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Research Paper

The Influence of Perceived Stress and Sleep Quality on Migraine Frequency Among University Students in India

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ABSTRACT

This study investigated the influence of perceived stress and sleep quality on migraine frequency among 100 English-speaking university students in India (Mean=20.43 years), using a cross-sectional survey design. Data were collected via the Perceived Stress Scale (PSS-10), Pittsburgh Sleep Quality Index (PSQI), and ID-Migraine™ screener, alongside self-reported migraine frequency. Results indicated significant positive correlations between higher perceived stress (r=.278, p<.01) and poorer sleep quality (r=.366, p<.001) with increased migraine frequency. Multiple regression analysis confirmed both perceived stress (β=0.48, p=.018) and poor sleep quality (β=0.97, p=.002) as unique, independent predictors, together explaining 15% (R2=.15) of variance in migraine frequency. No significant gender differences emerged for stress or sleep quality. Findings highlight that perceived stress and poor sleep are distinct, modifiable contributors to migraine frequency, suggesting interventions addressing both are needed for Indian university students to potentially reduce their migraine burden.

Keywords: *Migraine, Perceived Stress Sleep Quality, University Students, India*

Migraine is a prevalent and often debilitating neurological disorder, recognized globally as a significant public health concern. Characterized by recurrent, severe headaches—frequently unilateral and pulsating—migraine episodes are commonly accompanied by debilitating symptoms such as nausea, vomiting, photophobia, and phonophobia (Headache Classification Committee of the International Headache Society, 2018). Beyond the acute suffering during attacks, migraine profoundly impacts individuals' quality of life, impairing daily functioning, academic or occupational performance, and social engagement. The economic burden is also substantial, stemming from direct healthcare expenditures and indirect costs associated with lost productivity (Steiner et al., 2015). Understanding the factors that trigger or exacerbate migraine is crucial for developing effective prevention and management strategies.

The burden of migraine is particularly pertinent among young adults, a demographic that includes university students. This population frequently encounters a confluence of academic pressures, social adjustments, and lifestyle changes that may heighten vulnerability to migraine (Flynn et al., 2022). University life, while a period of growth and

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opportunity, inherently presents numerous demands that can act as potent stressors. Flynn et al. (2022), in a comprehensive systematic review and meta-analysis, highlighted the significant prevalence and impact of migraine within university student populations globally, underscoring the unique challenges these individuals face. The university period represents a critical developmental phase where individuals often establish long-term health behaviors and coping mechanisms. Migraine onset or an increase in attack frequency during these formative years can have lasting repercussions, potentially affecting academic success, career trajectories, and overall future health and well-being. Given that patterns of managing (or not managing) health conditions developed during this time can persist, a deeper understanding of migraine correlates in this specific group is essential for timely and effective interventions.

Among the myriad factors implicated in migraine, psychosocial elements, particularly perceived stress, have garnered considerable attention. Perceived stress refers not to the presence of objective stressors alone, but rather to an individual's subjective appraisal of situations as threatening, unpredictable, uncontrollable, or overwhelming, exceeding their perceived ability to cope (Cohen et al., 1983). This conceptualization aligns with the transactional model of stress and coping proposed by Lazarus and Folkman (1984), which posits that stress arises from an ongoing interaction between an individual and their environment, mediated by cognitive appraisal processes. Within this framework, the university environment, with its inherent academic rigor, examinations, social reconfigurations, and concerns about the future, provides a fertile ground for the generation of perceived stress.

A substantial body of evidence links perceived stress to the triggering and exacerbation of migraine attacks. Stress is consistently reported as one of the most common and potent precipitants of migraine episodes (Kelman, 2007; An et al., 2019). For instance, Kelman (2007) found that nearly 80% of individuals in a large clinic-based sample identified stress as a trigger for their migraines. Similarly, studies have demonstrated that individuals with migraine often report higher levels of perceived stress compared to those without migraine or with other headache types (Moon et al., 2017). The pathophysiological pathways connecting stress to migraine are thought to involve the dysregulation of key neurobiological systems, including the hypothalamic-pituitary-adrenal (HPA) axis and the autonomic nervous system (ANS) (Sic et al., 2025). Chronic or heightened perceived stress can lead to alterations in these systems, promoting neuroinflammation, reducing pain thresholds, and inducing vascular changes, all of which are implicated in migraine pathogenesis. The focus on *perceived* stress, as typically measured by instruments like the Perceived Stress Scale (PSS-10; Cohen et al., 1983), is particularly salient because it underscores a modifiable psychological target. While objective stressors in an academic setting, such as examination schedules or assignment deadlines, may be difficult to alter, an individual's appraisal of these stressors and their perceived coping capacity are amenable to change. This distinction suggests that interventions aimed at modifying stress appraisal and enhancing coping strategies, such as cognitive-behavioral therapy or mindfulness-based stress reduction, could be valuable in mitigating the impact of stress on migraine, even if the external demands remain constant.

