

Impact of Sleep Quality on the Quality of Life of Medical Students: A Study on the Mediating Role of Depression

Bin Wang^{1,2,†}, Yuehan Zhu^{1,2,†}, Dawei Liu^{1,2}, Leyi Xie^{1,2}, Jia Liu^{1,2}, Yuting Wei^{1,2}, Yuan Yang^{1,2}, Jiansheng Cai^{1,2}, Liang Cao^{1,3}, You Li^{1,2,a,*}

¹Department of Environmental Health and Occupational Medicine, School of Public Health, Guilin Medical University, Guilin, 541199, China

²Guangxi Health Commission Key Laboratory of Entire Lifecycle Health and Care, Guilin Medical University, Guilin, 541199, China

³Department of Experimental Teaching Center, School of Public Health, Guilin Medical University, Guilin, 541199, China

^aliyoun121300@163.com

[†]These authors contributed equally to this work

* Corresponding author

Abstract: To examine the relationships among sleep quality, depression, and quality of life (physical and mental health) in medical students, and to explore the mediating role of depression, a cross-sectional survey of 857 medical students was conducted using the SF-36, PSQI, and CES-D. Correlation and mediation analyses (PROCESS v4.1) were performed. Sleep quality was negatively correlated with physical health ($r = -0.233$) and mental health ($r = -0.432$); depression was negatively correlated with physical health ($r = -0.134$) and mental health ($r = -0.554$); sleep quality was positively correlated with depression ($r = 0.485$) ($P < 0.01$). Depression partially mediated the relationship between sleep quality and mental health ($B = -0.656$, 95% CI: -0.778 to -0.538), with an indirect effect accounting for 51.5% of the total effect. Good sleep quality benefits both physical and mental health. Depression partially mediated the effect of sleep quality on mental health.

Keywords: Medical students, Quality of life, Sleep quality, Depression, Mediation analysis

1. Introduction

College students are a special group of individuals who are in a critical transition period from adolescence to adulthood, which can be among the most stressful periods in life, and their physical and mental health issues are of increasing concern on college campuses.[1] As an important group of college students, medical students face not only the double pressure of theoretical knowledge and professional skills but also fierce job competition; after employment, they encounter the pressure of complex social environments, such as doctor-patient conflicts. These problems increase the likelihood of medical students suffering from mental health impairments, such as insomnia, anxiety and depression.[2] These negative effects affect medical students' academic performance, interpersonal relationships, quality of life and other aspects, thus potentially compromising the quality of healthcare they will provide in the future.

The quality of life of medical students refers to the advantages, disadvantages, and subjective experiences of medical students in different social backgrounds and environments, such as learning, living, and promoting their comprehensive development. A survey on the quality of life of medical students revealed that the mental health score for the quality of life of medical students was low and that psychological problems were more prominent.[3] The results revealed that the quality of life score of medical students was lower than that of nonmedical students and that psychological stress was a negative predictor of quality of life.[4] Personal factors, family life, mobile phone use time, sleep duration, physical activity level, anxiety, social support and depression are the main influencing factors of medical students' quality of life.[5–7] Sleep quality also has a certain effect on depression and anxiety, and poor sleep quality is an important risk factor for depression and anxiety.[8]

Despite substantial evidence linking sleep quality and depression to quality of life among medical

students, most existing studies have examined these associations in a pairwise manner, i.e., sleep quality and quality of life, or depression and quality of life-without clarifying whether and how these three constructs interact. In particular, the potential mediating role of depression in the relationship between sleep quality and quality of life remains largely unexplored in this population.

From a theoretical perspective, poor sleep quality is known to impair emotion regulation, increase negative affect, and reduce psychological resilience, all of which may lead to or exacerbate depressive symptoms. A recent systematic review and meta-analysis of over 50 years of experimental research found that sleep loss-including total sleep deprivation, partial sleep restriction, and sleep fragmentation-significantly reduces positive affect, increases anxiety symptoms, and blunts arousal in response to emotional stimuli, thereby compromising an individual's capacity to regulate emotions.[9] Moreover, among medical students specifically, psychological resilience and adaptive cognitive emotion regulation strategies have been shown to partially mediate the impact of life events on sleep quality, suggesting that similar pathways may operate in the sleep-depression-quality of life relationship.[10]

Depression, in turn, is characterized by loss of interest, fatigue, social withdrawal, and diminished perceived well-being, which directly lowers both mental and physical dimensions of quality of life. Therefore, it is plausible that depression acts as a mediator linking sleep disturbances to poorer quality of life, especially for the mental health component.

However, few studies have quantitatively tested this mediation pathway in medical students-a group facing high academic stress, irregular schedules, and elevated risks of both sleep problems and depression. Moreover, it remains unclear whether the mediating role of depression differs between the physical and mental components of quality of life, as sleep may affect physical health directly through biological mechanisms (e.g., inflammation, metabolic changes) rather than solely through psychological pathways.

