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Impact Of Academic Stress On Executive Functions And Sleep Quality Among University Students: A Cross-Sectional Study

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Abstract:
Background: *Research reveals that general stress can impair executive functions and sleep, but there is limited research that examines the specific effects of academic stress among university students. Poor sleep is associated with reduced concentration, impaired memory, weakened immunity, and increased anxiety/depression. Understanding how academic stress influences sleep patterns can help identify preventable health risks.*
Objective: *This study aims to investigate the impact of academic stress on executive functions and sleep quality among university students.*
Materials and Methods: *A cross-sectional study was conducted with a total of 401 students from Universiti Tunku Abdul Rahman, Malaysia. The Perception of Academic Stress Scale, Pittsburgh Sleep Quality Index, and Trail Making Test Part B were used to measure perceived academic stress, sleep quality, and executive functions, respectively. A convenience sampling method was adopted.*
Results: *Academic stress was positively correlated with poorer sleep quality (r 0.375, $p < 0.001$) and marginally associated with impaired executive functions ($r = 0.107$, $p = 0.032$). Sleep quality also showed a weak positive correlation with executive functions ($r = 0.185$, $p < 0.001$). No significant differences in academic stress or sleep quality were found across demographic variables, but females demonstrated better executive function than males.*
Conclusion: *Academic stress harms both executive functions and sleep quality. Executive functions are also significantly correlated with sleep quality.*
Keywords: *academic stress; sleep quality; executive function; working memory; university students*

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I. Introduction

Psychological stress typically occurs when individuals believe that environmental demands surpass their ability to cope effectively, thereby affecting their mental and physical health.[1] Previous studies reported that both acute and chronic stress significantly impact executive functions, including motor memory, cognitive flexibility, and inhibitory control.[2,3] Academic stress is a specific form of stress experienced by students, originating from various factors within the educational environment. It is defined as the psychological tension caused by ongoing social pressures and self-imposed stress in the school setting, which exhausts students. Sources of academic stress often include high academic expectations, heavy workloads, examinations, self-perceptions, and the desire for success, and they often impede students' academic performance.

According to Diamond (2013), executive function comprises a set of key psychological processes, which are very important for tasks that require concentration, attention, and decision-making, especially in the case of insufficient automatic or instinctive response.[4] These cognitive functions are characterized by efforts and conscious efforts to transcend automatic response, resist temptation, and adapt to a dynamic environment. According to Nelson et al. (2022), sleep quality is a subjective evaluation of the overall satisfaction and effectiveness of personal sleep experience.[5] It analyses many problems, including the length, depth, continuity, and recoverability of sleep, and the existence of sleep disorders or obstacles. The positive effects of good sleep quality include feeling well-rested, functioning normally, and having happy relationships. Fatigue, irritation, daytime dysfunction, slowed reflexes, and increased caffeine/alcohol consumption are all results of poor sleep quality. Therefore, sleep is a crucial component of overall health, which could have a profound impact on both physical and mental well-being.

Unlike general stress, academic stress is specifically tied to the pressures of academic performance, deadlines, and expectations, making it a critical area of exploration as it directly impacts students' mental health and cognitive functioning. By targeting this unique stressor, the study addresses a gap in the literature. It provides insights into how academic stress affects executive functions, a key cognitive domain essential for decision-making, problem-solving, and self-regulation. Executive function is crucial for academic success, and understanding how academic stress impacts it can lead to targeted interventions aimed at optimizing students' performance and well-being.

Given the rising prevalence of academic stress among university populations, this research is highly relevant for educational institutions. By addressing this critical gap, the study has the potential to enhance students' overall academic experiences and foster resilience, thereby promoting long-term success and well-being in an increasingly competitive academic environment. Therefore, this study aims to determine the impact of academic stress on executive functions and sleep quality among university students.

II. Materials And Methods

Study Design: Cross-sectional study design

Study Location: Universiti Tunku Abdul Rahman, Malaysia.

Study Duration: November 2024 to January 2025

Sample size: 367 participants

Sample size calculation: The sample size for this study was calculated using G-Power.

Subjects & selection method: The participants were university students at Universiti Tunku Abdul Rahman, Malaysia. We enrolled a total of 401 participants, including 259 females (64.6%) and 142 males (35.4%). A convenience sampling method was employed.

Inclusion criteria:
1. Full-time students in any programme in UTAR Sungai Long
2. Either sex
3. Aged between 18 and 30 years,
3. Able to understand English.

