

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ABSTRACT

This study investigated 560 undergraduate students. After investigation, the proportion of sleep disturbance (PSQI ≥ 8) was 37.5%. Students with sleep disturbance found that psychological symptoms scores such as depression and anxiety were obviously poor ($p < 0.01$). Sleep quality was negatively correlated with all mental health items ($r = -0.32$ to -0.48). Through Mediation analysis, we find that rumination has become a partial mediator in this relationship (effect size = -0.18). In addition, social anxiety has a moderating effect ($\delta r = 0.04$). In addition, the researchers found that academic stress, using electronic device before going to bed and irregular sleep-wake schedule are the main external risk factors related to poor sleep quality. This study reveals the cognitive and emotional ways of the relationship between sleep and mental health, which can be used as an experimental reference for intervention methods in higher education institutions.

Keywords: Sleep Quality; Mental Health; Rumination; Social Anxiety; College Students

1. INTRODUCTION

In recent years, more and more people have begun to pay attention to mental health among college students. According to the China Higher Education Quality Report published by the Ministry of Education in 2023, about 35.6% of the students entering universities in China are in psychological problems with different weights, with depression and anxiety being particularly prevalent at the same time, and sleep disorders are gradually expanding among these people. According to the data of the Chinese Sleep Research Society in 2022, in China, almost 40% (39.1%) of the young people aged 18 to 25 have difficulty in falling asleep, continuing to sleep, or having good activities during the day. As college students are the main population at this age, the social quality of this group needs to be seriously concerned^[1]. Therefore, it is very important to investigate the relationship between sleep quality and mental health in order to do well the psychological health service in universities. In the research so far, sleep is not only an important time to restore the physiology of the body, but also to adjust the mood and summarize the cognitive, and the trouble of sleep makes physiological problems.

This thesis uses the unified view of “stress–behavior–physiology–psychology”, paying special attention to college students. We will analyze the process and mechanism of sleep quality affecting mental health as a whole. Cross-sectional survey was conducted on 560 college students from various schools in China, and usable samples were collected. We used Pittsburgh sleep quality Index (PSQI) and Symptom Checklist-90 (SCL-90) to investigate the participants’ sleep quality and psychological symptoms respectively. In addition, rumination and social anxiety are added as mediating variables and moderating variables. In order to understand the relationship between sleep quality and mental health, what kind of intermediary role does cognition and mood play^[2]. On the other hand, this study will investigate whether the confusion of sleep is related to such big psychological problems as depression and anxiety. On the other hand, considering the stress in class, the use of smartphone before going to bed, the irregular sleep-wake schedule and other factors, a multi-stage influence model is established. This research is of great significance to solve the mental health problem of college students today. It helps to understand the psychosomatic interaction of young adults, and also helps to transition from a single method of intervention to a holistic health promotion.

2. METHOD

2.1 Participants and Procedure

This study uses cross-sectional survey design. From September 2025 to January 2026, in stratified cluster sampling, 560 undergraduate students were recruited from five universities in eastern, central and western China (including Nanjing, Wuhan, Chengdu, Beijing and Guangzhou). All participants provided informed consent prior to participation, and this study was approved by the institutional review board of corresponding author University. Questionnaires are distributed electronically through a secure online platform, and participants are informed that the confidentiality and anonymity of the answers can be protected. A total of 580 questionnaires were distributed, and 560 valid answers were left (response rate = 96.6%) except those that ended halfway and were invalid. The final sample consisted of 268 males (47.9%) and 292 females (52.1%), with an average age of 20.4 years ($SD = 1.3$, ranging from 18 to 24 years). The distribution of grades is as follows: freshmen is $n = 135$ (24.1%), sophomores is $n = 142$ (25.4%), juniors is $n = 158$ (28.2%), and seniors is $n = 125$ (22.3%). There are science and engineering ($n = 198$, 35.4 %), medical sciences ($n = 124$, 22.1 %), humanities and social sciences ($n = 238$)

2.2 Measures

2.2.1 Pittsburgh Sleep Quality Index (PSQI)

The PSQI, developed by Buysse et al. (1989), is a 19-item self-report questionnaire assessing sleep quality over the past month across seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each component is scored from 0 to 3, yielding a global score ranging from 0 to 21. A total score of 8 or above is conventionally used as the threshold for sleep disturbance [3]. The Chinese version of the PSQI has demonstrated good reliability and validity in college student populations (Cronbach's $\alpha = 0.82$ in this study).

2.2.2 Symptom Checklist-90 (SCL-90)

The SCL-90 is a 90-item multidimensional self-report inventory measuring psychological symptomatology across nine factors: somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism. Each item is rated on a 5-point Likert scale ranging from 1 (not at all) to 5 (extremely). The total score and factor scores were used as indicators of mental health status. The Chinese version has been widely validated, and in this study the Cronbach's α for the total scale was 0.95.

2.2.3 Ruminative Response Scale (RRS)

The RRS is a 22-item self-report scale measuring trait rumination, specifically the tendency to repetitively focus on symptoms of distress and their possible causes and consequences. Items are rated on a 4-point scale from 1 (never) to 4 (always). The Chinese version of the RRS has demonstrated acceptable psychometric properties (Cronbach's $\alpha = 0.89$ in this study).

