EXPLORING THE RELATIONSHIP BETWEEN SLEEP QUALITY AND COGNITIVE PERFORMANCE AMONG UNIVERSITY STUDENTS EXPERIENCING ACADEMIC STRESS

Original Article

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ABSTRACT

Background: Sleep quality plays a vital role in maintaining cognitive functions such as attention, memory, and executive control, particularly in young adults under academic pressure. University students often compromise sleep due to demanding schedules, which may impair cognitive performance and academic outcomes. Despite growing awareness, few studies in South Asia have quantified this relationship using objective cognitive assessments and standardized stress evaluations.

Objective: To investigate how variations in sleep quality affect cognitive performance in university students experiencing academic stress in the Lahore region of Pakistan.

Methods: A cross-sectional study was conducted over eight months involving 422 undergraduate students selected through stratified random sampling from multiple universities in Lahore. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), and perceived stress levels were measured using the Perceived Stress Scale (PSS-10). Cognitive performance was evaluated through the Cambridge Neuropsychological Test Automated Battery (CANTAB), including sustained attention (RVP), working memory (SWM), and executive function (SOC) modules. Statistical analyses included t-tests, ANOVA, Pearson correlation, and multivariate linear regression, with significance set at $p < 0.05$.

Results: Poor sleepers (62.6%) had significantly lower cognitive scores across all domains compared to good sleepers ($p < 0.001$). High perceived stress was associated with both higher PSQI scores and lower cognitive performance. Regression analysis confirmed that both sleep quality ($\beta = -0.48$) and stress ($\beta = -0.35$) independently predicted cognitive decline.

Conclusion: Poor sleep quality and elevated academic stress independently and significantly impair cognitive functioning in university students. These findings underscore the need for targeted interventions promoting sleep hygiene and stress management within academic institutions.

Keywords: Academic Performance, Cognition, Cross-Sectional Studies, Executive Function, Memory, Sleep, Stress, Students, Universities, Working Memory.

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INTRODUCTION

Sleep is a fundamental biological function, yet it is frequently sacrificed in pursuit of academic success, especially among university students. In this population, academic demands often result in irregular sleep schedules, reduced sleep duration, and compromised sleep quality. These changes in sleep behavior occur at a critical developmental stage where the brain's cognitive faculties—such as attention, memory, problem-solving, and executive function—are both highly active and vulnerable to disruption (1). The intersection of academic stress and sleep disturbance represents a growing concern in higher education settings, with mounting evidence suggesting that sleep quality significantly influences cognitive performance and academic outcomes (2). Recent decades have seen an increasing recognition of the link between sleep and cognitive health, but it is among university students—arguably one of the most stressed populations—that this link becomes particularly urgent to understand. Several studies have established that poor sleep quality impairs critical cognitive functions necessary for academic success, such as sustained attention, working memory, and information processing speed (3,4). Cognitive performance is not merely diminished by total sleep deprivation, but is significantly affected even by chronic partial sleep loss—a common pattern among students during exam periods. Academic stress itself is known to affect sleep quality. University students often experience elevated stress due to course workloads, examinations, and future career uncertainties (5). This stress can lead to difficulties initiating or maintaining sleep, as well as non-restorative sleep, which compounds its cognitive effects. A substantial number of studies have reported that students under academic stress frequently report poor sleep, with associated declines in academic performance (6-8). Despite these connections, sleep remains an under-addressed factor in academic performance interventions. Many students view reduced sleep as a necessary trade-off for productivity, unaware that compromised sleep may actually reduce their ability to learn, retain, and apply knowledge effectively. In a cross-sectional study among Nigerian undergraduates, students with good sleep quality had significantly higher cumulative GPAs than those with poor sleep, and poor sleepers also reported higher stress levels (9). This is consistent with other findings indicating that students who report sleeping at least 7–8 hours per night tend to achieve higher academic results and report better mental wellness (10).