To address these gaps, this study aimed to: 1) describe the current status of sleep quality, depression, and quality of life among medical students; 2) identify factors influencing their physical and mental quality of life; 3) examine the mediating effect of depression on the relationship between sleep quality and quality of life, separately for the physical and mental health components. We hypothesized that depression would partially mediate the relationship between sleep quality and quality of life, with a stronger mediation effect for mental health than for physical health.

2. Materials and methods

2.1 Participants

In this study, a multistage sampling method was used for investigation and research, and medical students from colleges and universities in Guangxi were selected as research objects. The inclusion criterion was currently studying medical students who voluntarily participated in this study. The exclusion criteria were: 1) recent major life events (e.g., death of a family member, serious personal illness) within the past three months; 2) unwillingness to participate; 3) presence of congenital diseases, cardiovascular diseases, inflammatory joint diseases, or musculoskeletal diseases as identified by physical examination or medical records. No participants were excluded based on sleep or mental health status, as these conditions are naturally distributed in the target population and are central to the research questions. Finally, 857 people were selected as the study subjects. Before the investigation, all of the investigators received relevant training and had the ability to perform onsite investigations. During the investigation, the purpose and content of the study were clarified to the research subjects via unified terminology. All questionnaires were completed at one time in the prescribed time frame. The questionnaires were checked and entered by two people at the same time. Before the survey, all of the subjects signed an informed consent form and voluntarily agreed to participate in the questionnaire. The study was conducted with the approval of the Ethics Committee of Guilin Medical University (GYLL2022091).

2.2 Data collection

2.2.1 Exposure

To assess sleep quality, we used the Pittsburgh Sleep Quality Index (PSQI) scale.[11] The scale contains 19 questions of 9 items, covering 7 factors, including sleep quality, sleep onset time, sleep efficiency, sleep duration, sleep disorders, hypnotic drugs and daytime dysfunction. Among these, the 19th self-rated item and 5 other-rated items were not included in the scoring. Each component was scored

on a scale from 0 to 3. The sum of the scores of each factor was the total score of the scale. The total score ranged from 0 to 21, where higher scores indicated worse sleep quality.

2.2.2 Outcomes

To assess quality of life, we used the SF-36 scale.[12] The scale includes 8 dimensions, namely, physical functioning (PF), role emotional (RE), role physical (RP), bodily pain (BP), vitality (VT), social functioning (SF), mental health (MH) and general health (GH), with a total of 36 items. Each item had 3 to 6 answers to different degrees. The total score of each dimension ranges from 0 to 100, with higher scores indicating better health status in the corresponding dimension. The physical component summary (PCS) and mental component summary (MCS) were calculated by weighting each dimension.

2.2.3 Mediating variable

The Center for Epidemiologic Studies Depression Scale (CES-D)[13] was used to investigate depression status. The scale consists of 20 items, including 16 items concerning negative affect and 4 concerning positive affect. Each item was scored from 0 to 3 points, and the sum of all item scores was the total score of depression (range 0 to 60). A total score of ≤ 15 was defined as no depression, 16-19 as possible depression, and ≥ 20 as definite depressive symptoms.

2.2.4 Covariates

A custom-made personal information questionnaire was used to collect data, which included sociodemographic information such as age, sex, and family status and personal academic information such as grade, major, and academic performance. Family status included annual household income, education level and occupation type of parents.

2.3 Statistical analysis

SPSS 28.0 was used for data analysis. For the missing data, we used the interpolation method. For quantitative data, after normality testing, the median and interquartile range were used for description, whereas for qualitative data, relative numbers and percentages were used for description. A rank-sum test was performed to compare PCS and MCS scores across different participant characteristics. Pearson correlation analysis was used for associations between quality of life and sleep quality, and Spearman correlation analysis for associations involving depression (which was not normally distributed). Multiple linear regression was used to identify factors independently associated with PCS and MCS scores, treating both outcomes as continuous variables to maintain consistency with the mediation analysis. Multicollinearity was assessed using variance inflation factor (VIF), with a threshold of <5 . Covariates were selected based on univariate associations ($P < 0.2$) and theoretical considerations. Mediation analysis was performed using the PROCESS macro (v4.1) for SPSS with 5,000 bootstrap resamples to generate 95% confidence intervals for indirect effects.

3. Results

3.1 General information

Of the 857 respondents, 631 (73.6%) were female, 316 (36.9%) were freshmen, 265 (30.9%) were sophomores, and 276 (32.2%) were juniors or above. The majority of the participants were in clinical medicine (354, 41.3%) or nursing (219, 25.6%), with other specialties accounting for a smaller proportion. There were 641 (71.8%) people with rural household registration. The annual family income was less than 11,400 yuan for 114 (13.3%) participants, 10,000-30,000 yuan for 209 (24.4%) participants, 30,000-50,000 yuan for 226 (26.4%) participants, 50,000-100,000 yuan for 170 (19.8%) participants, and only 138 (16.1%) participants had an annual family income greater than 100,000 yuan. The academic performance of 37 (4.32%) students was poor, accounting for a relatively small proportion.