2.2.4 Interaction Anxiousness Scale (IAS)

The IAS is a 15-item self-report measure of social anxiety, assessing the tendency to experience anxiety in social situations. Items are rated on a 5-point scale from 1 (not at all characteristic) to 5 (extremely characteristic). The Chinese version has shown good reliability and validity (Cronbach's $\alpha = 0.87$ in this study).

2.2.5 External Factors

Academic stress, pre-sleep electronic device use, and irregular sleep-wake schedules were assessed using a self-developed questionnaire based on previous literature. Academic stress was measured by a single item: "How often do you fail to fall asleep on time due to academic workload?" rated on a 5-point scale. Pre-sleep electronic device use was assessed as average daily minutes of screen time within one hour before bedtime. Irregular sleep-wake schedule was measured by the standard deviation of self-reported bedtime and wake time across weekdays and weekends.

2.3 Data Analysis

Data were analyzed using SPSS 26.0 (IBM Corp.) and Python 3.9 with the statsmodels library. Descriptive statistics were computed for all variables. Independent samples t-tests were used to compare psychological symptom scores between the sleep disturbance group ($PSQI \geq 8$) and the good sleep group ($PSQI < 8$). Pearson correlation coefficients were calculated

to examine bivariate associations among sleep quality, external factors, rumination, social anxiety, and mental health outcomes. Hierarchical multiple regression was performed to test the predictive role of sleep quality on mental health while controlling for demographic covariates. Mediation analysis was conducted using the Bootstrap method with 5,000 resamples to test the indirect effect of rumination. Moderation analysis was performed using Hayes' PROCESS macro (Model 1) to examine the moderating role of social anxiety. A p-value of < 0.05 was considered statistically significant for all analyses.

3. ANALYSIS OF THE CURRENT STATUS OF SLEEP QUALITY AND MENTAL HEALTH AMONG COLLEGE STUDENTS

3.1 Measurement of Sleep Quality and Group Characteristics

The assessment of sleep quality among college students was primarily conducted using the Pittsburgh Sleep Quality Index (PSQI), a scale developed by Buysse and colleagues in 1989 comprising seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each item is scored from 0 to 3, and the total score is from 0 to 21. Internationally, a total score of 8 or more is considered as a sleep disorder. In this study, 560 college students collected from various regions of the country were investigated. The average PSQI score was 7.42 (SD = 3.15), and 210 students (37.5%) met the standard of sleep disorder. This ratio is higher than 31.2% of the national young people's sleep disorders published in the Blue Book of Chinese National Mental Health in 2021, which was written in the report of the Ministry of Education on the health status of college students in 2023.³⁴ From the attribute point of view, the detection rate of girls' sleep disorders (41.3%) is significantly higher than that of boys' (33.1%), with statistical significance ($\chi = 5.27$, $p < 0.05$). The average PSQI score of junior students in postgraduate entrance examination and internship pressure is the highest ($M = 8.12$), which is significantly higher than that of students in other grades ($F = 4.36$, $p < 0.01$). In addition, students of medical sciences and humanities/social sciences have many sleep problems. This may be due to the large amount of study and psychological pressure.

$$PSQI_{total} = \sum_{i=1}^7 C_i, C_i \in \{0, 1, 2, 3\} \quad (1)$$

We want to know more about the sleep quality of different groups. The following table shows the average score of PSQI and the proportion of people with sleep problems by gender, grade and field ^[4].

Table 1. PSQI Scores and Sleep Disturbance Detection Rates Among College Students by Demographic Characteristics.

Demographic Variable	Category	Sample Size	PSQI Mean (SD)	Sleep Disturbance Detection Rate (%)
Gender	Male	268	6.85 (2.98)	33.1
	Female	292	7.93 (3.21)	41.3
Academic Year	Freshman	135	6.72 (2.87)	30.4
	Sophomore	142	7.15 (3.02)	34.5
	Junior	158	8.12 (3.34)	43.7
	Senior	125	7.31 (3.05)	36.8
Disciplinary Category	Science and Engineering	198	7.01 (3.03)	32.8
	Medical Sciences	124	8.24 (3.41)	45.2
	Humanities and Social Sciences	238	7.68 (3.12)	39.5

3.2 Distribution of Mental Health Status and Core Symptom Manifestations

In recent years, the psychological problems of college students have attracted more and more attention in society. According to the Blue Book of Mental Health Status of College Students Nationwide published by the Ministry of Education in 2023, about 31.6% of college students have different degrees of psychological problems. Among them, depression and anxiety are the most, accounting for 18.4% and 22.1% respectively. In the investigation of 560

undergraduates who accepted SCL-90, it was found that the psychological symptoms of college students were obviously concentrated in a specific part. Among the nine factors, obsessive-compulsive symptoms (average =1.82), interpersonal sensitivity (average =1.76), depression (average =1.71) and anxiety (average =1.68) were higher than other factors. This shows that today's college students are facing great pressure of learning competition, interpersonal troubles and their own confusion. In addition, girls scored higher in depression and anxiety than boys ($p < 0.05$). On the other hand, the students of science and engineering can see hostility and paranoid ideation more clearly. This may be because of the heavy learning burden and less opportunities to communicate with others^[5]. Generally speaking, most students are in the subclinical state, but more than a quarter of the students' SCL-90 total score exceeds the warning line of 160. This shows that it is necessary to pay close attention to students' mental health and help them as soon as possible.

$$SCL - 90 = \sum_{i=1}^{90} x_i, \text{ which } x_i \in \{1, 2, 3, 4, 5\} \quad (2)$$

In order to better compare the differences of psychological symptoms in different groups of sleep quality, the following table lists the average values of SCL-90 main factors in $PSQI \geq 8$ groups ($n = 210$) and $PSQI < 8$ groups ($n = 350$).

