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ASSOCIATION BETWEEN MIGRAINE FREQUENCY, SLEEP QUALITY, AND STRESS LEVELS AMONG ADULT NEUROLOGY OUTPATIENTS IN PAKISTAN: A CROSS-SECTIONAL STUDY

(*Original Research*)

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Abstract

Background: E-cigarettes are increasingly marketed as safer alternatives to conventional tobacco products, particularly among young adults. However, growing evidence suggests that e-cigarette use may adversely impact periodontal health through mechanisms involving inflammation and microbial imbalance. Understanding this relationship is essential for guiding dental practice and public health interventions.

Objective: To determine the prevalence of e-cigarette use among young adult dental patients and evaluate its association with bleeding on probing, probing pocket depth, and plaque index after adjusting for potential confounding variables.

Methods: A cross-sectional investigation was carried out over a five-month period within a dental teaching hospital located in Lahore. Systematic random sampling was used to recruit 420 patients between the ages of 18 and 35 years. Each participant filled out a structured questionnaire that gathered information on demographics, oral hygiene routines, and history of electronic cigarette use. Standardized periodontal examinations were performed by calibrated clinicians to record clinical measures such as bleeding on probing (BOP), probing pocket depth (PPD), and plaque index (PI). All statistical analyses were conducted using SPSS software, version 26.0. Comparisons between groups for categorical and continuous variables were performed using the Chi-square test and independent samples t-test, respectively. To evaluate independent relationships, multivariate linear regression was employed, adjusting for potential confounders including age, sex, socioeconomic status, and oral hygiene habits.

Results: E-cigarette use prevalence was 27.6%. Current users exhibited significantly higher mean BOP (34.2% ± 8.1), deeper PPD (3.8 ± 0.9 mm), and elevated PI (2.4 ± 0.6) compared with non-users ($p < 0.001$ for all). In multivariate models, e-cigarette use independently predicted worsened periodontal outcomes, with adjusted β-coefficients of 0.29 for BOP, 0.25 for PPD, and 0.31 for PI ($p < 0.05$).

Conclusion: E-cigarette use among young adults was significantly associated with greater periodontal inflammation, reflected in higher bleeding, deeper pockets, and greater plaque accumulation. These findings highlight the need for integrating e-cigarette risk awareness into dental counseling and preventive care strategies. Longitudinal studies are recommended to confirm causality and assess long-term periodontal impacts.

Keywords: Cross-Sectional Studies; Dental Plaque Index; Electronic Nicotine Delivery Systems; Gingival Hemorrhage; Periodontal Diseases; Periodontal Pocket; Young Adult.

Introduction

Migraine is one of the most prevalent and disabling primary headache disorders, affecting an estimated 15–20% of the global adult population and representing a leading cause of neurological morbidity (1). Characterized by recurrent attacks of pulsating headache often accompanied by nausea, photophobia, and phonophobia, migraine significantly impairs daily functioning, productivity, and quality of life. In clinical settings, the management of migraine remains challenging due to its multifactorial etiology and the wide interindividual variability in attack frequency and intensity (2). Emerging evidence suggests that both sleep quality and psychological stress play critical roles in modulating migraine activity, yet these associations remain incompletely understood, particularly within low- and middle-income countries such as Pakistan, where sociocultural and environmental stressors may further influence disease patterns (3). The relationship between migraine and sleep is bidirectional and complex (4). Sleep disturbances, including insomnia, fragmented sleep, and irregular sleep-wake cycles, are frequently reported by migraine patients and are considered both precipitating and perpetuating factors for headache attacks (5). Neurophysiological studies have indicated that disruptions in hypothalamic and brainstem regulation of sleep may contribute to migraine pathophysiology through altered pain modulation and autonomic imbalance (6). Conversely, recurrent migraines may interfere with restorative sleep, leading to a vicious cycle of poor sleep quality and increased attack frequency (7). Clinical data demonstrate that individuals with poor sleep tend to experience higher headache frequency, greater pain severity, and reduced responsiveness to preventive therapy (8).