Alongside perceived stress, sleep disturbances represent another critical modifiable psychosocial factor with a strong and complex relationship with migraine. Adequate sleep is fundamental for maintaining physiological homeostasis and psychological well-being, and

disruptions in sleep quality or quantity are widely recognized as potential triggers for various health problems, including headaches. The connection between sleep and migraine is robust and often described as bidirectional: poor sleep can trigger migraine attacks, and migraine-related pain can, in turn, disrupt sleep (Tiseo et al., 2020). A systematic review by Tiseo et al. (2020) confirmed that sleep disturbance is a well-established trigger and a common comorbidity in individuals with migraine, with potential shared neurobiological underpinnings involving brain regions like the hypothalamus, which regulates both sleep-wake cycles and pain processing. Studies have consistently found that individuals with migraine report poorer sleep quality and a higher prevalence of sleep disorders compared to control populations (Almansour et al., 2025; Lin et al., 2016). For example, Lin et al. (2016) demonstrated a significant correlation between higher migraine frequency and poorer scores on the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), even after controlling for anxiety and depression. More recent preclinical evidence suggests that sleep disruption may be more likely to increase vulnerability to migraine-like pain rather than pain itself, significantly disrupting sleep architecture, further emphasizing the role of poor sleep as a precursor (Lillo Vizin et al., 2024). The high prevalence of poor sleep quality frequently observed among university students—a group often contending with irregular sleep schedules due to academic workloads, social activities, and other commitments—may establish a state of chronic physiological vulnerability. This sustained pattern of compromised sleep could lower the threshold for migraine attacks, potentially interacting with or amplifying the effects of other triggers, such as acute stressors. Thus, poor sleep quality may function as a pervasive background factor that heightens susceptibility to migraine in this population.

Perceived stress and poor sleep quality often co-occur, particularly within the demanding milieu of university life. Elevated stress levels can contribute to difficulties initiating or maintaining sleep, while insufficient or unrefreshing sleep can, in turn, exacerbate stress perception, impair emotional regulation, and reduce an individual's capacity to cope effectively with daily challenges (Dikmen et al., 2015). The unique pressures faced by university students—ranging from academic performance expectations and examination stress to social integration and concerns about future careers—can create a synergistic cycle where stress and sleep problems fuel each other, potentially increasing the risk or frequency of migraine attacks.

While the individual associations between stress and migraine, and sleep and migraine, are relatively well-documented in global literature, there is a specific need to understand these relationships within diverse cultural and academic contexts. The present study focuses on English-speaking university students in India, a demographic that may experience a unique interplay of academic, social, and cultural factors influencing both their stress levels, sleep patterns, and migraine experiences. Research from non-Western contexts, such as India, is essential for a more comprehensive global understanding of migraine and its correlates, as findings from Western populations may not be universally generalizable. Furthermore, gender differences in migraine prevalence are well-established, with women typically exhibiting higher rates. Studies among Indian university students also suggest potential gender disparities in perceived stress and sleep quality. These observations raise the question of whether gender might moderate the relationships between these psychosocial factors and migraine frequency. A critical question that remains less explored, particularly in this specific demographic, is whether perceived stress and poor sleep quality make unique, independent contributions to predicting migraine frequency when considered

simultaneously, and whether these relationships differ by gender. Understanding such independent and potentially gender-specific effects is vital; if both factors uniquely predict migraine frequency, and these relationships vary for male and female students, then interventions aimed at reducing migraine burden would need to address both stress management and sleep hygiene in a gender-sensitive manner. Conversely, if their predictive power significantly overlaps or does not differ by gender, a more generalized intervention might be sufficient. This specificity is crucial for developing culturally attuned and resource-efficient health initiatives within university settings. The current investigation seeks to address this gap by examining these relationships specifically among Indian university students.