Exclusion criteria:
1. Part-time students in UTAR Sungai Long
2. Students diagnosed with psychiatric and neurological disorders

Procedure methodology

A questionnaire was distributed to the participants face-to-face, which consisted of a section on an informed consent form, demographic details, Perception of Stress (PAS) Scale, the Pittsburgh, and Sleep Quality Index (PSQI). After completing the questionnaire, participants were asked to attend for executive function measurement. Upon arrival, the Trail Making Test Part B (TMT-B) was introduced to them, and to ensure their comprehension, a printed TMT-B and a pencil were provided for connecting numbers and letters in alternating order. A practice round helps participants familiarize themselves with the task. Once ready, start the stopwatch when the actual test begins, and record the time taken to complete the sequence. If the participant makes a mistake during the test, the examiner will point it out immediately and allow the participant to correct it. These errors will affect the participant's score, because correcting errors is included in the task completion time. Stop the stopwatch once the participant has completed the TMT-B. Scoring was based on the time taken to complete the TMT-B. This study was approved by the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman. Informed consent was obtained from all participants, and data confidentiality was ensured.

Outcome measures

Perception of Stress (PAS) Scale

The Perception of Academic Stress (PAS) Scale is a psychometric tool designed to measure how undergraduate university students perceive the causes of their academic stress. The PAS Scale has 18 items divided into three subscales: Academic Expectations (4 items), Workload and Examinations (8 items), and Students' Academic Self-Perceptions (6 items). Each question is answered on a 5-point Likert scale, with 1 representing "strongly disagree" and 5 representing "strongly agree." Participants must answer all questions. A higher PAS score indicates greater academic stress. The scale typically takes about five minutes to complete.[6]

The Pittsburgh Sleep Quality Index (PSQI)

PSQI is a widely used self-reported questionnaire designed to assess an individual's sleep quality and sleep disturbances over the past month. It was developed by Buysse and colleagues in 1989 and is considered one of the most reliable tools for evaluating sleep problems in both clinical and non-clinical populations, including university students. The PSQI consists of 19 self-rated items and 5 items rated by a bed partner or roommate (the partner-rated items are optional and not used in scoring). The PSQI has been extensively validated across different populations and demonstrates strong psychometric properties. The original validation study reported Cronbach's alpha of 0.83, indicating high internal consistency. Test–retest reliability over one month has been reported as r = 0.85, reflecting good stability of the instrument.[7]

Trail Making Test Part B (TMT-B)

The Trail Making Test (TMT) is a timed, neuropsychological test that involves visual scanning and working memory. The TMT has two parts: the TMT A (rote memory) and TMT B (executive functioning). TMT-B alternates between numbers and letters, so the participants must sequentially switch between them as fast as possible (Ciolek & Lee, 2020). For example, consider drawing lines to join the numbers and letters in the sequence 1-A-2-B.[8] The time it takes to finish the exam determines the TMT score. An average score is 75 seconds; exceeding 273 seconds means there is a deficiency in executive function. If the participants are unable to finish it within 5 minutes, then the exam will stop (Ciolek & Lee, 2020). Also, TMT-B is considered validated as it exhibits construct validity as a measure of task-switching ability and working memory.[9]

Statistical analysis

The data were analyzed by using Microsoft Excel and IBM Statistical Package for the Social Sciences (SPSS) software version 27.0.1.0. For analyzing the distribution of data, the Kolmogorov-Smirnov test and the Shapiro-Wilk method were used. For inferential statistics, Spearman correlation (r) was used to investigate the relationship between academic stress, executive function, and sleep quality. The p-value was used to evaluate whether the correlation coefficient is statistically significant, with a threshold of $p< 0.05$, indicating a significant relationship. Then, the Mann-Whitney U and Kruskal-Wallis tests were utilized to examine the differences in academic stress, executive function, and sleep quality based on demographics. In short, the statistical technique used in this study is descriptive statistics, normality testing, and inferential analysis to reveal potential connections between academic stress, executive function, and sleep quality in study participants.

III. Result

After data collection, 401 individuals were successfully recruited for this study. More than half of the participants were female (64.6%), with a frequency of 259 out of 401 participants, while the percentage of male participants was 35.4% with a frequency of 142 out of 401 participants.60 participants (14.9%) were in the 18-19 age group, more than half (53.4%) of the participants falls into 20-21 age group (n=214; 53.4%). 99 participants (24.7%) were in the 22-23 age group, 24 participants (6.0%) were in the 24-25 age group, and 2 participants (0.5%) were in both the 26-27 and 28-29 age groups.