Psychological stress similarly exerts a strong influence on migraine occurrence and progression. Stressful life events, emotional strain, and occupational or familial pressures are well-documented migraine triggers (9). The hypothalamic-pituitary-adrenal (HPA) axis plays a central role in mediating the physiological response to stress, and its dysregulation has been associated with increased cortical excitability, vascular reactivity, and inflammatory responses—all mechanisms implicated in migraine generation (10). Chronic stress not only precipitates attacks but may also lower the threshold for migraine activation by altering central pain processing pathways. The overlap between stress-related neuroendocrine disturbances and sleep disruption further complicates the clinical presentation, creating a multidimensional interplay that perpetuates headache burden (11). International studies have explored the association between stress, sleep, and migraine, but most have been conducted in Western populations with distinct lifestyle, healthcare access, and psychosocial profiles. In South Asian contexts, including Pakistan, cultural expectations, economic instability, and limited mental health support may amplify stress perception and influence coping behaviors, thereby modifying migraine patterns (12). Despite the high prevalence of migraine in Pakistan—estimated between 12–17% among adults—few studies have systematically examined the interrelations of sleep quality and stress within local neurology outpatient populations. Understanding these associations is essential to guide comprehensive management approaches that address both biological and behavioral determinants of disease.

The impact of migraine on patients' functional and emotional well-being underscores the need for integrated evaluation of associated modifiable factors. Sleep hygiene and stress management are increasingly recognized as non-pharmacological interventions that can complement conventional pharmacotherapy to reduce attack frequency and enhance quality of life. However, without localized data delineating the magnitude and direction of these relationships, clinical recommendations remain largely extrapolated from international evidence, which may not fully reflect the lived realities of Pakistani patients (13). Identifying context-specific patterns of association can provide a more accurate foundation for patient counseling and multidisciplinary care planning. The current study was therefore designed to analyze the relationship between migraine frequency, sleep quality, and perceived stress levels among adult neurology outpatients in Pakistan. By quantifying the strength of these associations using validated measurement tools, this research aims to elucidate the behavioral and physiological correlates of migraine activity in a clinical setting. The objective was to determine whether poor sleep quality and elevated stress levels were significantly associated with increased migraine frequency, thereby contributing to the understanding of modifiable risk factors and informing holistic management strategies for migraine patients in Pakistan.

Methods

The study employed a cross-sectional analytical design to investigate the relationship between migraine frequency, sleep quality, and perceived stress levels among adult neurology outpatients in Lahore, Pakistan. The research was conducted over a five-month period, from March to July 2025, in the neurology outpatient department of a tertiary care teaching hospital. This design was selected to capture

the simultaneous prevalence and associations of key behavioral and physiological variables in a clinical population of migraine patients. The sample size was determined using an online calculator (Raosoft®) with a confidence level of 95%, a margin of error of 5%, and an estimated response distribution of 50%, assuming the population of adult neurology outpatients in the hospital to be approximately 8,000 over the study duration. The calculated minimum sample size was 367 participants, which was increased to 400 to compensate for possible incomplete responses or data attrition. A non-probability consecutive sampling technique was used to recruit participants who met the eligibility criteria during their outpatient visits.

The study enrolled adults between 18 and 55 years of age, regardless of gender, who had received a clinical diagnosis of migraine based on the ICHD-3 criteria and were under ongoing care at the neurology clinic. To limit potential confounding variables, individuals with secondary headache disorders, pre-existing psychiatric conditions, chronic medical illnesses (including diabetes, thyroid disease, or hypertension), or those taking medications that affect sleep or mood were not included. Prior to enrollment, written informed consent was obtained from every subject, and the study protocol received approval from the relevant institutional ethics committee. Data privacy and participant anonymity were upheld in compliance with the principles outlined in the Declaration of Helsinki.

Information was gathered through a structured questionnaire, administered by an interviewer, which covered four key areas: sociodemographic details, migraine frequency, sleep quality, and levels of perceived stress. The sociodemographic section captured age, gender, marital status, educational background, occupation, and how long the participant had been diagnosed with migraine. To determine migraine frequency, patients reported the average number of days per month they experienced migraine over the preceding three-month period, which was then verified against their medical charts. Based on these figures, participants were grouped into low (≤4 days/month), moderate (5–14 days/month), or high (≥15 days/month) frequency categories, consistent with established clinical classifications.

Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), a well-validated tool common in sleep and neurological studies. This instrument generates a total score between 0 and 21 by evaluating seven domains: subjective sleep quality, sleep onset latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep aids, and daytime impairment. Higher overall PSQI scores reflect worse sleep quality, with a score exceeding 5 defined as indicative of poor sleep.