Therefore, the overarching objective of the present study was to clarify how two modifiable psychosocial factors—perceived stress and sleep quality—relate to the frequency of migraine attacks among English-speaking university students in India. The emphasis on "modifiable" factors underscores the potential for these findings to inform targeted interventions aimed at improving student well-being.

To achieve this objective, the study sought to explore four specific research questions:

- What is the relationship between perceived stress (as measured by PSS-10 scores) and migraine attack frequency in Indian university students?
- What is the relationship between global sleep quality (as measured by PSQI scores) and migraine attack frequency in Indian university students?
- When considered simultaneously, do perceived stress and sleep quality each make a unique, independent contribution to predicting migraine frequency in this population?
- Are there gender differences in the relationships between perceived stress, sleep quality, and migraine attack frequency among Indian university students?

METHOD

Sample

The final sample comprised 100 university students, aged between 17 to 25 years (M = 20.43, SD = 1.77). The sample comprised 49 % men (n = 49), 43 % women (n = 43), and 8 % who identified as “other” (n = 8). Participants were enrolled in accredited undergraduate or graduate programs across various Indian universities. All participants possessed sufficient English proficiency to comprehend and respond to the survey instruments. Demographic information, including age, gender, and academic program, was collected to characterize the sample.

Sampling Methods

A two-stage non-probability sampling strategy was employed. Initially, convenience sampling involved disseminating a survey link through university listservs and student-run social media platforms (e.g., Facebook, Instagram, WhatsApp). Subsequently, snowball sampling was utilized by requesting participants to share the survey link with peers, thereby broadening the reach. Although the initial recruitment goal was 300 participants, data collection ceased when daily response rates fell below one for 10 consecutive days. A post-hoc power analysis indicated that a sample size of 100 provided 80% power to detect medium effect sizes ($r \geq .28$) (Faul et al., 2009).

- **Inclusion Criteria:**

Participants were eligible to take part in the study if they were at least 18 years old and currently enrolled in an accredited undergraduate or graduate program in India. Additional requirements included the ability to read and understand English sufficiently to complete the survey instruments, as well as access to a stable internet connection. Crucially, participants were required to screen positive for probable migraine using the ID-Migraine™ screener (Lipton et al., 2003), which identifies individuals who experience at least two of the following during headaches: nausea, sensitivity to light, or functional impairment (e.g., missed school or work). This criterion ensured that the study sample reflected individuals with clinically suggestive migraine symptoms.

- **Exclusion Criteria:**

Participants were excluded from the study if they self-reported any major neurological disorder other than migraine, such as epilepsy or multiple sclerosis. Individuals currently taking daily migraine prophylactic medications, benzodiazepines, or prescription sleep aids were also excluded, given the potential confounding effects of these treatments on both stress and sleep measures. Additional exclusion criteria included incomplete survey responses, defined as completion of fewer than 50% of core items, and failure to pass an embedded attention-check item within the Perceived Stress Scale (PSS-10), which served to verify respondent attentiveness and data integrity.

Tools Used

- **Perceived Stress:** Perceived stress was measured using the **Perceived Stress Scale–10 (PSS-10)** developed by Cohen, Kamarck, and Mermelstein (1983). The PSS-10 is a widely used self-report instrument designed to assess the degree to which individuals appraise situations in their life as stressful, unpredictable, uncontrollable, and overwhelming during the past month. It is grounded in the transactional model of stress and coping, emphasizing subjective appraisal rather than objective stressors. The scale comprises 10 items rated on a 5-point Likert-type scale ranging from 0 ("never") to 4 ("very often"). Four of the items are positively worded and are reverse-scored. Total scores range from 0 to 40, with higher scores indicating greater perceived stress. Psychometric evaluations have demonstrated strong reliability: the original development study reported Cronbach's alpha values ranging from .84 to .86 in college and community samples (Cohen et al., 1983), and a meta-analysis by Lee (2012) confirmed a pooled alpha of .78 across 19 studies. In the present sample, internal consistency was also good, with Cronbach's $\alpha = .82$. In terms of validity, the PSS-10 has shown good construct validity, with scores correlating positively with measures of anxiety and depression and negatively with measures of life satisfaction and perceived control (Cohen et al., 1983; Lee, 2012). Criterion-related validity is also supported, as the scale predicts physiological markers of stress such as salivary cortisol levels (Pruessner et al., 2003).
- **Sleep Quality:** Subjective sleep quality was assessed using the **Pittsburgh Sleep Quality Index (PSQI)** developed by Buysse, Reynolds, Monk, Berman, and Kupfer (1989). The PSQI is a standardized self-report questionnaire that evaluates sleep habits and disturbances over the preceding month. It was designed to discriminate "good" from "poor" sleepers and is frequently used in both clinical and non-clinical populations. The PSQI contains 19 self-rated items grouped into 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 on a 0 to 3 scale, and the sum of these components yields a global score ranging from 0 to 21. A global score greater than 5 indicates poor sleep quality, a cut-off supported by sensitivity (89.6%) and specificity (86.5%) estimates in distinguishing individuals with primary insomnia from healthy controls (Buysse et al., 1989). The PSQI has demonstrated strong psychometric properties, with internal consistency estimates typically above $\alpha = .70$. In this study, Cronbach's alpha for the global score was $\alpha = .75$. The PSQI has also shown good convergent validity, correlating with polysomnographic and actigraphic indices of sleep, and with clinical diagnoses of sleep disorders (Carpenter & Andrykowski, 1998). It has been validated in Indian student populations, further supporting its use in this context (Saini et al., 2016).