Among all the participants, 462 (53.9%) had no depression, 109 (12.7%) were possibly depressed, and 286 (33.4%) were depressed. The median score for sleep quality was 7 (5, 9). After the scores of each dimension were weighted, the median total score of the PCS was 53.32 (48.53, 56.53), and the median total score of the MCS was 41.72 (34.55, 49.17).

3.2 Univariate analysis of factors influencing the quality of life of medical students

Table 1 presents the baseline situation and the results of the rank sum test under different

characteristics. The results revealed statistically significant differences in the PCS scores of medical students in relation to different family annual income conditions, academic performance, and depression statuses ($P < 0.05$); there were also statistically significant differences in the MCS scores of medical students based on sex, grade, academic performance, and depression status ($P < 0.05$).

Table 1 A comparison of the quality of life among medical students with different characteristics

Variables	Number($n=857$)	PCS $M(P25,P75)$	MCS $M(P25,P75)$
Sex			
Male	226	53.45(49.00,56.32)	43.96(37.52,50.30)
Female	631	53.26(48.41,56.56)	41.15(33.69,48.81)
Z		0.017	3.37
P values		0.987	<0.001
Grade			
Freshmen	316	53.61(49.40,57.14)	42.92(36.08,50.34)
Sophomores	265	53.31(48.38,56.31)	41.36(34.55,48.54)
Juniors and above	276	52.77(48.35,56.46)	40.73(33.33,48.21)
H		3.261	6.06
P values		0.19	0.04
Household registration			
Rural	641	53.44(48.97,56.58)	41.64(34.22,49.21)
Urban	216	53.13(47.80,56.45)	42.07(35.49,49.01)
Z		1.172	-.761
P values		0.24	0.44
Major			
Clinical medicine	354	53.16(48.35,56.67)	40.58(33.26,48.06)
Preventive medicine	82	52.38(45.73,56.37)	41.97(32.08,48.48)
Nursing	219	54.01(49.77,56.70)	42.56(35.97,49.62)
Pharmacy	80	53.86(48.26,56.25)	44.34(33.83,50.48)
Other medical-related	77	53.38(50.27,56.50)	43.29(37.50,49.78)
Non-medical	45	50.07(45.42,55.41)	44.59(37.47,50.55)
H		9.733	8.766
P values		0.08	0.12
Annual family income			
<10,000	114	51.24(46.52,55.59)	40.56(34.29,48.43)
10,000-	209	53.27(48.71,56.67)	41.77(34.26,49.35)
30,000-	226	54.37(49.61,57.35)	41.98(34.07,49.98)
50,000-	170	53.19(49.17,56.16)	42.03(35.45,47.75)
100,000-	138	53.31(48.34,56.17)	42.75(34.47,50.29)
H		12.97	2.641
P values		0.01	0.62
Academic performance			

Poor	37	46.27(39.55,52.36)	34.60(23.15,41.03)
Satisfactory	594	53.27(48.67,56.47)	41.70(34.16,48.88)
Good	177	54.03(50.14,56.82)	43.26(36.14,50.18)
Excellent	49	53.91(48.23,57.90)	44.66(38.63,52.83)
<i>H</i>		22.211	25.32
<i>P</i> values		<0.001	<0.001
Depression			
No	462	53.90(50.17,56.53)	47.54(40.50,52.31)
Possibly	109	53.38(48.25,58.02)	38.94(34.61,44.69)
Yes	286	51.09(46.04,56.00)	34.55(28.65,40.69)
<i>H</i>		5.282	26.467
<i>P</i> values		0.02	<0.001
Sleep quality			
Good	256	54.04(50.12,56.88)	47.85(40.16,52.44)
Poor	601	53.02(47.90,56.50)	40.10(32.87,46.56)
<i>Z</i>		2.354	9.224
<i>P</i> values		0.02	<0.001

PCS: physical component summary; MCS: mental component summary.

Table 2 presents the results of the correlation analysis for quality of life, sleep quality, and depression. Specifically, Pearson correlation analysis was conducted for quality of life and sleep quality, whereas Spearman correlation analysis was performed for depression and both quality of life and sleep quality. The results revealed that sleep quality score was negatively correlated with physical health ($r = -0.233$, $P < 0.01$) and mental health ($r = -0.432$, $P < 0.01$), that depression was negatively correlated with physical health ($r = -0.134$, $P < .01$) and mental health ($r = -0.554$, $P < 0.01$), and that the sleep quality score was positively correlated with depression ($r = 0.485$, $P < 0.01$).