Cognitive functions such as memory consolidation, problem-solving, and emotional regulation—key elements of academic success—are significantly influenced by sleep quality. A well-documented mechanism through which sleep affects cognition is the consolidation of newly acquired information during slow-wave and REM sleep (11). Poor sleep can disrupt these processes, thereby impairing memory retention and recall during exams or class participation. Moreover, chronic sleep deprivation can impair decision-making and increase mental fatigue, compounding stress levels and creating a vicious cycle of poor sleep and academic underperformance (12,13). It is also important to consider individual perceptions of sleep. Subjective sleep quality, as measured by tools like the Pittsburgh Sleep Quality Index (PSQI), has been shown to correlate with academic outcomes. For example, students who rated their sleep as poor tended to perform worse on high-stakes exams, even if their total sleep duration was adequate (14). This underscores the importance of both the quantity and the perceived restorative value of sleep in understanding its cognitive impact. Despite these insights, sleep quality remains an under-recognized determinant of academic performance in university policy and student support services. Many institutions focus on tutoring, counseling, and workload management, yet fail to educate students about the cognitive and academic implications of poor sleep hygiene. There is a growing call for evidence-based sleep education and stress management programs aimed at promoting cognitive resilience and academic well-being (15,16). In light of this context, the present study seeks to investigate the relationship between sleep quality and cognitive performance among university students experiencing academic stress. Specifically, it aims to explore how variations in sleep quality affect attention, memory, and executive function during periods of academic pressure. The objective is to provide empirical evidence to inform interventions that promote sleep as a vital component of student mental performance and academic success.

METHODS

This cross-sectional study was conducted over a period of eight months in the Lahore region of Pakistan, with the primary objective of investigating the impact of sleep quality on cognitive functioning among university students experiencing academic stress. The study setting included multiple public and private universities across Lahore to ensure representation across different academic environments and socioeconomic backgrounds. The research was designed to comprehensively capture the interaction between sleep disturbances and cognitive outcomes in a high-pressure academic context. A calculated sample size of 384 participants was determined using Cochran's formula, assuming a 5% margin of error, a 95% confidence interval, and an anticipated prevalence of poor sleep quality among university students of approximately 50%, which is consistent with findings in prior regional studies. To account for potential dropouts or

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incomplete responses, the target sample was increased by 10%, resulting in a final recruitment goal of 422 students (2). Participants were selected through stratified random sampling, with stratification based on academic year and discipline to ensure adequate representation from a variety of academic workloads and cognitive demands. Eligibility criteria included students aged between 18 and 26 years who were currently enrolled full-time in undergraduate programs and had completed at least one academic semester. Students were required to be free of any diagnosed psychiatric disorders, chronic neurological conditions, or ongoing pharmacological treatment that could independently affect sleep or cognitive function. Those with reported histories of substance abuse or recent major life events—such as bereavement or hospitalization—were also excluded to minimize confounding influences.

Data collection involved a structured self-administered questionnaire distributed both in print and digital formats, ensuring accessibility and increased response rates. Prior to participation, all students were provided with detailed information about the study's purpose and confidentiality measures. Informed consent was obtained electronically or in writing, depending on the mode of participation. Ethical approval was granted by the Institutional Review Board of the University of Lahore and all procedures were carried out in accordance with the ethical standards of the Declaration of Helsinki. The primary exposure variable, sleep quality, was assessed using the Pittsburgh Sleep Quality Index (PSQI), a validated instrument that measures subjective sleep quality across seven domains over the past month. A global PSQI score greater than 5 was used to define poor sleep quality. The PSQI has been widely employed in similar populations and is known for its good internal consistency and construct validity. To evaluate cognitive functioning, the study employed the Cambridge Neuropsychological Test Automated Battery (CANTAB), specifically selecting modules related to attention, working memory, and executive function—domains known to be sensitive to sleep disruption. The cognitive tasks included the Rapid Visual Information Processing (RVP) test for sustained attention, the Spatial Working Memory (SWM) test for working memory, and the Stockings of Cambridge (SOC) test for planning and problem-solving abilities (14-16). These computer-based assessments were administered in a quiet, controlled environment within university computer labs, supervised by trained research assistants.