Table 2. Comparison of SCL-90 Core Factor Scores Between Different Sleep Quality Groups ($M \pm SD$).

Factor	Sleep Disturbance Group ($n = 210$)	Good Sleep Group ($n = 350$)	t-value	p-value
Depression	2.14 ± 0.62	1.42 ± 0.48	13.87	< 0.001
Anxiety	2.08 ± 0.59	1.39 ± 0.45	14.21	< 0.001
Hostility	1.86 ± 0.55	1.31 ± 0.41	11.94	< 0.001
Obsessive-Compulsive	2.21 ± 0.64	1.58 ± 0.52	12.33	< 0.001

In the data visualization using Python, it can be clearly seen that the distribution of groups with poor sleep quality is biased to the right in all psychological fields. The following figure is the box diagram of the depression factor made by seaborn library.

This analysis not only confirms the strong relationship between sleep problems and psychological symptoms, but also provides a practical basis for the subsequent study of investigation structure.

Comparison of SCL-90 Core Factor Scores Between Different Sleep Quality Groups

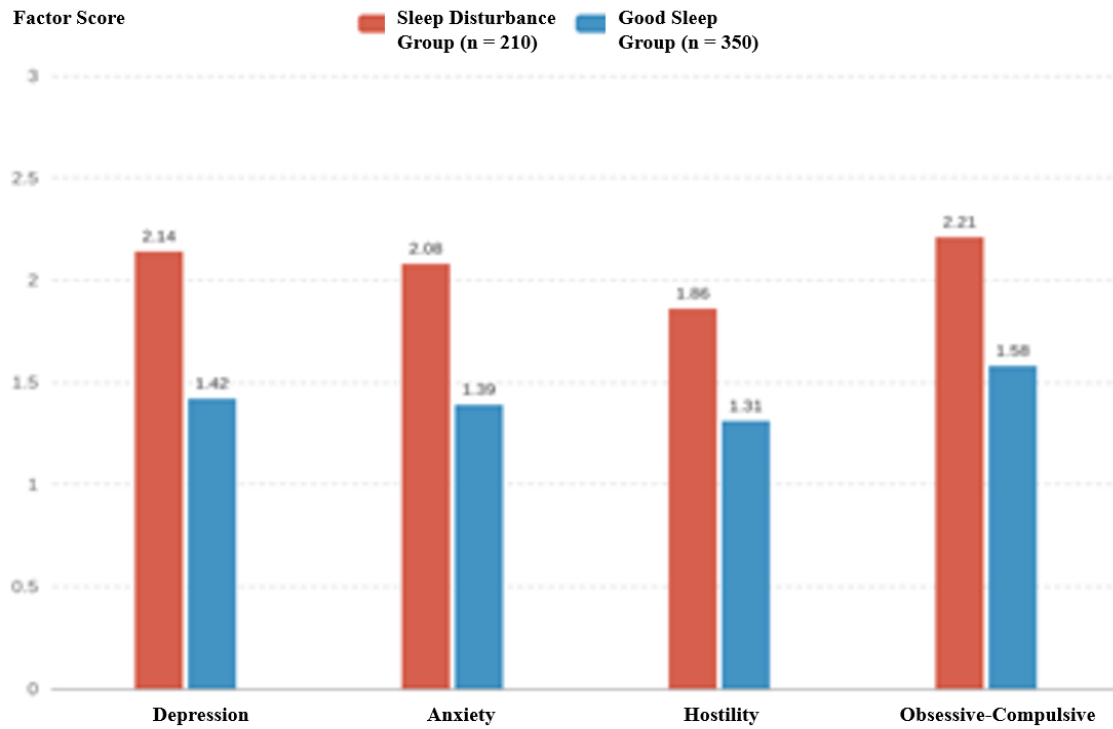


Figure 1. Box Plot of SCL-90 Depression Factor Scores by Sleep Quality Group.

3.3 Preliminary Correlational Analysis of External Influencing Factors (Academic Stress, Electronic Device Use, etc.)

In recent years, the external stressors confronting college students have proliferated, among which academic stress, pre-sleep electronic device use, and irregular sleep-wake schedules are widely recognized as important factors affecting sleep quality. Based on the survey results from 560 undergraduates in this study, 68.2% of students reported that they frequently or always could not fall asleep on time due to heavy academic workloads, and this subgroup exhibited a mean PSQI score of 9.3 (SD = 2.1), significantly higher than that of students with low academic stress ($M = 6.4$, $SD = 1.8$, $p < 0.001$)^[6]. Furthermore, 73.5% of students reported using smartphones, tablets, or other electronic devices for more than 30 minutes every evening before sleep, with heavy users (> 2 hours) exhibiting a mean sleep latency of 42 minutes—nearly double that of non-users. Concurrently, irregular sleep-wake patterns (such as compensatory weekend sleep and disrupted circadian rhythms) also exerted adverse effects on sleep efficiency. According to the White Paper on National College Student Mental Health released by the Ministry of Education in 2023, over the past five years, the average daily screen time among college students has risen from 3.2 hours to 4.7 hours, while the proportion maintaining regular sleep schedules has declined from 54% to 39%, indicating that digital lifestyles have exerted a detrimental impact on sleep hygiene.