- **Migraine Screening and Frequency:** Migraine status was determined using the **ID-Migraine™ screener** developed by Lipton et al. (2003). This is a brief, validated screening tool widely used in epidemiological studies to identify probable migraine without requiring a clinical diagnosis. The tool comprises three yes/no items assessing (a) nausea, (b) sensitivity to light, and (c) disability (i.e., interruption of daily activities) during recent headaches. Endorsing at least two of the three items constitutes a positive screen for probable migraine. The ID-Migraine™ has demonstrated good diagnostic accuracy in primary care settings, with a reported sensitivity of 81% and specificity of 75% compared to neurologist-confirmed migraine diagnoses (Lipton et al., 2003). Although it is not a formal diagnostic tool, it is endorsed for population-based research due to its brevity and ease of use. In addition to the screener, participants were asked to report the **number of migraine attacks experienced in the past four weeks**, using a single open-ended numeric item ("Please enter the exact number of migraine headaches you have had in the last 28 days"). A 4-week recall period is standard in clinical trials and shows strong concordance with prospective diary counts when recall does not exceed one month (Lipton et al., 2019).

Research Design

This study utilized a quantitative, cross-sectional, correlational survey design to examine associations between perceived stress, sleep quality, and migraine frequency among Indian university students. A cross-sectional design entails collecting data from a population at a single point in time, providing a snapshot of variables of interest (APA, 2007). Correlational research assesses the statistical relationship between two or more variables without inferring causality (APA, 2007). This design was appropriate for testing associative hypotheses. Although the design precludes causal inference and is susceptible to common-method variance, cross-sectional surveys remain the standard first step for mapping associations in large, geographically dispersed populations where random assignment and longitudinal follow-up are logistically prohibitive (Shadish, Cook, & Campbell, 2002). All focal variables referenced the same four-week period to minimise temporal mismatch.

Procedure

Participants were recruited online through recruitment announcements containing a brief study description and a hyperlink to the survey form, which were distributed through student groups. The recruitment message invited eligible students to participate in a study on stress, sleep, and migraine. Upon accessing the survey link, participants were first presented with an informed consent form. Only individuals who provided consent were permitted to

proceed to the main questionnaire. The survey was self-administered and presented in the following fixed order: demographic and eligibility screening items, the ID-Migraine™ screener, a single-item migraine frequency question, the Perceived Stress Scale–10 (PSS-10), and the Pittsburgh Sleep Quality Index (PSQI). To ensure data integrity and participant privacy, no identifying information (e.g., names, IP addresses) was collected.

Data Analysis

Data were analysed with IBM SPSS Statistics 28. Preliminary screening addressed missingness (< 2 % per variable) and univariate outliers (> 3 SD). Scale scores were computed per scoring manuals (Buysse et al., 1989; Cohen et al., 1983). Descriptive statistics summarised central tendency and variability. Pearson's correlations tested RQ1 and RQ2. To evaluate RQ3, migraine frequency served as the dependent variable in an ordinary least-squares multiple regression with PSS-10 and PSQI scores as simultaneous predictors. Assumptions of linearity, homoscedasticity, and multicollinearity (variance inflation factor < 2) were checked; both residual histograms and scatterplots indicated acceptable fit. Statistical significance was set at $\alpha = .05$ (two-tailed). Effect sizes (r, β) were interpreted via conventional benchmarks (Cohen, 1988).