Table 2 Correlation analysis of PCS, MCS with sleep quality and depression

Variables	PCS	MCS	Sleep quality score	Depression
PCS	1	-	-	-
MCS	-0.122**	1	-	-
Sleep quality score	-0.233**	-0.432**	1	-
Depression	-0.134**	-0.554**	0.485**	1

** $P < 0.01$; PCS: physical component summary; MCS: mental component summary.

3.3 Linear regression analysis

A multiple linear regression model was built to estimate the possible impact of each variable on the quality of life of medical students. The results for PCS are shown in Table 3. After adjusting for sex, grade, major, annual family income, academic performance, depression, and sleep quality, higher family income was significantly associated with higher PCS scores. Compared with students from families with an annual income below 10,000 yuan, those with an income of 30,000-50,000 yuan had a significantly higher PCS score ($B = 2.690$, 95% CI: 1.282-4.099, $P < 0.001$). Academic performance was a strong positive predictor: students with satisfactory ($B = 5.541$, 95% CI: 3.446-7.636, $P < 0.001$), good ($B = 6.331$, 95% CI: 4.075-8.587, $P < 0.001$), or excellent ($B = 5.040$, 95% CI: 2.334-7.746, $P < 0.001$) performance had substantially higher PCS scores than those with poor performance. Non-medical majors had lower PCS scores than clinical medicine students ($B = -3.038$, 95% CI: -5.029 to -1.047, $P = 0.003$). Sleep quality score was negatively associated with PCS: each one-point increase in PSQI score (worse sleep) was associated with a 0.396-point decrease in PCS (95% CI: -0.547 to -0.245, $P < 0.001$).

Table 3 Linear regression analysis of factors associated with PCS

Variable	B(95% CI)	P
Sex		
Male	<i>Ref</i>	
Female	-0.044 (-1.024, 0.937)	0.930
Grade		
Freshmen	<i>Ref</i>	
Sophomores	-0.756 (-1.843, 0.331)	0.173
Juniors and above	-0.865 (-1.927, 0.197)	0.110
Major		
Clinical medicine	<i>Ref</i>	
Preventive medicine	-1.034 (-2.544, 0.476)	0.179
Nursing	0.354 (-0.849, 1.558)	0.564
Pharmacy	-1.339 (-2.873, 0.196)	0.087
Other medical-related	-0.347 (-1.945, 1.251)	0.670
Non-medical	-3.038 (-5.029, -1.047)	0.003
Annual family income		
<10,000	<i>Ref</i>	
10,000-	1.184 (-0.247, 2.614)	0.105
30,000-	2.690 (1.282, 4.099)	<0.001
50,000-	1.287 (-0.195, 2.770)	0.089
100,000-	1.336 (-0.222, 2.893)	0.093
Academic performance		
Poor	<i>Ref</i>	
Satisfactory	5.541 (3.446, 7.636)	<0.001
Good	6.331 (4.075, 8.587)	<0.001
Excellent	5.040 (2.334, 7.746)	<0.001
Depression		
No	<i>Ref</i>	
Possibly	0.575 (-0.745, 1.894)	0.393
Yes	-0.032 (-1.089, 1.024)	0.952
Sleep quality score	-0.396 (-0.547, -0.245)	<0.001
<i>Constant</i>	49.236 (46.596, 51.877)	<0.001

PCS: physical component summary.

The results for MCS are presented in Table 4. Female was associated with lower MCS scores compared with males (B = -2.461, 95% CI: -3.695 to -1.228, P < 0.001). Depression showed a strong negative gradient: compared with students without depression, those with possible depression had a 5.314-point lower MCS (95% CI: -6.978 to -3.650, P < 0.001), and those with definite depression had a 9.520-point lower MCS (95% CI: -10.850 to -8.189, P < 0.001). Better academic performance was also associated with higher MCS scores (satisfactory: B = 3.688, 95% CI: 1.049-6.327, P = 0.006; good: B = 4.323, 95% CI: 1.485-7.162, P = 0.003; excellent: B = 6.521, 95% CI: 3.112-9.929, P < 0.001). Sleep quality score was negatively associated with MCS (B = -0.562, 95% CI: -0.752 to -0.371, P < 0.001). Among majors, nursing (B = 1.868, 95% CI: 0.359-3.376, P = 0.015) and pharmacy (B = 1.979, 95% CI:

0.047-3.910, $P = 0.045$) had significantly higher MCS scores than clinical medicine students. Grade and other major categories were not significant.

Table 4 Linear regression analysis of factors associated with MCS

Variable	B(95% CI)	P
Sex		
Male	<i>Ref</i>	
Female	-2.461 (-3.695, -1.228)	<0.001
Grade		
Freshmen	<i>Ref</i>	
Sophomores	-0.210 (-1.577, 1.158)	0.764
Juniors and above	0.005 (-1.335, 1.345)	0.994
Major		
Clinical medicine	<i>Ref</i>	
Preventive medicine	0.898 (-1.010, 2.806)	0.356
Nursing	1.868 (0.359, 3.376)	0.015
Pharmacy	1.979 (0.047, 3.910)	0.045
Other medical-related	1.548 (-0.473, 3.568)	0.133
Non-medical	1.972 (-0.546, 4.489)	0.125
Academic performance		
Poor	<i>Ref</i>	
Satisfactory	3.688 (1.049, 6.327)	0.006
Good	4.323 (1.485, 7.162)	0.003
Excellent	6.521 (3.112, 9.929)	<0.001
Depression		
No	<i>Ref</i>	
Possibly	-5.314 (-6.978, -3.650)	<0.001
Yes	-9.520 (-10.850, -8.189)	<0.001
Sleep quality score	-0.562 (-0.752, -0.371)	<0.001
<i>Constant</i>	46.428 (43.261, 49.594)	<0.001

MCS: mental component summary.