Academic stress was quantified using the Perceived Stress Scale (PSS-10), a well-established psychometric tool for measuring perceived levels of stress in the preceding month. The PSS-10 was included to ensure that the relationship between sleep quality and cognitive performance could be analyzed specifically within a context of heightened academic pressure, aligning with the study's objective. All data were entered into SPSS version 28 for statistical analysis. Descriptive statistics were used to summarize demographic characteristics, PSQI scores, PSS-10 scores, and cognitive test outcomes. The data met assumptions for normality as verified by the Shapiro-Wilk test. Independent samples t-tests were employed to compare cognitive performance scores between good and poor sleepers. One-way ANOVA with post hoc Tukey testing was used to explore differences across categories of stress severity and sleep quality. Pearson's correlation coefficients were calculated to examine linear associations between PSQI scores, stress levels, and cognitive test performance. Finally, multivariate linear regression was conducted to assess the independent effect of sleep quality on cognitive outcomes after adjusting for age, gender, academic year, and perceived stress scores. Throughout the study, rigorous efforts were made to maintain the reliability of data collection and the integrity of statistical procedures. Data confidentiality was preserved using anonymized ID codes, and all electronic files were stored on password-protected systems accessible only to the primary research team. No adverse events or ethical concerns were reported during the study period. This methodology was deliberately designed to provide a robust, replicable framework for examining how sleep quality variations influence cognitive performance among students in real-world academic settings. The combination of validated tools, stratified sampling, and appropriate statistical modeling ensures that the findings will contribute meaningfully to the understanding of student well-being and academic functioning under stress.

RESULTS

A total of 422 students participated in the study, with a mean age of 21.3 years (SD ± 1.8). Of these, 44.1% were male and 55.9% female. Participants were drawn from four primary academic disciplines: medical sciences, engineering, business, and arts, and were distributed nearly equally across all undergraduate academic years. Among the total respondents, 264 students (62.6%) were classified as poor sleepers based on PSQI scores above 5, while 158 students (37.4%) were categorized as good sleepers. The mean global PSQI score among poor sleepers was 9.3 (SD ± 2.2), significantly higher than the 4.1 (SD ± 0.6) recorded in the good sleepers group. In relation to cognitive performance as measured by the CANTAB modules, poor sleepers demonstrated significantly lower scores across all three domains evaluated. The mean score for sustained attention (RVP) was 89.4 (SD ± 4.2) among good sleepers, compared to 77.8 (SD ± 6.3) for poor sleepers ($p < 0.001$). Working memory (SWM) scores were similarly affected, with good sleepers achieving a mean of 81.1 (SD ± 5.0) versus 72.5 (SD ± 6.8) in poor sleepers ($p < 0.001$). Executive function, as measured by the SOC test, also showed a marked decline among poor sleepers with a mean score of 66.4 (SD ± 7.4), compared to 76.3 (SD ± 6.1) for those with better sleep quality (p <

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0.001). These results are visually summarized in Figure 1. Perceived stress levels were assessed using the PSS-10, with most students falling into the moderate stress category (53.1%), followed by high stress (31.3%) and low stress (15.6%). A direct association was observed between increasing stress levels and poorer sleep quality. Students with high stress had a mean PSQI score of 10.4 (SD ± 2.3), whereas those with low stress exhibited a mean PSQI of 5.2 (SD ± 1.3). Additionally, a decline in composite cognitive scores was observed with escalating stress levels, from 83.6 (SD ± 3.5) in low-stress students to 66.1 (SD ± 5.9) in high-stress students, as illustrated in Figure 2. Multivariate linear regression analysis further confirmed that both poor sleep quality ($\beta = -0.48$; 95% CI: -0.57 to -0.39; $p < 0.001$) and higher perceived stress scores ($\beta = -0.35$; 95% CI: -0.43 to -0.26; $p < 0.001$) were significant independent predictors of diminished cognitive performance. Other demographic variables such as age, gender, and academic year were not found to be statistically significant in influencing cognitive outcomes in the adjusted model. No significant interaction effects were noted between gender and sleep quality or between academic year and stress level. These findings collectively reinforce the inverse relationship between sleep quality and cognitive functioning, particularly under academic stress. Both PSQI scores and PSS scores showed clear gradients in relation to cognitive test outcomes, indicating a dose-dependent effect of both sleep disruption and stress on mental performance.