Perceived stress was measured with the 10-item Perceived Stress Scale (PSS-10). Respondents rated how frequently they found their life situations stressful during the past month, using a 5-point Likert scale ranging from 0 (never) to 4 (very often). Summed scores can range from 0 to 40, with higher totals representing greater perceived stress. For interpretation, scores were categorized as low stress (0–13), moderate stress (14–26), or high stress (27–40).

To ensure participant ease and reduce recall bias, data collection took place in a calm, private consultation room. All assessments were conducted by trained healthcare staff who were unaware of the study's specific aims to preserve objectivity and consistency throughout the process. For analysis, data were first compiled in Microsoft Excel and then processed with IBM SPSS (version 26.0). Continuous measures—including age, migraine frequency, Pittsburgh Sleep Quality Index (PSQI) scores, and Perceived Stress Scale (PSS) scores—were summarized using means and standard deviations. Categorical variables such as gender, sleep quality classification, and stress categories were reported as counts and percentages. The Shapiro–Wilk test confirmed that continuous data were normally distributed, permitting the use of parametric statistical methods. Inferential analyses included Pearson's correlation to evaluate the strength and direction of associations among migraine frequency, PSQI scores, and PSS scores. Differences in mean sleep quality and stress scores between the migraine frequency groups (low, moderate, high) were examined with one-way analysis of variance (ANOVA), supplemented by Tukey's post hoc tests for pairwise comparisons. Gender-based differences in stress and sleep parameters were assessed using independent samples t-tests. A p-value below 0.05 defined statistical significance for all tests.

Primary outcomes consisted of monthly migraine attack frequency, global PSQI scores, and total PSS scores. Secondary outcomes explored relationships between these measures and demographic factors like age, gender, and employment status. The reliability of the PSQI and PSS instruments was confirmed via Cronbach's alpha, with coefficients of 0.83 and 0.87, respectively, indicating good internal consistency.

Methodological rigor was maintained by standardizing data collection procedures, strictly following inclusion and exclusion criteria, and implementing double data entry to prevent errors. This approach yielded a valid cross-sectional overview of the links between

migraine severity, sleep quality, and perceived stress in an outpatient clinical sample from Lahore, contributing context-specific insights into the behavioral factors associated with migraine frequency in a South Asian setting.

Results

The study included a total of 400 adult neurology outpatients diagnosed with migraine according to ICHD-3 criteria. The mean age of participants was 33.8 ± 8.9 years, ranging from 18 to 55 years. Females constituted a greater proportion of the sample (68.0%, n=272) compared to males (32.0%, n=128). The majority of participants were unmarried (56.8%), while 43.2% were married. Most respondents held an undergraduate or higher-level education (74.5%), and 59.3% were employed. The mean duration of migraine diagnosis was 4.7 ± 2.5 years. Demographic details are summarized in Table 1.

Table 1: Demographic Characteristics of Participants (n=400)

Variable	Category	n (%) / Mean ± SD
Age (years)	—	33.8 ± 8.9
Gender	Male	128 (32.0)
	Female	272 (68.0)
Marital Status	Unmarried	227 (56.8)
	Married	173 (43.2)
Education	Undergraduate or below	102 (25.5)
	Graduate or above	298 (74.5)
Employment Status	Employed	237 (59.3)
	Unemployed/Students	163 (40.7)
Duration of Migraine (years)	—	4.7 ± 2.5

The mean migraine frequency was 8.9 ± 5.6 attacks per month. When categorized, 29.3% (n=117) had low-frequency migraine (≤4 days/month), 46.0% (n=184) had moderate frequency (5–14 days/month), and 24.8% (n=99) had high-frequency migraine (≥15 days/month). The mean global Pittsburgh Sleep Quality Index (PSQI) score was 9.1 ± 3.4, with 72.0% (n=288) classified as poor sleepers (PSQI > 5). The mean Perceived Stress Scale (PSS-10) score was 21.8 ± 6.1, and 63.5% (n=254) of participants demonstrated moderate stress levels, while 21.5% (n=86) exhibited high stress levels.