3.4 Mediation analysis

We performed a mediation analysis to better understand the relationships that depression had with sleep quality and quality of life. All mediation models were adjusted for covariates including sex, grade, major and annual family income. The mediation analysis revealed that the sleep quality score had a negative effect on PCS ($B = -0.458$, $P < 0.001$, 95% CI = -0.591 to -0.325). The direct effect of the sleep quality score on PCS was negative ($B = -0.442$, $P < 0.001$, 95% CI = -0.593 to -0.290), and the direct effect accounted for 96.4%. The mediating effect coefficient B of depression between sleep quality and the PCS score was -0.016, and the indirect effect accounted for 3.6% of the total effect. The 95% CI of the bootstrap test included 0, and the mediating effect diagram revealed that the regression coefficient of depression relative to physical health was -0.121, which was not statistically significant, as shown in Table 5 and Figure 1.

Table 5 Mediation effect of depression in the association between sleep quality and PCS

Effect	B	SE	t	P	Relative effect(%)	Bootstrap95%CI
Total effect	-0.458	0.068	-6.741	<0.001	100	-0.591 to -0.325
Direct effect	-0.442	0.077	-5.718	<0.001	96.4	-0.593 to -0.290
Indirect effect	-0.016	0.041			3.6	-0.098 to 0.064

PCS: physical component summary

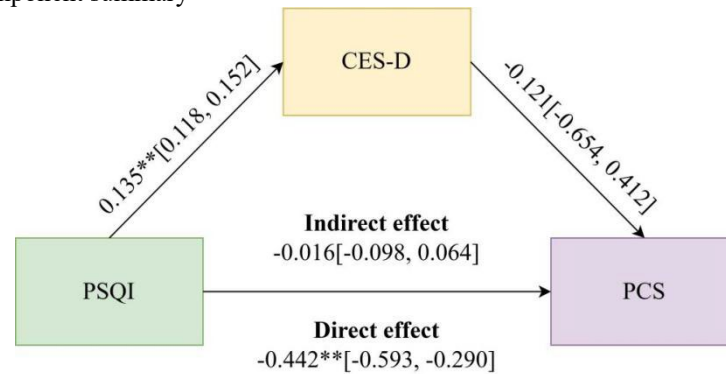


Figure 1 Examined mediation models with PCS as consequent, depression as mediator. PSQI: the total score of the Pittsburgh Sleep Quality Index. CES-D: the total score of the Center for Epidemiologic Studies Depression Scale. PCS: The physical component summary in the SF-36 scale. ** $P < 0.001$.

The sleep quality score also had a negative effect on the MCS score ($B = -1.276$, $P < 0.001$, 95% CI = -1.462 to -1.090). For these, the direct effect was negative ($B = -0.620$, $P < 0.001$, 95% CI = -0.810 to -0.430), accounting for 48.5%. The mediating effect of depression on the relationship between sleep quality score and mental health score was negative ($B = -0.656$, 95% CI = -0.778 to -0.538), with an indirect effect of 51.5%, as shown in Table 6 and Figure 2.

Table 6 Mediation effect of depression in the association between sleep quality and MCS

Effect	B	SE	t	P	Relative effect(%)	Bootstrap95%CI
Total effect	-1.276	0.095	-13.450	<0.001	100	-1.462 to -1.090
Direct effect	-0.620	0.097	-6.404	<0.001	48.5	-0.810 to -0.430
Indirect effect	-0.656	0.060			51.5	-0.778 to -0.538

MCS: mental component summary

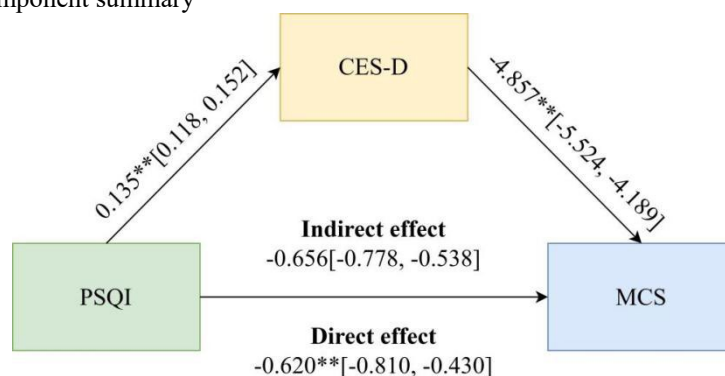


Figure 2 Examined mediation models with MCS as consequent, depression as mediator. PSQI: the total score of the Pittsburgh Sleep Quality Index. CES-D: the total score of the Center for Epidemiologic Studies Depression Scale. MCS: The mental component summary in the SF-36 scale. ** $P < 0.001$.