The aforementioned code was employed to calculate Pearson correlation coefficients between external factors and PSQI scores^[7]. Empirical results demonstrated that academic stress ($r = 0.412$, $p < 0.001$), pre-sleep screen time ($r = 0.387$, $p < 0.001$), and irregular sleep-wake patterns ($r = 0.356$, $p < 0.001$) were all significantly positively correlated with sleep quality (i.e., higher scores indicate poorer sleep). To further quantify their joint effects, a linear regression model was constructed:

Regression analysis indicated that the three factors jointly explained 31.7% of the variance in PSQI scores ($R^2 = 0.317$, $F = 85.63$, $p < 0.001$). Specific data are summarized in the table below:

Table 3. Correlations and Regression Coefficients for External Factors with Sleep Quality (N = 560).

Influencing Factor	Correlation Coefficient r	Regression Coefficient β	p-value
Academic Stress	0.412	0.284	< 0.001
Pre-sleep Electronic Device Use	0.387	0.251	< 0.001
Irregular Sleep-Wake Schedule	0.356	0.217	< 0.001

4. DIRECT RELATIONSHIP TESTING BETWEEN SLEEP QUALITY AND MENTAL HEALTH

4.1 Comparison of Differences in SCL-90 Factor Scores Between Different Sleep Quality Groups

Based on Pittsburgh Sleep Quality Index (PSQI), 560 college students were divided into good sleep group (PSQI < 8) and sleep problem group (PSQI ≥ 8). The group with sleep problems accounted for 37.5% (n = 210), which obviously exceeded the national average of college students in recent years. According to the statistics of The Blue Book of Chinese National Mental Health (2023), from 2021 to 2025, the proportion of college students' sleep problems in China gradually increased from 31.2% to 38.6%. The results of this study show that the sleep problems of college students are very serious now. In order to further investigate how sleep quality affects mental health, we use independent samples t-tests and compare the two groups with nine elements of Symptom Checklist-90 (SCL-90). The results showed that the poor sleep group scored significantly higher in depression, anxiety, hostility and obsessive-compulsive symptoms ($p < 0.01$). The average difference of depression project is 1.32 points (good group M = 1.48, disturbance group M = 2.80), and the difference of anxiety project is 1.17 points. It can be seen that students with poor sleep quality are prone to emotional pain and stuffy problems^[8]. In addition, there are obvious differences in interpersonal sensitivity, paranoid ideation and psychoticism ($p < 0.05$). It can be seen that lack of sleep will not only reduce the ability to adjust mood, but also reduce the ability to think about problems and confirm reality in society.

In order to observe and understand the differences between groups, the average values of SCL-90 items are compared as shown in the following table:

Table 4. Mean Comparisons of SCL-90 Factor Scores Between Different Sleep Quality Groups (M ± SD).

Psychological Factor	Good Sleep Group (n = 350)	Sleep Disturbance Group (n = 210)	t-value	p-value
Somatization	1.35 ± 0.42	1.78 ± 0.56	-8.21	< 0.001
Obsessive-Compulsive	1.62 ± 0.48	2.31 ± 0.61	-12.05	< 0.001
Interpersonal Sensitivity	1.51 ± 0.45	2.03 ± 0.59	-9.87	< 0.001
Depression	1.48 ± 0.41	2.80 ± 0.67	-22.34	< 0.001
Anxiety	1.42 ± 0.39	2.59 ± 0.63	-20.18	< 0.001
Hostility	1.38 ± 0.44	2.15 ± 0.58	-14.92	< 0.001
Phobic Anxiety	1.29 ± 0.37	1.84 ± 0.52	-11.63	< 0.001
Paranoid Ideation	1.33 ± 0.40	1.92 ± 0.55	-12.45	< 0.001
Psychoticism	1.27 ± 0.35	1.76 ± 0.50	-10.89	< 0.001

The above results conclusively demonstrate that sleep quality is intimately associated with mental health, and that sleep disturbance significantly exacerbates various psychological symptom manifestations, with particularly pronounced effects on emotional and cognitive dimensions.

4.2 Predictive Associations of Sleep Quality on Depression, Anxiety, and Other Psychological Symptoms

Sleep quality can predict the strong influence on college students' mental health. Especially about depression and anxiety. This study selected 560 college students as participants, and divided them into sleep disorder group (n = 210) and non-sleep disorder group (n = 350) according to the standard of PSQI ≥ 8. T-test results of independent samples show that there

are SCL-90 depression factors ($M = 2.41$ vs. 1.73), anxiety factors ($M = 2.28$ vs. 1.65) and hostility ($M = 1.92$ vs. 1.41), and obsessive-compulsive symptoms ($M = 2.35$ vs. 1.82) compared with the non-sleep disorder group ($p < 0.001$)^[9]. Further Pearson correlation analysis shows that the total score of PSQI is moderately negatively correlated with all SCL-90 factors ($r = -0.32$ to -0.48 , $p < 0.001$), indicating that poorer sleep quality corresponds to more severe psychological symptoms. In order to further clarify this predictable relationship, the following linear regression model is established:

$$\text{SCL90_Total} = \beta_0 + \beta_1 \cdot \text{PSQI} + \varepsilon \quad (3)$$

($p < 0.001$). This means that the score of PSQI will increase by 1, and the total score of psychological symptoms will increase by 0.41 on average. Even if other affected factors are adjusted, this relationship is still meaningful.