As shown in Table 1, the PAS global score, PSQI global score, and TMT-B score had a p-value less than 0.05 (p=0.000), indicating the results obtained were not normally distributed. The p-value for PAS global score, PSQI global score, and TMT-B score is <0.001. Since the p-value is less than 0.05, it implies that the data does not follow a normal distribution. As a result, nonparametric statistical approaches were used in the following investigations to account for the non-normal distribution of the data.

Table No. 1: Test of Normality for PAS scale, TMT-B, and PSQI

	Statistic	df	p-value	Statistic	df	p-value
PAS global score	0.072	401	<0.001	0.985	401	<0.001
PSQI global score	0.132	401	<0.001	0.970	401	<0.001
TMT-B score	0.139	401	<0.001	0.790	401	<0.001

Note: a = Lilliefors Significance Correction

Academic stress was measured using the PAS scale. It consists of 18 items, and every item's score ranges from 1 to 5. The responses are then added to get a global score. The higher the PAS global score, the higher the levels of academic stress. PAS scale can be further divided into three subscales: Academic Expectations (4 items), Workload and Examinations (8 items), and Students' Academic Self-Perceptions (6 items).

Table No. 2 Mean and Standard Deviation of PAS Global and Subscale Scores

Variables	Mean (SD)	Mean Item (SD)
PAS global scores	54.71 (11.1)	-

Subscales		
Academic Expectations	11.53 (3.22)	2.88 (0.80)
Workload and Examinations	25.63 (5.89)	3.2 (0.74)
Students' Academic Self-Perceptions	17.55 (4.29)	2.93 (0.72)

Table 2 shows that the mean score of the PAS global score is 54.71, with a standard deviation of 11.1. Among the subscales, the Workload and Examinations subscale had the highest mean item score (3.2, SD = 0.74), indicating that this area contributed the most to participants' academic stress. The Students' Academic Self-Perceptions subscale followed with a mean item score of 2.93 (SD = 0.72), suggesting that this aspect of academic stress is less than the subscale workload and examination. Finally, the Academic Expectations subscale had the lowest mean item score (2.88, SD = 0.80), reflecting relatively less stress compared to the other subscales.

Sleep quality of the participants was measured by PSQI. It measures seven components of sleep. The component scores are then added together to produce a global score. The poorer the sleep quality, the higher the scores obtained by the participants. The cutoff point for the poor sleepers was those who obtained 6 marks or above in the PSQI global score.

Table No. 3. Assessment of sleep quality using PSQI

Variables	Category	Frequency (%)	Mean	SD
PSQI global score	Good	184 (45.9%)	6.04	2.83
PSQI category	Poor	217 (54.1%)	-	-

Table No. 3 depicts the general sleep quality using the PSQI, and it shows a mean global score of 6.04 (SD = 2.83), indicating that participants had poor sleep quality on average. When categorized based on sleep quality, 184 participants (45.9%) were classified as having good sleep quality (PSQI ≤ 5), while 217 participants (54.1%) were classified as having poor sleep quality (PSQI > 5). The findings suggested that a slightly greater proportion of the participants had experienced poor sleep quality.

Table No. 4. Assessment of Executive Function using TMT-B

Variables	**Category**	**Frequency (%)**	**Mean**	**SD**
TMT-B score	-	-	58.37	28.73
TMT-B category	Normal	400 (99.8%)	-	-
	Deficit	1 (0.2%)	-	-

Table No. 4 shows that the mean of the TMT-B distribution is 58.37 seconds, with a standard deviation of 28.73. Since the threshold for executive function deficiency is defined as a completion time exceeding 273 seconds, the mean of 58.37 seconds is well within the normal range. Additionally, the standard deviation indicates that even participants at the upper end of the distribution (mean + 2 SD = approximately 115.83 seconds) are still well below the cutoff value, suggesting most participants have normal executive function. Only one participant exceeded this threshold, indicating a deficiency in executive function.

Association between Academic Stress and Sleep Quality

Spearman's Rho was used to investigate the relationship between academic stress and sleep quality because both are continuous data, and the data do not have a normal distribution.