4. Discussion

This study investigated the current status of quality of life among medical students and its relationship with sleep quality and depression, as well as exploring the mediating role of depression in the relationship

between quality of life and sleep quality. The key findings are threefold. First, medical students had normal physical health (PCS) but significantly lower mental health (MCS) compared with population norms. Second, better academic performance and higher family income were associated with better PCS, whereas female sex and poor sleep quality were associated with worse MCS. Third, depression partially mediated the association between sleep quality and MCS (indirect effect accounting for 51.5% of the total effect), but did not mediate the association between sleep quality and PCS. These results clarify how sleep disturbances translate into reduced mental well-being and suggest distinct pathways for physical versus mental health outcomes.

4.1 Mental health status of medical students

The finding that MCS scores were substantially below normative levels while PCS scores remained within normal range is consistent with previous reports.[3,14] A large cross-sectional study among Chinese medical graduate students found that individuals sleeping less than 7 hours had a 1.65-fold higher depression risk, and poor sleep quality further exacerbated this risk in short sleepers.[15] The high prevalence of poor sleep quality among medical students (reported as 67.9% in a Croatian sample and exceeding 60% in multiple studies) underscores the urgency of addressing sleep health in this population.[16,17] Medical students face chronic academic stress, exposure to human suffering, and high professional expectations, which may disproportionately affect psychological well-being without immediately manifesting as physical complaints. Moreover, a nationwide cross-sectional study of Chinese medical and non-medical students ($n = 11,972$) found that although medical students experienced higher psychological stress, their sleep quality was not proportionally worse - a phenomenon the authors termed “stress-sleep decoupling”, suggesting that the structured environment of medical education may buffer the relationship between stress and sleep.[18]

4.2 Factors influencing PCS and MCS

Better academic performance was strongly associated with higher PCS and MCS scores. While reverse causality is possible (healthier students perform better), a dose-response pattern was observed (B increasing from satisfactory to good, then slightly decreasing for excellent). This pattern may reflect that moderate academic success promotes health through routine and self-efficacy, whereas extreme excellence might involve overwork and stress. However, the exact mechanism warrants longitudinal investigation.

Higher family income (30,000-50,000 yuan vs. <10,000 yuan) was associated with higher PCS but not MCS. This suggests that economic advantage protects physical health-perhaps through better nutrition, healthcare access, and living conditions-but does not necessarily buffer mental health in a high-stress academic environment. In contrast, female sex was a strong negative predictor of MCS, confirming well-established sex differences in internalizing disorders.[19] This is consistent with a recent study in which female medical students exhibited significantly higher PSQI scores and higher levels of depression, anxiety, and stress than their male counterparts.[17] The same study reported moderate positive correlations between PSQI total scores and depression ($\rho = 0.566$, $P < 0.001$) and anxiety ($\rho = 0.489$, $P < 0.001$). Notably, nursing and pharmacy majors had higher MCS scores than clinical medicine students, possibly because the latter face heavier workloads, longer study hours, and higher career-related anxiety.

4.3 Mediation by depression: contrasting patterns for MCS and PCS

The core contribution of this study is the demonstration that depression mediates the sleep-MCS relationship but not the sleep-PCS relationship. The indirect effect of sleep quality on MCS via depression was substantial ($B = -0.656$, 95% CI excludes 0), accounting for more than half of the total effect. This finding aligns with the emotion regulation deficit model. A growing body of research supports that sleep loss impairs the functional connectivity between the prefrontal cortex and amygdala. A 2026 conference abstract reported that as time awake increased, resting-state functional connectivity between the amygdala and medial prefrontal cortex underwent linear changes, weakening the prefrontal cortex's inhibitory top-down regulation of the amygdala.[20] This mechanistic explanation is echoed in a recent Chinese study on medical graduate students, which proposed that high-quality sleep may reduce cortisol levels by inhibiting HPA axis overactivation and enhance prefrontal-amygdala neuromodulation, thereby improving mood regulation and alleviating depressive symptoms.[15] Consequently, individuals with poor sleep are more likely to experience persistent low mood, irritability, and anhedonia-core

depressive symptoms that directly lower the mental health domains of QoL (vitality, social functioning, role emotional, and mental health).[21]

Similar mediation pathways have been documented in recent studies. A 2025 study among 864 Chinese university students found that anxiety and depression mediated the association between dysfunctional sleep beliefs and sleep quality, highlighting that negative emotional states are key pathways linking cognitive sleep-related factors to poor sleep outcomes.[22] A meta-analysis of 12 studies ($n = 5,786$ students) conducted during the COVID-19 pandemic confirmed robust correlations between poor sleep quality and increased anxiety, depression, and stress, with correlation coefficients ranging from 0.34 to 0.66.[23] These consistent findings across different populations and outcomes strengthen the generalizability of the mediating role of depression in the sleep–mental health relationship.