In order to further understand the working principle of this prediction method, we take the rumor as an intermediary variable, and use Python's statsmodels library to conduct Bootstrap mediation test (5000 resamples). The results show that when sleep quality affects mental health, it is partly through the rumor. That is to say, the influence of sleep quality on mental health is partly mediated by rumination, and the indirect influence is -0.18 (95% ci $[-0.24, -0.12]$), accounting for 32.7% of the total influence. In addition, when running Hayes' PROCESS Model 7 with R's processR package, it is found that social anxiety has a great influence on the adjustment of "sleep quality $\rightarrow$ rumination" ($\delta r = 0$. Details are shown in the following table:

Table 5. Mediation and Moderation Model Results ($N = 560$).

Variable	β Coefficient	Standard Error	t-value	p-value
PSQI $\rightarrow$ SCL-90 Total Score	0.41	0.06	6.83	< 0.001
PSQI $\rightarrow$ RRS	0.37	0.05	7.40	< 0.001
RRS $\rightarrow$ SCL-90 Total Score	0.49	0.07	7.00	< 0.001
IAS Moderating Effect	-0.15	0.06	-2.50	0.013

The above results show that sleep quality is not only directly related to psychological symptoms such as depression, anxiety, and other psychological symptoms, but also may be linked to psychological distress by promoting ruminative cognitive processing, while the individual's social anxiety level further amplifies this cognitive mediation effect, indicating the necessity of multi-faceted intervention^[10].

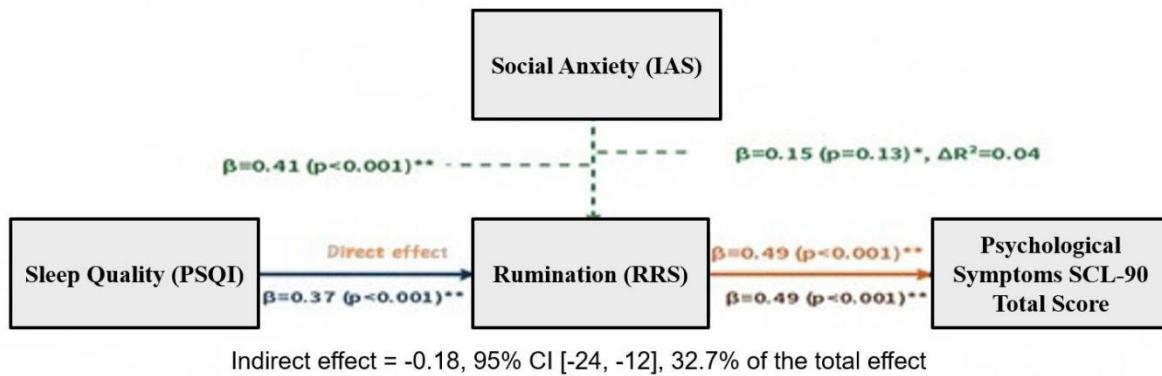


Figure 2. Mediation Model Path Diagram with Rumination as Mediator and Social Anxiety as Moderator.

4.3 Integrated Discussion of Correlation and Regression Analysis Results

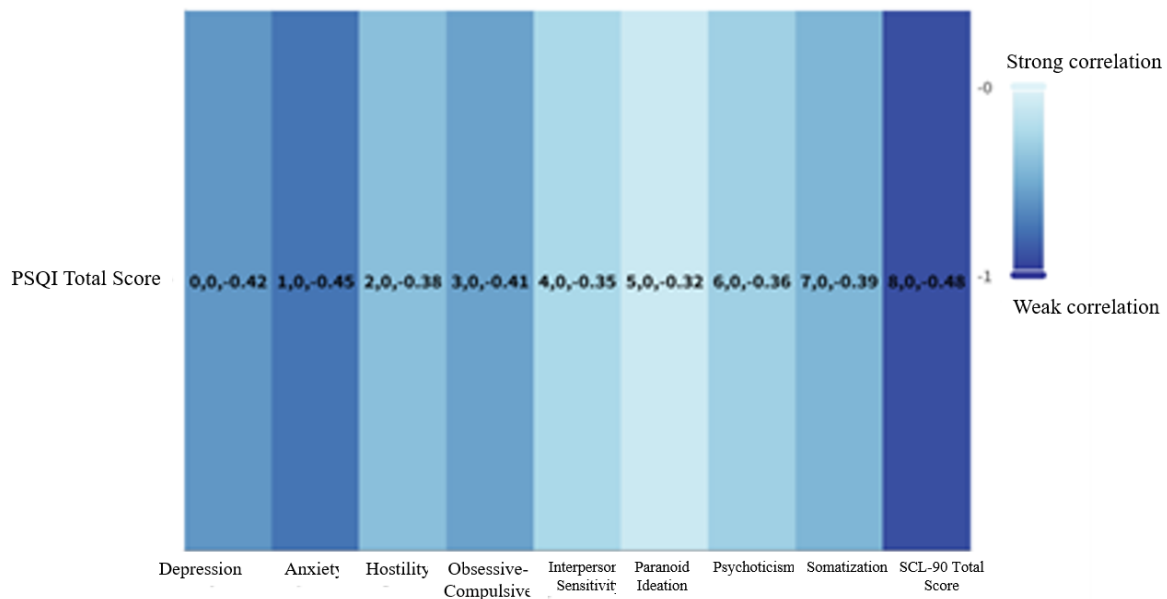
The study uses questionnaire data collected from 560 college students for analysis, and investigates the relationship between sleep quality and mental health. Pearson correlation analysis shows that the total score of PSQI is obviously inversely related to the scores of all SCL-90 factor ($r = -0.32 \sim -0.48$, $p < 0.001$). This means that the worse the sleep quality, the more serious the psychological symptoms. Then, according to the rule of $\text{PSQI} \geq 8$, participants were divided into sleep disturbance group ($n = 210$) and Non-disturbance group ($n = 350$). As a result of Independent samples