RESULTS

Descriptive Statistics

Descriptive statistics for the main study variables—perceived stress (PSS), sleep quality (PSQI), and migraine frequency—are presented in Table 1. The average perceived stress score was 19.94 (SD = 4.42), and the average sleep quality score was 10.49 (SD = 2.93). Participants reported a mean migraine frequency of 3.98 episodes (SD = 1.98). The total sample consisted of 100 participants.

Table 1 Descriptive Statistics for Main Variables (N = 100)

Variable	M	SD	Min	Max
Perceived Stress	19.94	4.42	10	30
Sleep Quality	10.49	2.93	3	18
Migraine Frequency	3.98	1.98	1	9

Correlational Analyses

Pearson correlation coefficients were computed to assess the relationships among the three primary variables. As shown in Table 2, perceived stress was positively correlated with migraine frequency ($r = .278$, $p < .01$), and sleep quality was also positively correlated with migraine frequency ($r = .366$, $p < .001$). These results suggest that greater perceived stress and poorer sleep quality are both associated with increased migraine frequency.

Table 2 Correlation Matrix of Key Variables

	PSS	PSQI	Migraine Frequency
PSS	1.000	.040	**.278****
PSQI	.040	1.000	**.366*****
Migraine Frequency	**.278****	**.366*****	1.000

Note. $p < .05$ = *, $p < .01$ = **, $p < .001$ = ***

Multiple Regression Analysis

A multiple linear regression was conducted to examine whether perceived stress and sleep quality significantly predicted migraine frequency. The model was significant, $F(2, 97) = 8.47$, $p < .001$, and explained approximately 15% of the variance in migraine frequency ($R^2 = .15$).

Both perceived stress and sleep quality were significant predictors. Perceived stress significantly predicted migraine frequency, $B = 0.102$, $SE = 0.042$, $\beta = 0.48$, $t(97) = 2.41$, $p = .018$. Sleep quality also emerged as a significant predictor, $B = 0.205$, $SE = 0.063$, $\beta = 0.97$, $t(97) = 3.24$, $p = .002$. This indicates that individuals experiencing higher levels of stress and poorer sleep quality tend to report more frequent migraines.

Table 3 Multiple Regression Predicting Migraine Frequency

Predictor	B	SE B	β	t	p
Constant	-0.202	1.067	-0.96	-0.19	.850
PSS Score	0.102	0.042	0.48	2.41	.018*
PSQI Score	0.205	0.063	0.97	3.24	.002**

Note. $p < .05$ = *, $p < .01$ = **, $p < .001$ = ***

Gender Differences

To examine whether perceived stress, sleep quality, and migraine frequency differed across gender groups, a series of one-way analyses of variance (ANOVAs) were conducted. The gender categories included Woman ($n = 43$), Men ($n = 49$), and Other ($n = 8$). Descriptive statistics by gender are presented in Table 4.

The ANOVA for perceived stress scores revealed no significant differences among gender groups, $F(2, 97) = 1.08$, $p = .344$. Similarly, sleep quality did not significantly differ across genders, $F(2, 97) = 0.52$, $p = .594$.

There was a trend toward significance for migraine frequency, $F(2, 97) = 2.84$, $p = .063$. Although this finding did not meet the conventional threshold for statistical significance ($p < .05$), the result suggests potential gender-based differences in migraine frequency that may warrant further investigation in larger or more targeted samples.

Table 4 Descriptive Statistics of Main Variables by Gender

Gender	Variable	M	SD	N
Woman	Perceived Stress	19.65	4.60	43
	Sleep Quality	10.47	2.90	
	Migraine Frequency	4.23	2.09	
Man	Perceived Stress	20.29	4.18	49
	Sleep Quality	10.51	3.00	
	Migraine Frequency	3.59	1.75	
Other	Perceived Stress	19.50	5.00	8
	Sleep Quality	10.63	2.72	
	Migraine Frequency	4.25	2.12	

Note. N = number of participants in each gender group.

DISCUSSION

This study investigated the influence of perceived stress and sleep quality on migraine frequency among university students in India. The findings offer valuable insights into the interplay of these psychosocial factors and their collective impact on a population known to experience significant academic and lifestyle pressures. The discussion will interpret the findings for each research question, integrating them with existing literature, and consider the study's limitations and implications for future research and intervention.