Table 1: Demographics

Variable	Value
Total Participants	422
Age (Mean ± SD)	21.3 ± 1.8
Gender	
Male	186 (44.1%)
Female	236 (55.9%)
Academic Year	
1st	110
2nd	102
3rd	112
4th	98
Field of Study	
Medical	138
Engineering	114
Business	96
Arts	74

Table 2: Sleep Quality (PSQI Scores)

Sleep Quality Category	n (%)	Mean PSQI Score ± SD
Good Sleepers (PSQI ≤ 5)	158 (37.4%)	4.1 ± 0.6
Poor Sleepers (PSQI > 5)	264 (62.6%)	9.3 ± 2.2

Table 3: Cognitive Performance by Sleep Quality

Cognitive Domain	Good Sleepers (Mean ± SD)	Poor Sleepers (Mean ± SD)	p-value
Sustained Attention (RVP)	89.4 ± 4.2	77.8 ± 6.3	<0.001
Working Memory (SWM)	81.1 ± 5.0	72.5 ± 6.8	<0.001
Executive Function (SOC)	76.3 ± 6.1	66.4 ± 7.4	<0.001

Table 4: Sleep Quality and Cognitive Score by Stress Level

Stress Level	n (%)	Mean PSQI Score ± SD	Mean Cognitive Score ± SD
Low (0–13)	66 (15.6%)	5.2 ± 1.3	83.6 ± 3.5
Moderate (14–26)	224 (53.1%)	7.8 ± 1.9	74.5 ± 5.2
High (27–40)	132 (31.3%)	10.4 ± 2.3	66.1 ± 5.9

Table 5: Multivariate Regression Results

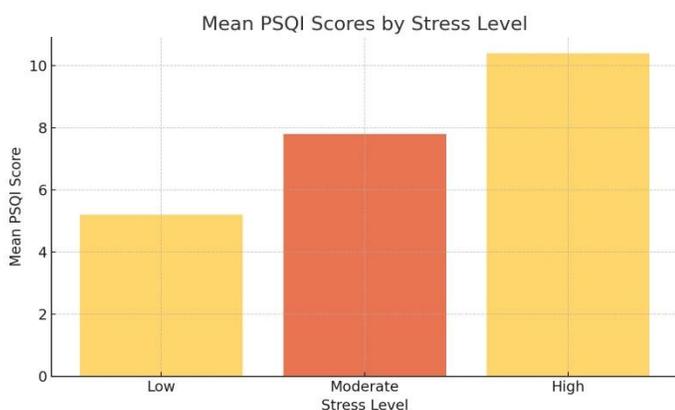| Variable	β Coefficient	95% CI	p-value
PSQI Score	-0.48	-0.57 to -0.39	<0.001
PSS Score	-0.35	-0.43 to -0.26	<0.001
Age	0.02	-0.01 to 0.06	0.22
Gender (Ref: Female)	0.11	-0.06 to 0.27	0.19
Academic Year	0.04	-0.01 to 0.08	0.08

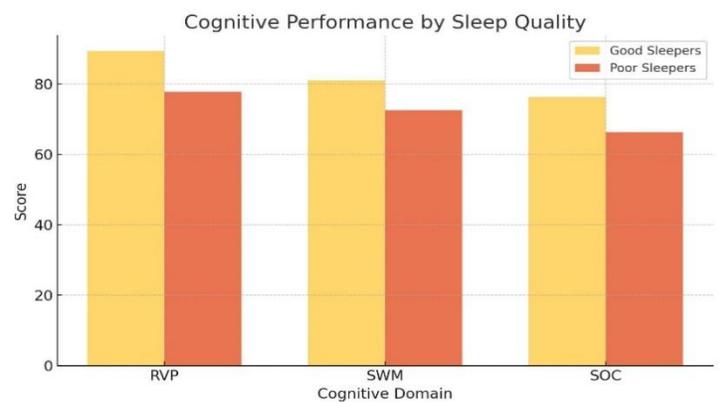*Figure 2 Mean PSQI Scores by Stress Level*