What makes this mediation robust for MCS but absent for PCS? One explanation is that sleep affects physical health through direct biological pathways that bypass depression. Sleep deprivation triggers pro-inflammatory cytokine release (e.g., IL-6, TNF- α), impairs glucose metabolism, and increases sympathetic nervous system activity.[24] A 2026 study on the association between body composition and sleep disturbance found that inflammation statistically mediated 10.64% to 36.43% of the association depending on the inflammation marker used.[25] A recent narrative review summarizing evidence from 2010-2025 concluded that poor sleep quality among medical students, frequently exceeding 60%, shows strong associations with anxiety, depression, burnout, and diminished overall quality of life.[16] In our data, the direct effect of sleep quality on PCS ($B = -0.442$) remained strong even after controlling for depression, whereas the indirect path was negligible ($B = -0.016$). This pattern supports a “dual-pathway” model: sleep influences physical health via direct physiological pathways, and it affects mental health partially through depressive symptoms.

A secondary but important observation is that depression itself was not a significant predictor of PCS in the linear regression model (Table 3). This may seem counterintuitive because depression often includes somatic symptoms. However, the SF-36 PCS is heavily weighted toward physical functioning and bodily pain, which in young, generally healthy medical students might be less affected by mood state. This finding supports a “dual-pathway” model: sleep affects physical health through direct biological mechanisms (e.g., inflammation, metabolic changes) that bypass depression, whereas its impact on mental health is substantially mediated by depressive symptoms.

4.4 Comparison with previous literature

Our mediation findings extend previous work in several important directions. A study of medical students in Mogadishu found that depressive symptoms mediated the relationship between social support and sleep quality.[26] Another study of medical students residing in dormitories in Iran ($n = 380$) reported that sleep quality indirectly affected quality of life through social relations quality (indirect effect = -0.09 , 95% CI: -0.18 to -0.02).[27] A path-analytic study of 402 medical students found that poor sleep quality was associated with depressive symptoms ($P < 0.001$) and that mental health problems mediated the effect of problematic internet use on sleep quality.[28] These studies converge on the conclusion that sleep quality does not operate in isolation—its impact on well-being is channeled through psychological and social mediators, with depression playing a particularly prominent role across diverse populations and settings.

4.5 Limitations and future directions

Several limitations must be acknowledged. The cross-sectional design precludes causal inference; the temporal order of sleep, depression, and QoL cannot be definitively established. Longitudinal studies with repeated measures are needed to confirm the directionality of the mediation. Second, the sample was geographically restricted to Guangxi and predominantly female (73.6%), limiting generalizability to other regions or male-dominated medical cohorts. Third, unmeasured confounders—particularly anxiety, social support, physical activity, and coping styles—may influence the observed associations. Fourth, self-report scales (PSQI, CES-D, SF-36) are subject to recall and social desirability biases. Future research should incorporate objective sleep measures and clinical interviews for depression. Future multi-centre longitudinal studies with well-designed intervention arms are needed to test whether improving sleep quality and reducing depressive symptoms leads to sustained improvements in QoL among medical students.

5. Conclusion

Medical students in this study had normal physical health but significantly impaired mental health-related QoL. Poor sleep quality was associated with worse outcomes in both domains. Critically, depression mediated more than half of the effect of poor sleep on mental health, identifying a modifiable pathway. For physical health, sleep affected QoL directly, suggesting that separate intervention strategies may be required. Improving sleep hygiene, providing emotion regulation training, and offering early psychological support for depressive symptoms could effectively enhance medical students' overall well-being.

Acknowledgments

We thank all participants of the study, including the volunteers and researchers.

This research was funded by the National College Students' Innovative Entrepreneurial Training Plan Program(S202310601151) and the National Natural Science Foundation of China (NSFC-82460629).