The primary aim was to clarify how perceived stress and sleep quality relate to migraine attack frequency in this specific demographic. The study hypothesized that higher perceived stress and poorer sleep quality would be associated with more frequent migraines and that these factors would independently contribute to migraine frequency. Gender differences were also explored.

The first research question explored the link between perceived stress, measured by the Perceived Stress Scale-10 (PSS-10), and the frequency of migraine attacks. The study identified a statistically significant positive correlation (r=.278) between these variables, suggesting that students reporting higher levels of perceived stress also tended to experience migraines more often. This observation is broadly consistent with a large body of research that identifies stress, particularly an individual's subjective appraisal of it, as a prominent factor in migraine (Kelman, 2007; An et al., 2019). For instance, a study by An et al. (2019) on clinical outpatients in Taiwan found that higher perceived stress was significantly associated with increased migraine frequency (P<.001), with individuals experiencing high-frequency migraines reporting greater stress levels than those with low-frequency migraines (P<.05). While the current study did not categorize migraine frequency in the same way, the correlational finding points in a similar direction. The link between stress and migraine is often conceptualized as stress acting as a potent trigger for migraine attacks or as an exacerbating factor for an existing migraine condition (Martin et al., 2016). The physiological mechanisms underlying this relationship are complex, potentially involving the activation of the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system, which can, in turn, influence neuropeptide release and neuroinflammation implicated in migraine pathophysiology (Sauro & Becker, 2009).

The second research question investigated the association between global sleep quality, measured by the Pittsburgh Sleep Quality Index (PSQI), and migraine attack frequency. The findings revealed a statistically significant positive correlation (r=.366, p<.001), indicating that students with poorer sleep quality tended to report more frequent migraine attacks. This result aligns robustly with extensive research highlighting a strong, often bidirectional, relationship between sleep disturbances and migraine (Almansour et al., 2025; Kelman, 2007; Lin et al., 2016; Tiseo et al., 2020). Tiseo et al. (2020), in a systematic review, confirmed that sleep disturbance is a well-recognized trigger and a common comorbidity in migraine, potentially linked through the hypothalamus, a brain region involved in regulating both sleep-wake cycles and migraine generation. Similarly, Al Harbi et al. (2025) in a Saudi Arabian population, which included a large proportion of university students (75.5%), found a significant positive correlation between poorer sleep quality (PSQI) and higher migraine severity as measured by the MIDAS (r=0.179, p<.001). Although Al Harbi et al. (2025) focused on severity rather than frequency directly, migraine severity and frequency are often interrelated. Furthermore, Çakmak et al. (2024) found that adult migraine patients presenting to an emergency department had significantly higher PSQI scores (indicating poorer sleep)

compared to healthy controls (p=0.020), underscoring the link between disturbed sleep and active migraine. Similarly, Termine et al. (2020), in a study of female college students, found that migraine frequency was significantly related to sleep disturbance (p=.003) as measured by the Medical Outcomes Study Sleep Scale. The current study's finding in an Indian university student cohort adds to this evidence, emphasizing that compromised sleep is a significant correlate of more frequent migraines in this population.

The third research question addressed whether perceived stress and sleep quality each make unique, independent contributions to predicting migraine frequency when considered simultaneously. The multiple linear regression analysis provided an affirmative answer: both perceived stress (PSS-10 scores; β=0.48, p=.018) and poor sleep quality (PSQI global scores; β=0.97, p=.002) emerged as statistically significant independent predictors of migraine attack frequency.1 The overall model was significant, $F(2,97)=8.47$, $p<.001$, and accounted for approximately 15% of the variance in migraine frequency ($R2=.15$).1 This finding is particularly important as it suggests that perceived stress and poor sleep quality are not merely redundant or overlapping constructs in their association with migraine frequency; rather, they appear to exert distinct influences. This implies that interventions aimed at reducing migraine burden may need to target both factors. Some research has explored these factors in conjunction; for example, Kim et al. (2020) found that worse sleep quality was independently associated with a greater headache-related impact, with an indirect effect mediated by headache frequency and severity in individuals with migraine.20 The current study builds upon this by demonstrating their independent predictive value specifically for migraine frequency within an Indian university student cohort.