The correlation analysis revealed a significant positive association between migraine frequency and both sleep disturbance and perceived stress. Pearson's correlation showed that migraine frequency was strongly correlated with PSQI score ($r = 0.61$, $p < 0.001$) and PSS score ($r = 0.57$, $p < 0.001$). Furthermore, sleep quality and stress levels were also positively correlated ($r = 0.48$, $p < 0.001$), indicating that higher stress was associated with poorer sleep outcomes (Table 2).

Table 2: Correlation Matrix between Key Variables

Variables	Migraine Frequency	PSQI Score	PSS Score
Migraine Frequency	—	0.61	0.57
PSQI Score	0.61	—	0.48

Variables	Migraine Frequency	PSQI Score	PSS Score
PSS Score	0.57	0.48	—

$p < 0.05$; $p < 0.01$; $p < 0.001$

Analysis of variance demonstrated significant differences in both sleep quality and stress levels across migraine frequency groups. Participants with high-frequency migraine had the poorest sleep quality (mean PSQI = 11.8 ± 3.2) and highest stress scores (mean PSS = 25.7 ± 5.8), compared with those in the low-frequency group (PSQI = 6.4 ± 2.1; PSS = 17.2 ± 4.9). These differences were statistically significant ($p < 0.001$ for both comparisons) (Table 3).

Table 3: Comparison of Sleep and Stress Scores by Migraine Frequency

Migraine Frequency Group	n	PSQI (Mean ± SD)	PSS (Mean ± SD)	p-value
Low (≤4 days/month)	117	6.4 ± 2.1	17.2 ± 4.9	<0.001
Moderate (5–14 days/month)	184	8.9 ± 2.7	21.4 ± 5.2	<0.001
High (≥15 days/month)	99	11.8 ± 3.2	25.7 ± 5.8	<0.001

Post hoc analysis (Tukey's HSD) confirmed that significant pairwise differences existed between all migraine frequency categories for both PSQI and PSS scores ($p < 0.001$).

Gender-based comparison indicated that female participants had significantly higher migraine frequency (9.4 ± 5.8) than males (7.9 ± 5.1, $p = 0.02$). Females also demonstrated poorer sleep quality (mean PSQI = 9.5 ± 3.5 vs. 8.3 ± 3.1, $p = 0.03$) and higher stress levels (mean PSS = 22.5 ± 6.0 vs. 20.2 ± 5.9, $p = 0.01$).

Table 4: Gender-Based Comparison of Key Variables

Variable	Male (n=128)	Female (n=272)	p-value
Migraine Frequency (per month)	7.9 ± 5.1	9.4 ± 5.8	0.02
PSQI Score	8.3 ± 3.1	9.5 ± 3.5	0.03
PSS Score	20.2 ± 5.9	22.5 ± 6.0	0.01