References

- [1] Ghrouz AK, Noohu MM, Dilshad Manzar M, et al. Physical activity and sleep quality in relation to mental health among college students. *Sleep Breath*. 2019;23(2):627–634.
- [2] Haykal K-A, Pereira L, Power A, et al. Medical student wellness assessment beyond anxiety and depression: A scoping review. *PLoS One*. 2022;17(10):e0276894.
- [3] Freitas PHB de, Meireles AL, Ribeiro IK da S, et al. Symptoms of depression, anxiety and stress in health students and impact on quality of life. *Rev Lat Am Enfermagem*. 2023;31:e3884.
- [4] Noreen A, Iqbal N, Hassan B, et al. Relationship between psychological distress, quality of life and resilience among medical and non-medical students. *J Pak Med Assoc*. 2021;71(9):2181–2185.
- [5] Seo EH, Kim S-G, Lee J-H, et al. Psychosocial Factors Influencing Quality of Life Among Medical Students. *Psychiatry Investig*. 2023;20(11):1077–1085.
- [6] Li L, Feng X, Luo S, et al. Internet addiction and health-related quality of life in adolescents: The mediating role of sleep disturbance. *Sleep Medicine*. 2024;117:53–59.
- [7] Paro HBMS, Morales NMO, Silva CHM, et al. Health-related quality of life of medical students. *Med Educ*. 2010;44(3):227–235.
- [8] Wang Y, Guang Z, Zhang J, et al. Effect of Sleep Quality on Anxiety and Depression Symptoms among College Students in China's Xizang Region: The Mediating Effect of Cognitive Emotion Regulation. *Behav Sci (Basel)*. 2023;13(10):861.
- [9] Palmer CA, Bower JL, Cho KW, et al. Sleep loss and emotion: A systematic review and meta-analysis of over 50 years of experimental research. *Psychol Bull*. 2024;150(4):440–463.
- [10] Zhu B, Gao X-M, Zhou M, et al. The mediating roles of cognitive emotion regulation and resilience in the association between life events and sleep quality among medical students. *Front Psychiatry*. 2025;16:1466138.
- [11] Buysse DJ, Reynolds CF, Monk TH, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213.
- [12] Ware JE, Gandek B. Overview of the SF-36 Health Survey and the International Quality of Life Assessment (IQOLA) Project. *J Clin Epidemiol*. 1998;51(11):903–912.
- [13] Roberts RE, Vernon SW. The Center for Epidemiologic Studies Depression Scale: its use in a community sample. *Am J Psychiatry*. 1983;140(1):41–46.
- [14] Rotenstein LS, Ramos MA, Torre M, et al. Prevalence of Depression, Depressive Symptoms, and Suicidal Ideation Among Medical Students: A Systematic Review and Meta-Analysis. *JAMA*. 2016;316(21):2214–2236.
- [15] He H, Zeng Y, Chen Z, et al. Associations Between Sleep Duration, Sleep Quality, and Depressive Symptoms: Evidence from Medical Graduate Students in China. *NSS*. 2025; Volume 17:1853–1862.
- [16] Nagabhushan S, Kumar M, Ghosh S, et al. Impact of Sleep Quality, Sleep Disturbances on Quality of Life Among Medical Students Worldwide: A Narrative Review. *Cureus*. 2026;18(5):e108356.
- [17] Vidović S, Rakić N, Kraštek S, et al. Sleep Quality and Mental Health Among Medical Students: A Cross-Sectional Study. *Journal of Clinical Medicine*. 2025;14(7):2274.
- [18] Shen Z, Wang T, Zeng X, et al. Discrepant Associations Between Psychological Stress and Sleep Quality Among Medical and Non-Medical Students: A Nationwide Cross-Sectional Study in China. *Behav Psychol [Internet]*. 2025 [cited 2026 June 14];33(3).

- [19] Altemus M, Sarvaiya N, Epperson CN. Sex differences in anxiety and depression clinical perspectives. *Front Neuroendocrinol.* 2014;35(3):320–330.
- [20] Killgore W, Katz J, Henderson-Arredondo K, et al. 0225 Reconsidering the Human Emotional Brain Without Sleep: Is it a 'Prefrontal-Amygdala Disconnect' or Reorganization of Amygdala-Centric Networks? *Sleep.* 2026;49(Supplement_1):A98–A99.
- [21] Pandi-Perumal SR, Monti JM, Burman D, et al. Clarifying the role of sleep in depression: A narrative review. *Psychiatry Res.* 2020;291:113239.
- [22] Wang P, Xie C, Qian J, et al. Dysfunctional sleep beliefs and sleep quality among Chinese university students: the mediating roles of depression, anxiety, and stress. *BMC Psychol.* 2025;13(1):844.
- [23] Katsikidou M, Anastasiadou S, Plakias S, et al. Sleep, Anxiety, and Depression Among Healthcare Students During COVID-19: A Systematic Review and Meta-analysis. *Curr Sleep Medicine Rep.* 2025;11(1):33.
- [24] Sang D, Lin K, Yang Y, et al. Prolonged sleep deprivation induces a cytokine-storm-like syndrome in mammals. *Cell.* 2023;186(25):5500-5516.e21.
- [25] Zhang L, Yang Q, Wu X, et al. The inverse association between skeletal muscle mass to visceral fat ratio (SVR) and sleep disturbance: the mediating role of inflammation and aging acceleration. *BMC Psychiatry [Internet].* 2026 [cited 2026 June 14]; doi: 10.1186/s12888-026-08248-x.
- [26] Mohamed NA, Mohamud RYH, Hassan MS, et al. Restless nights, demanding days: assessment of the prevalence and associated factors of poor sleep quality among medical students in Mogadishu, Somalia. *BMC Med Educ.* 2025;26(1):70.
- [27] Karimi N, Pasyar N, Rambod M. Social relations and cellphone addiction mediate the relationship between sleep and quality of life in medical students residing in dormitories. *Sci Rep.* 2025;15(1):30980.
- [28] Shadzi MR, Salehi A, Vardanjani HM. Problematic Internet Use, Mental Health, and Sleep Quality among Medical Students: A Path-Analytic Model. *Indian J Psychol Med.* 2020;42(2):128–135.