The standardized beta coefficient for poor sleep quality (β=0.97) was notably larger than that for perceived stress (β=0.48) in this model, suggesting that poor sleep quality had a stronger independent association with migraine frequency among these students. This reinforces the observation from the bivariate correlations and implies that, when controlling for perceived stress, a one standard deviation increase in the PSQI score (indicating poorer sleep) is associated with a nearly one standard deviation increase in reported migraine frequency. This represents a substantial independent effect and could guide the prioritization of intervention targets. However, the model explained 15% of the total variance in migraine frequency. While statistically significant, this proportion indicates that perceived stress and poor sleep quality, even when considered together, account for a modest part of the overall variability in why students experience migraines at differing frequencies. This underscores the recognized multifactorial etiology of migraine. A host of other factors not measured in this study—such as genetic predispositions, specific dietary triggers, hormonal fluctuations (particularly relevant in a sample comprising 69% women), other environmental influences, or different facets of stress (e.g., academic-specific pressures versus general perceived stress)—likely contribute significantly to migraine frequency (Flynn et al., 2022; Kelman, 2007). While this study focused on independent contributions, future investigations might also explore potential interaction effects, for instance, whether high levels of stress exacerbate the impact of poor sleep on migraine frequency beyond their simple additive effects, a phenomenon suggested by some literature (Hammond et al., 2019).

The fourth research question explored potential gender differences in perceived stress, sleep quality, and migraine attack frequency. One-way ANOVAs indicated no statistically significant differences among female (n=43), male (n=49), and other gender identity (n=8) groups for perceived stress scores ($F(2,97) =1.08$, $p=.344$) or for global sleep quality scores

($F(2,97) = 0.52$, $p=.594$). The absence of significant gender differences in perceived stress is consistent with a body of literature that shows mixed results, with some studies indicating higher stress in female students and others finding no significant differences or more similarities than differences. or example, Jain and Das (2021) found that female Indian university students experienced significantly higher perceived stress than male students ($p<.01$) during the pandemic. Similarly, Kaur and Bajaj (2023) reported significantly higher perceived stress levels among female college students ($M=21.50$) compared to males ($M=19.45$) in Ludhiana, Punjab ($t=2.88$). Similarly, while some research suggests that female students may experience worse sleep quality, the current study did not find significant gender variations in PSQI scores. For migraine attack frequency, the analysis revealed a trend towards significance ($F(2,97)=2.84$,$p=.063$). Although not statistically significant, The trend towards higher migraine frequency in women ($p=.063$) observed in this study is consistent with extensive epidemiological data indicating that migraine is more prevalent and can be more frequent in women (Stewart et al., 2008). The current study's sample size, especially for the 'Other' gender category, might have limited statistical power to detect existing differences. This observed trend, however, underscores the potential importance of gender as a factor in migraine frequency within this student population, consistent with global patterns of women being more affected by migraines, and suggests that further research with larger, more diverse samples is warranted to fully elucidate these gender-specific patterns in the Indian university context.

Strengths, Limitations, and Future Directions

This study possesses several strengths, including its focus on an important public health issue within a specific and relevant demographic—university students in India—thereby contributing valuable data from a non-Western context where such research may be less prevalent. The use of standardized and validated instruments for assessing perceived stress (PSS-10; Cohen et al., 1983; Lee, 2012), sleep quality (PSQI; Buysse et al., 1989; Carpenter & Andrykowski, 1998; Manzar et al., 2015), and for migraine screening (ID-Migraine™; Lipton et al., 2003) enhances the reliability of the findings. Notably, both the PSS-10 (Cronbach's $\alpha=.82$) and the PSQI (Cronbach's $\alpha=.75$) demonstrated good internal consistency within the current sample. The simultaneous examination of both stress and sleep allows for a more nuanced understanding of their roles than if studied in isolation, and a post-hoc power analysis indicated that the study was adequately powered to detect medium-sized correlations. However, the study is not without limitations. The primary limitation is its cross-sectional design, which prohibits the establishment of causal relationships or the determination of temporal precedence between stress, poor sleep, and migraine attacks (Shadish, Cook, & Campbell, 2002). It remains possible, for instance, that frequent migraines contribute to increased perceived stress or result in poorer sleep quality, rather than vice-versa, although existing literature often suggests stress and poor sleep act as triggers (Kelman, 2007; Tiseo et al., 2020). Secondly, the use of non-probability sampling methods (convenience and snowball sampling) may restrict the generalizability of the findings to the broader population of English-speaking university students in India, as the sample may not be fully representative. Thirdly, the reliance on self-report questionnaires for all key variables introduces the potential for biases, such as recall bias (particularly for migraine frequency reported over a four-week period, although the study methodology references Lipton et al., 2019, in support of this recall duration) and social desirability bias. Fourthly, migraine status was ascertained using a screening tool (ID-Migraine™) rather than a clinical diagnosis by a healthcare professional. While the ID-Migraine™ has demonstrated good sensitivity and specificity (Lipton et al., 2003), it is not a substitute for a formal