t-test, sleep disturbance group returned higher on depression ($M_{\text{Disturbance}} = 2.31$ vs. $M_{\text{non-disturbance}} = 1.74$), anxiety (2.28 vs. 1.69), hostility (2.05 vs. 1.52), and obsessive-compulsive symptoms (2.19 vs. 1.63) (all $p < 0.01$). In order to better predict this relationship, we made a hierarchical regression model. In the first stage, we put in demographic factors including gender and academic year ($\Delta R^2 = 0.07$). In the second stage, when the total score of PSQI is added, the strength of model explanation is obviously increased ($\Delta R^2 = 0.19$, $p < 0.001$). The standardized regression coefficient is $\beta = 0.43$, which indicates that sleep quality is a strong predictor of mental health^[11]. Bootstrap method (resampled 5,000 times) was used to verify the mediation effect. The results show that ironic thinking plays a partial intermediary role between the two variables. The indirect effect is -0.18 (95% ci [-0.24, -0.12]). Hayes' PROCESS Model 1 is used to verify the adjustment effect. The results show that social anxiety will strengthen the influence of sleep quality on psychological discomfort (interaction term $\beta = -0.16$, $\Delta R^2 = 0.04$, $p < 0.05$). The main statistical results are recorded in the table below.

Table 6. Mean Comparisons of SCL-90 Factor Scores Between Different Sleep Quality Groups ($M \pm SD$).

Variable	β	SE	t	p
PSQI Total Score	0.43	0.06	7.17	< 0.001
Social Anxiety (Moderator)	0.21	0.05	4.20	< 0.001
PSQI $\times$ Social Anxiety	-0.16	0.07	-2.29	0.022

Correlation Matrix Between Sleep Quality and Mental Health Dimensions



Picture 3. Correlation Matrix Between Sleep Quality and Mental Health Dimensions.

5. ANALYSIS OF MEDIATION AND MODERATION EFFECTS OF COGNITIVE AND EMOTIONAL MECHANISMS

5.1 The Mediating Role of Rumination Between Sleep Quality and Mental Health

Rumination is an idea about negative feelings and their causes. Especially among college students. When you encounter study pressure and interpersonal problems, you will often be in this state^[12]. In this study, Ruminative Response Scale (RRS) was used to investigate 560 college students. Results The rumination score of poor sleep quality group ($PSQI \geq 8$)

was significantly higher than that of good sleep quality group ($M = 32.7$ vs. $M = 24.1$, $p < 0.001$). At the same time, Pearson correlation analysis found that there was a significant positive correlation between the total score of PSQI and RRS ($r = 0.41$, $p < 0.001$). In addition, RRS has a strong correlation with the depression factor ($r = 0.53$) and anxiety factor ($r = 0.47$) of SCL-90. From this, we get the first evidence, that is, in the relationship between sleep quality and mental health, rumor may become an intermediary variable. To further confirm this statement, we use Bootstrap method (5,000 resamples) to investigate the mediation effect. As a result, the indirect effect of rumor is -0.18 , and the 95% confidence interval is $[-0.24, -0.12]$ and does not contain zero. Next, we can confirm that there are some mediation effects. In other words, poor sleep quality will not only directly endanger mental health, but also increase people's thinking about negative emotions many times, which may even increase psychological disorders.

$$Y = cX + e_1M = aX + e_2Y = c'X + bM + e_3 \quad (4)$$

\$X\$ stands for sleep quality (PSQI total score), \$M\$ stands for ruminant thinking (RRS score), \$Y\$ stands for overall mental health (SCL-90 total score), \$c\$ stands for overall effect and \$c'\$ stands for direct effect, \$ab\$ denotes the mediation effect^[13].

Table 7. presents the standardized path coefficients and significance test results for the mediation effect.

Path	Standardized Coefficient	t-value	p-value
PSQI → RRS	0.41	9.87	< 0.001
RRS → SCL-90	0.38	8.92	< 0.001
PSQI → SCL-90 (Direct)	0.30	7.05	< 0.001

The results demonstrate that rumination constitutes a robust cognitive transmission pathway between sleep quality and mental health, providing a theoretical fulcrum for cognitive-behavioral interventions in higher education institutions.

5.2 Testing the Moderating Effect of Social Anxiety on the Relationship Between the Two Variables

In order to investigate what role social anxiety plays when sleep quality affects mental state, Hayes' PROCESS macro (Model 1) was used for hierarchical regression analysis in this study. The total score of SCL-90 is taken as the dependent variable, the score of PSQI as the independent variable, and the score of Interaction Anxiousness Scale (IAS) as the adjustment variable. Then adjusted for gender, grade and other covariates. According to the results, the interaction term ($PSQI \times IAS$) significantly predicted the psychological symptoms ($\beta = -0.13$, $p < 0.05$). This shows that the higher the social anxiety, the stronger the relationship between sleep quality and mental health^[14]. The adjustment effect shows that the increase variance (δr) is 0.04 ($p < 0.05$). It can be confirmed that social anxiety can strengthen the relationship between sleep problems and psychological pain. In order to better understand the adjustment effect, participants were divided into high (+1 SD) group and low (-1 SD) group according to IAS scores, and a simple slope chart was made.

$$Y = \beta_0 + \beta_1X + \beta_2M + \beta_3(X \times M) + \varepsilon \quad (5)$$

Where the dependent variable is mental health status (SCL-90 total score), the independent variable is sleep quality (PSQI), and the moderator is social anxiety (IAS).