Table No.5. Correlation between PAS and PSQI Global Score

			PAS global score	TMT-B score
Spearman's rho	PAS global score	Correlation Coefficient	1.000	0.107*
		Sig. (2-tailed)		0.032
		N	401	401
	TMT-B score	Correlation Coefficient	0.107*	1.000
		Sig. (2-tailed)	0.032	
		N	401	401

Note: *. Correlation is significant at the 0.05 level (2-tailed).

The analysis revealed several significant relationships among academic stress, sleep quality, and executive function. As shown in Table 5, academic stress and sleep quality showed a moderate positive correlation ($r = 0.375$, $p < 0.001$). This means higher academic stress is associated with poorer sleep quality. Academic stress and executive function demonstrated a weak positive correlation ($r = 0.107$, $p = 0.032$). This suggests that higher academic stress is only slightly associated with better executive function, though the relationship is very weak. Sleep quality and executive function showed a weak positive correlation ($r = 0.185$, $p < 0.001$). This indicates that poorer sleep quality is associated with poorer executive function. Additionally, the r^2 value (0.034) for the relationship between TMT-B and PSQI shows that only 3.4% of the variance in sleep quality is explained by executive function, meaning the relationship is weak and most variance is due to other factors.

Association between Executive Function and Sleep Quality

Spearman's Rho method is used to examine the association between executive function and sleep quality, as both results are continuous data and not normally distributed.

Table No. 6 Correlation between TMT-B Score and PSQI Global Score

TMT-B score			**PSQI global score**	
Spearman's rho	**TMT-B score**	Correlation Coefficient	1.000	0.185**
Sig. (2-tailed)			<0.001	
N		401	401	
PSQI global score	Correlation Coefficient	0.185**	1.000	
Sig. (2-tailed)			<0.001	
N			401	

The correlation analysis identified several significant relationships among executive function, sleep quality, and academic stress (Table 6). Executive function and sleep quality (TMT-B vs PSQI) showed a weak but significant positive correlation ($r = 0.185$, $p < 0.001$), indicating that poorer executive function is linked to poorer sleep quality. The r^2 value of 0.034 shows that executive function explains only 3.4% of the variance in sleep quality. Academic stress and sleep quality had a moderate positive correlation ($r = 0.375$, $p < 0.001$), meaning higher academic stress is associated with poorer sleep quality. Academic stress and executive function demonstrated a weak positive correlation ($r = 0.107$, $p = 0.032$), while sleep quality and executive function also showed a weak positive correlation ($r = 0.185$, $p < 0.001$), indicating that poorer sleep quality corresponds to weaker executive performance.

IV. Discussion

This study explored how academic stress influences executive function and sleep quality among university students. A total of 401 students from Universiti Tunku Abdul Rahman, Malaysia, participated in this cross-sectional study. Demographic variables such as gender, age, faculty, and year of study showed no significant differences in academic stress or sleep quality. However, executive function differed by gender and faculty, as females performed better than males, and students from the Faculty of Accounting and Management showed the weakest executive function.

The study identified a weak but statistically significant positive correlation between academic stress and executive function ($r = 0.107$, $p = 0.032$), indicating that higher academic stress is associated with poorer executive functioning. This aligns with earlier findings, such as Ma et al. (2025), who reported that academic stress exerts complex and varying effects on different components of executive function.[10] Their study showed that certain forms of self-imposed stress may enhance aspects of executive control, including interference inhibition, response inhibition, and attention switching.

The neurobiological basis for the link between stress and executive function is well established. Dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis under acute and chronic stress increases cortisol levels, which can impair synaptic plasticity and reduce prefrontal cortex activity, thus affecting learning and memory processes.[11,12] Acute stress disrupts working memory through glucocorticoid release and neural pathway activation, whereas chronic stress induces hormonal and neurotoxic changes in the hippocampus that impair working memory performance.[13] These mechanisms support the conclusion that academic stress can influence executive functioning. Despite being significant, the effect observed in this study was small, explaining only a minor portion of executive function variability. This finding contrasts with previous studies reporting stronger stress–executive function associations. The largely young adult sample (aged 18–29) may partially explain this, as younger individuals typically exhibit stronger executive functioning and working memory than older adults.[11] Thus, the narrow age range may limit generalisability to wider age groups. The relationship between stress and cognitive performance can also be interpreted through the Yerkes–Dodson law, which proposes an inverted Ushaped pattern in which moderate stress enhances performance, but excessive stress reduces cognitive efficiency.[4,14] This framework helps explain why academic stress may influence executive function differently depending on its intensity