Figure 2 Cognitive Performance by Sleep Quality

DISCUSSION

The present study aimed to explore the relationship between sleep quality and cognitive performance in university students experiencing academic stress. The results demonstrated a clear and consistent trend: students with poorer sleep quality performed significantly worse on cognitive tasks involving attention, working memory, and executive function. This association remained robust even after adjusting

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for confounding variables such as age, gender, and academic year, indicating a strong independent effect of sleep quality on cognitive outcomes. Elevated stress levels also correlated with reduced cognitive performance, reinforcing the dual burden of poor sleep and academic stress on student functioning. These findings are strongly supported by recent literature. For instance, a study reported that both poor sleep quality and stress were significantly associated with impaired academic performance in medical students, particularly during clinical years when academic demands are heightened (16). Similarly, a study found that students obtaining less than the recommended hours of sleep scored lower academically and reported poorer cognitive functioning in tasks requiring memory and concentration (17). These patterns align closely with the current study's results, adding to the growing body of evidence that supports the cognitive toll of disrupted sleep in high-stress academic contexts. The inverse relationship between perceived stress and cognitive scores observed in this study has also been validated by studies such as a study which identified a significant positive correlation between stress and sleep disruption, both of which impaired academic performance in medical students during the COVID-19 pandemic (18,19). Likewise, another study concluded that students with higher stress levels were more likely to report poor sleep quality, though the direct relationship with academic performance was less pronounced in their cohort (20). This discrepancy may reflect differences in cognitive outcome measurements or the academic environment. Contrasting perspectives do exist. A study observed that while perceived stress negatively impacted sleep quality, the relationship between sleep quality and academic performance was not always statistically significant, suggesting that mediating factors such as coping mechanisms or motivation might moderate this relationship (21). This nuance is critical, indicating that sleep and cognition are part of a broader psychosocial system influenced by emotional resilience, time management, and social support.

A major strength of the current study lies in its comprehensive approach—combining objective cognitive performance testing with validated tools for assessing sleep quality (PSQI) and stress (PSS-10). The use of multivariate regression enabled accurate isolation of predictors, enhancing the credibility of the findings. Moreover, the inclusion of diverse academic disciplines and stratification across academic years improves the generalizability of results within the university student population. However, several limitations must be acknowledged. The cross-sectional design precludes causal inference, and the reliance on self-reported tools like the PSQI may introduce recall bias. Although objective measures such as actigraphy could offer more precise sleep assessments, their implementation was limited by logistical and financial constraints. Additionally, while cognitive performance was measured through standardized computerized tasks, these may not capture all aspects of academic functioning, such as creativity, verbal reasoning, or emotional regulation. Cultural and regional factors specific to the Lahore region may also influence sleep behaviors and stress perception, limiting global generalizability. Future research would benefit from longitudinal designs to assess how sustained poor sleep and academic stress affect cognitive trajectories over semesters or academic years. Interventional studies testing sleep hygiene programs or stress reduction strategies like mindfulness or time management training could provide actionable solutions. Furthermore, studies incorporating biomarkers of stress (e.g., cortisol levels) alongside neurocognitive assessments may offer more nuanced insights into the physiological pathways linking sleep and cognition (22). In conclusion, this study underscores the critical role of sleep quality in supporting optimal cognitive functioning during periods of academic stress. As academic institutions face rising mental health concerns among students, addressing sleep hygiene and stress management is not merely beneficial but essential to academic resilience and long-term cognitive health.

CONCLUSION

This study concluded that poor sleep quality significantly impairs cognitive performance among university students, especially under academic stress. Attention, memory, and executive functions were markedly reduced in poor sleepers, highlighting sleep as a critical determinant of academic success. These findings emphasize the need for integrated student support programs that prioritize sleep hygiene and stress management to enhance cognitive resilience and academic outcomes.

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AUTHOR CONTRIBUTION

Author	Contribution
Anushka Majeed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Khudija Tul Kubra	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Asmara Shafqat	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Gulrukh Rana	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Shaikh Khalid Muhammad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Naveed	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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