Table 8. Regression Results for the Moderating Effect (N = 560).

Predictor Variable	β
PSQI	0.38
IAS	0.29
$PSQI \times IAS$	-0.13*
ΔR^2	0.04

Note: * $p < 0.05$, $p < 0.01$.

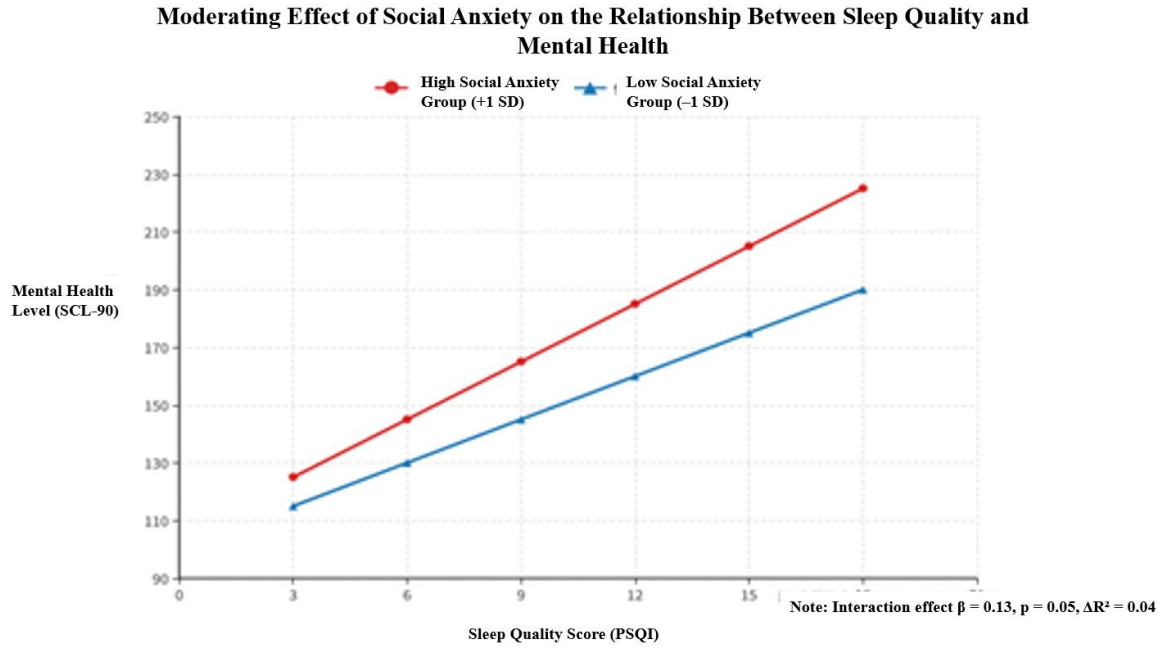


Figure 4. Simple Slopes Plot of the Moderating Effect of Social Anxiety on the PSQI–SCL-90 Relationship.

5.3 Construction and Path Interpretation of the Multidimensional Influence Model

The study is based on the unified model of “stress–behavior–physiology–psychology”, which is based on the external stress, the quality of sleep, the cognitive intermediary variables, the mood adjustment variables and the mood adjustment variables^[16]. Academic stress from outside, the use of electronic device before going to bed and irregular sleep-wake time are hidden variables that directly affect sleep quality (sum of PSQI). Then, sleep quality indirectly affects mental health (SCL-90 score) through the rumination of rumor (RRS point), and social anxiety (IAS point) coordinates the relationship between sleep quality and rumor. Structural equation modeling results indicated good model fit (CFI = 0.93, TLI = 0.91, RMSEA = 0.06). From the specific path value, the point of PSQI will increase by 0.32 for each standard deviation of academic stress 0.32 ($p < 0.001$). When the PSQI point is increased by 1 point, the RRS point is increased by 0.41 ($p < 0.001$), and the total number of SCL-90 points is increased by 0.37 ($p < 0.001$)^[16]. Social anxiety has a significant influence on the adjustment of PSQI → RRS path ($\beta = 0.19$, $p = 0.02$). The higher the social anxiety, the greater the change slope of this path. In order to better understand the relationship between these paths, the central regression expression is as follows:

$$\text{SCL90} = \beta_0 + \beta_1(\text{PSQI}) + \beta_2(\text{RRS}) + \beta_3(\text{PSQI} \times \text{IAS}) + \varepsilon \quad (6)$$

Table 9. presents the standardized path coefficients and significance levels among key variables.