These results align with prior research highlighting the adverse impact of academic stress on sleep patterns and overall sleep health. The findings from previous studies further support this relationship. For example, a cross-sectional study of 450 Indonesian college students revealed a significant correlation between stress levels and sleep quality, with students who had poor sleep quality being 4.7 times more likely to have greater stress levels than those who had good sleep quality.[15] With an emphasis on Malaysia, a study including 90 undergraduate students studying cognitive science at Universiti Malaysia Sarawak found a slight association between sleep quality and felt stress, suggesting that although there is a correlation, it is not very strong. Stress levels were also higher among those who reported having trouble sleeping.[16] This points to a moderate association between the two variables. A meta-analysis also showed that academic stress is associated with sleep quality among urban students, supporting the idea that as academic stress increases, sleep quality deteriorates.[17]

The link between academic stress and poor sleep quality can be explained through various mechanisms. Stress activates the hypothalamic-pituitary-adrenal (HPA) axis and increases the secretion of cortisol, a stress hormone that plays a crucial role in the body's response to stress.[11] Cortisol levels are vital for regulating the circadian rhythm, increasing immediately before awakening and decreasing during sleep. Elevated cortisol can disrupt this cycle, leading to difficulty in falling asleep and staying asleep, especially by reducing slow-wave sleep and increasing nighttime awakenings.[18] Poor sleep quality negatively affects cognitive performance, emotional health, and physical well-being, which is particularly concerning for university students as it can harm their academic success and overall health. To address these issues, targeted interventions such as mindfulness training, time management workshops, seeking support, and promoting good sleep hygiene can help lower academic stress and enhance sleep quality.

The present study observed a weak but statistically significant positive correlation between executive function and sleep quality ($r = 0.185$, $p < 0.001$), suggesting that better sleep quality is associated with improved executive function.

This finding aligns with prior research indicating that sleep is critical for cognitive processes, including working memory, attention, and decision-making, which are integral components of executive function.[19] For instance, Sen & Tai (2023) demonstrated that sleep deprivation leads to impairments in tasks requiring executive control, indicating that insufficient or poor-quality sleep can detrimentally affect cognitive performance.[20] Similarly, studies have shown that individuals with better sleep quality tend to perform better on tasks assessing executive functions.[21] Another study has shown that sleep duration of seven hours per day was related to the maximum cognitive performance, which dropped for every hour above and below this sleep duration.[22]

Sleep is also vital for memory consolidation (Klinzing et al., 2019), which is a process in which a temporary, labile memory is transformed into a more stable, long-lasting form.[23] During slow-wave sleep (SWS) and rapid eye movement (REM) sleep, the brain strengthens synaptic connections and integrates newly acquired information.[24] Poor sleep quality disrupts these phases, leading to fragmented memory consolidation and impaired hippocampal function. Without proper memory integration, working memory and cognitive flexibility suffer, making it harder to retain and apply new information.[25]

However, the weak correlation observed in this study suggests that while sleep quality is an important factor influencing executive function, it is not the sole determinant. This finding resonates with the work of Lim & Dinges (2010), who noted that while sleep deprivation can lead to significant cognitive deficits, individual differences in resilience and compensatory strategies may mitigate these effects.[26]

The study focused on university students aged 18 to 29, who are generally more resilient to the effects of sleep deprivation on executive function compared to older adults. While college students sleeping less than seven hours per night showed lower working memory and executive function scores, the impact was relatively minor.[27] In contrast, older adults face age-related cognitive declines and changes in sleep patterns, which worsen the effects of poor sleep quality. [20]

V. Conclusion

This study demonstrates that academic stress, sleep quality, and executive functioning are interrelated among university students, though the relationships are generally weak. Academic stress was associated with poorer sleep quality and reduced executive functioning, while sleep quality and executive functioning were also weakly linked. Gender and faculty differences emerged in executive functioning, but academic stress and sleep quality did not vary across demographic groups. These findings align with previous research and highlight the complex influences of neurobiological factors, developmental stages, and lifestyle behaviours. The limitations of this study, including its cross-sectional design and reliance on self-report instruments, indicate the need for stronger future research. Longitudinal studies, larger and more diverse samples, objective measurements, and more comprehensive assessments of executive function are recommended to deepen understanding of these relationships.

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