clinical diagnosis and may have led to some misclassification. Fifthly, although the sample size (N=100) was deemed adequate for detecting medium correlations, it is relatively modest for multiple regression analyses and for making broad generalizations to the diverse student population across India; the predominance of female participants (69%) also means findings may be more characteristic of female students. Finally, the study focused on two psychosocial factors, leaving other potential variables known to influence migraine, such as specific dietary habits, physical activity levels, hormonal cycles, precise academic stressors, and comorbid mental health conditions beyond general perceived stress, unexplored. The 15% variance in migraine frequency explained by the model underscores that a considerable portion of variability is attributable to these other unmeasured factors.

The findings of this study have several important implications and pave the way for future research. Clinically, the results highlight the necessity of screening for and addressing perceived stress and poor sleep quality among university students in India, particularly those who report frequent headaches. University health services and counseling centers could benefit from developing and implementing targeted psychoeducational programs and interventions that focus on evidence-based stress management techniques (e.g., mindfulness practices, cognitive-behavioral strategies) and comprehensive sleep hygiene education. Given the independent contributions of both stress and sleep, a dual-pronged approach that concurrently addresses both factors may prove more effective in mitigating the migraine burden experienced by this population. Future research should prioritize longitudinal studies to better investigate the temporal relationships and potential causal pathways linking perceived stress, sleep quality, and the development or exacerbation of migraines over time in this specific demographic. Intervention studies are also warranted to design and rigorously evaluate the efficacy of programs targeting stress reduction (e.g., Mindfulness-Based Stress Reduction, Cognitive Behavioral Therapy for stress) and sleep improvement (e.g., Cognitive Behavioral Therapy for Insomnia, tailored sleep hygiene protocols) on migraine frequency, severity, and related disability among Indian university students. To enhance generalizability, future studies should aim for larger, more diverse, and representative samples of students from various academic disciplines, types of institutions, and geographical regions across India. The incorporation of objective measures alongside self-reports—such as actigraphy for monitoring sleep patterns, ecological momentary assessment (EMA) for capturing real-time fluctuations in stress and headache occurrence, or physiological markers of stress like salivary cortisol (although its direct correlation with PSS scores can be complex, Pruessner et al., 2003)—would strengthen the robustness of findings. Further research could also delve into exploring the specific biopsychosocial mechanisms (e.g., HPA axis reactivity, autonomic nervous system function, inflammatory markers, individual coping styles, specific academic stressors) that mediate the observed relationships between perceived stress, poor sleep, and migraines within the unique Indian cultural and academic milieu. Developing more comprehensive predictive models that include a broader array of potential influencing factors—such as academic workload, examination-related stress, social support systems, dietary patterns, physical activity levels, and comorbid symptoms of clinical anxiety and depression—would likely explain a greater proportion of the variance in migraine frequency. Investigating potential interaction effects between stress and sleep, and how these might be moderated by other variables such as gender or coping strategies, would offer deeper insights. Finally, qualitative research methodologies could provide a rich, nuanced understanding of students' lived experiences of stress, sleep problems, and migraines, and their own perceptions of how these interconnected factors affect their lives. Collectively, this study provides a foundational platform for advocating

proactive, culturally attuned mental health and well-being initiatives within Indian higher education institutions.

CONCLUSION

In conclusion, this study provides evidence that among English-speaking university students in India, higher levels of perceived stress and poorer global sleep quality are significantly and independently associated with an increased frequency of migraine attacks. Both perceived stress and poor sleep quality emerged as distinct predictors, suggesting they are separate, albeit related, contributors to the migraine burden in this student population. While the study's cross-sectional design and reliance on self-report measures necessitate cautious interpretation regarding causality, its findings contribute valuable insights into migraine correlates within a specific and important demographic. These results underscore the potential utility of addressing these modifiable psychosocial factors through targeted interventions within university settings, with the aim of improving student well-being and potentially reducing the adverse impact of migraines on their academic and personal lives. This research serves as an impetus for university stakeholders to recognize and proactively manage the intertwined challenges of stress, poor sleep, and migraine, which can significantly affect students' educational attainment and overall quality of life.

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Conflict of Interest

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