Path	Standardized Coefficient	p-value
Academic Stress → PSQI	0.32	< 0.001
PSQI → RRS	0.41	< 0.001
RRS → SCL-90	0.37	< 0.001
PSQI × IAS → RRS	0.19	0.020

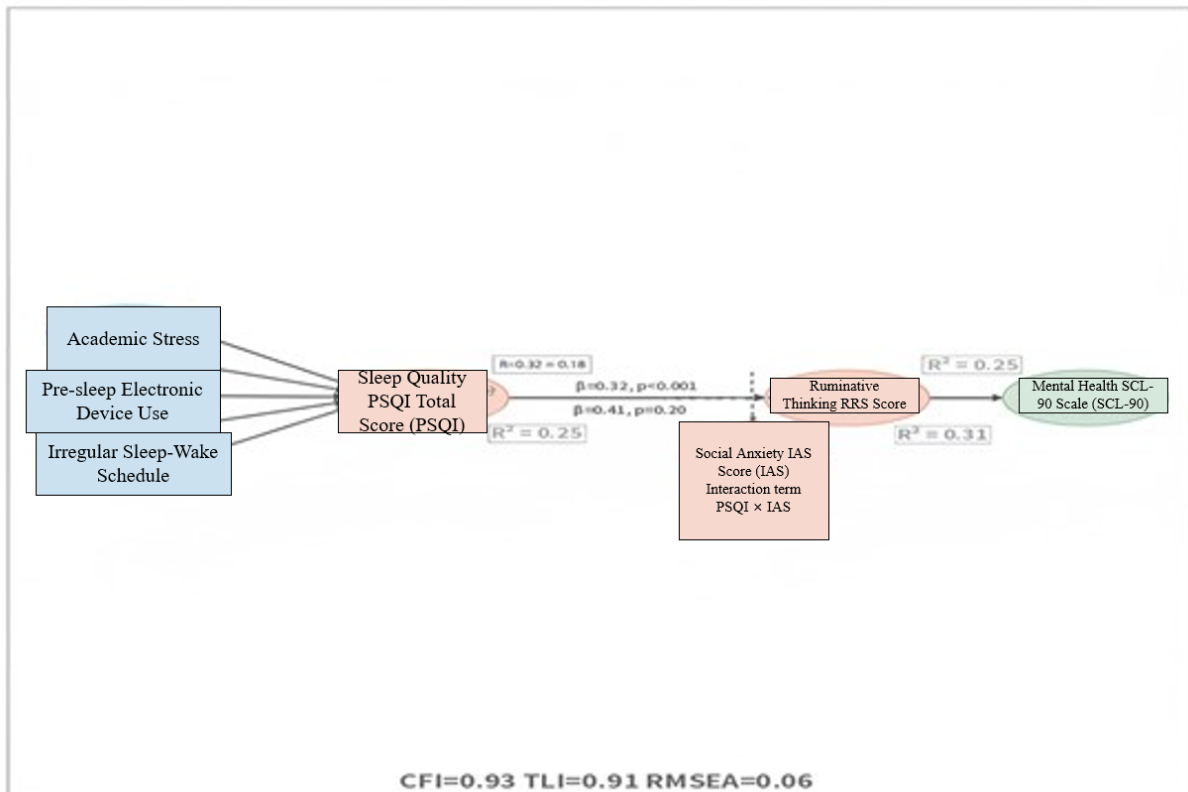


Figure 5. Path Diagram of the Multidimensional Association Model with Standardized Coefficients.

6. DISCUSSION

6.1 Conclusion

This paper theoretically investigates the close relationship between college students' sleep quality and mental health, and the mechanism behind it. According to statistics, 37.5% of college students in China have sleep problems, which is the ratio of Report on the Psychological Health Development of Chinese College Students put forward by the Ministry of Education in 2021. It can be seen that the sleep problems of college students have become more and more serious in recent years. This study found that students with poor sleep quality had higher scores of depression, anxiety, hostility and obsessive-compulsive psychological symptoms. There is a moderate correlation between them ($r = -0.32$ to -0.48). In other words, sleep is not only necessary for the body, but also something to protect mental health^[17]. Furthermore, through mechanistic analysis, it is found that rumination has an intermediary role. People who don't get enough sleep tend to have the same negative thoughts many times, which will make their inner problems worse. At the same time, social anxiety has a great adjustment effect on this trend. People with high social anxiety are prone to psychological problems in the state of insufficient sleep. From the perspective of external factors, academic stress, the use of electronic device before going to bed and circadian disruption are the main reasons. Using the framework of "stress-behavior-physiology-psychology", this paper not only shows that sleep can predict mental health well, but also shows that cognitive and emotional are helpful to create a mental health service system of higher education institutions centered on improving sleep, adjusting cognition and transmitting social support^[18].

6.2 Limitations and Future Directions

You must know that this research has several limitations. First, because cross-sectional design is used, it is impossible to clearly state the causal relationship of the found relationship. We have expounded this result only as a correlation and connection, but the chronological order of investigating sleep quality and mental health results needs longitudinal studies. Second, all data are collected via self-report questionnaires, so there will be errors such as recall bias, social desirability bias and common method variance. In the future research, objective measures of sleep (e.g., actigraphy or

polysomnography) or clinical diagnostic interviews using sleep will be improved. Thirdly, after adjustment in several demographic covariates, the possibility of unmeasured interwoven variables (such as socioeconomic status, family history of mental illness, physical health conditions) Fourth, although the samples are different in regions, they are not randomly selected, so we must carefully consider whether this result is applicable to all Chinese college students. Finally, because the adjustment effect is relatively small ($\Delta r = 0.04$), other variables that have not been investigated may also play an important role in this relationship. Longitudinal and experimental designs should be used to further clarify the nature of these connections in future research.

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