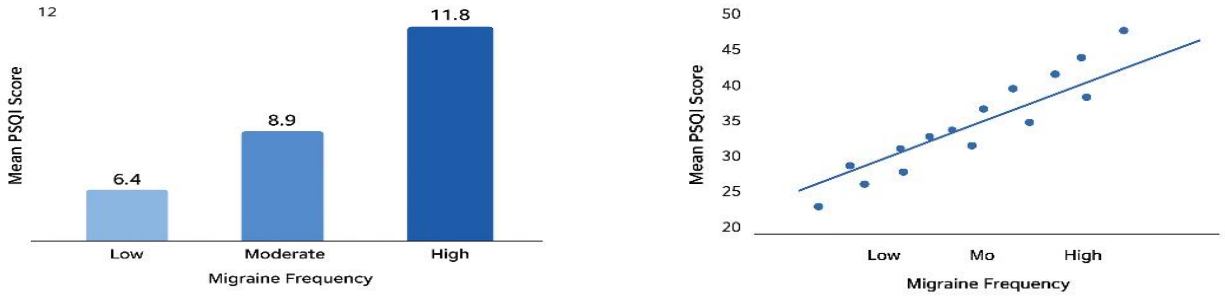

Figure 1 Migraine Frequency

Discussion

The findings of this study demonstrated a clear and statistically significant association between migraine frequency, sleep quality, and perceived stress levels among adult neurology outpatients in Lahore (14). Individuals experiencing higher migraine frequency reported greater sleep disturbances and elevated stress scores, suggesting that migraine may exist within a multidimensional cycle involving both physiological and psychological components (15). The positive correlations observed between migraine episodes and poor sleep, along with higher perceived stress, reinforce the biopsychosocial model of migraine pathophysiology, where environmental, behavioral, and neurological factors interact in a complex manner to influence disease expression and severity (16). These findings align closely with prior research indicating that sleep disturbance and stress are among the most common precipitating and perpetuating factors for migraine (17). A study by Ong et al. (2020) similarly identified poor sleep quality as a consistent predictor of migraine frequency and intensity, emphasizing the bidirectional relationship in which inadequate sleep increases migraine susceptibility while recurrent migraine episodes further disrupt restorative sleep (18). Comparable results have also been reported in South Asian populations, where cultural, dietary, and occupational stressors contribute to heightened physiological strain (19). The current study adds region-specific evidence by highlighting these patterns among Pakistani patients, a population often underrepresented in global migraine research.

Perceived stress levels were found to be substantially higher among individuals reporting frequent migraine attacks, consistent with evidence suggesting that chronic stress may alter pain modulation through hypothalamic–pituitary–adrenal (HPA) axis dysregulation and elevated cortisol release (20). The observed correlation between stress and migraine frequency supports findings by Sauro and Becker (2009), who noted that psychosocial stress acts as both a trigger and a sustaining factor for migraine chronification. These results underline the importance of addressing psychological well-being as part of migraine management. Moreover, the additive effect of poor sleep and stress may exacerbate neuronal excitability and vascular dysregulation, intensifying headache frequency and impairing functional quality of life (21). The relationship between migraine frequency and sleep quality in this study also underscores the physiological overlap between pain modulation and sleep regulation mechanisms. Disruptions in serotonin and melatonin pathways, both implicated in migraine pathophysiology, may explain this overlap. Patients experiencing chronic migraine often report insomnia, delayed sleep onset, and frequent awakenings, reflecting the neurochemical imbalance shared between migraine and sleep disorders. Such interdependence suggests that effective management of one domain may yield improvement in the other, reinforcing the role of multidisciplinary treatment approaches (22). The implications of these findings are clinically significant. Recognition of poor sleep and high stress as modifiable correlates of migraine provides opportunities for non-pharmacological interventions such as cognitive-behavioral therapy (CBT), stress management training, relaxation techniques, and sleep hygiene optimization. Integrating these behavioral strategies into standard neurological care could reduce migraine burden and improve overall patient outcomes. Furthermore, these findings advocate for regular screening of stress and sleep disturbances in migraine clinics to enable early identification and holistic management.

Despite its strengths, the study carried certain limitations. The cross-sectional design restricted causal inference, preventing confirmation of directional relationships between migraine, sleep quality, and stress. Data were based on self-reported measures, which may introduce recall or reporting bias. The study was also conducted in a single tertiary care hospital, limiting generalizability to broader populations. However, the use of validated tools such as the Pittsburgh Sleep Quality Index and the Perceived Stress Scale strengthened the reliability of findings, while the relatively large sample size enhanced statistical power. Another strength of the study lies in its simultaneous evaluation of behavioral and physiological correlates, allowing for a more comprehensive understanding of migraine-associated factors. Future research should adopt longitudinal or interventional designs to examine causal pathways and assess whether improvements in stress and sleep parameters can reduce migraine frequency or severity over time. Additionally, exploring gender differences, hormonal influences, and neuroendocrine biomarkers could offer deeper insights into underlying mechanisms. Multi-center studies across diverse Pakistani regions would also enhance representativeness and clarify cultural or environmental influences on migraine patterns.

Conclusion:

This study established significant associations between migraine frequency, poor sleep quality, and elevated stress levels among adult neurology outpatients in Lahore. The findings highlight the importance of addressing sleep and stress management as integral components of migraine care. Incorporating behavioral interventions alongside pharmacological therapy may substantially improve patient outcomes and quality of life.

AUTHOR'S CONTRIBUTIONS

Author	Contribution
Jahanzeb Akhtar*	Designed the study, performed data collection and analysis, and prepared the manuscript. Approved the final draft for submission.
Zia Ur Rehman	Contributed to study design, data acquisition, interpretation of findings, and performed critical review and editing of the manuscript. Approved the final draft for submission.

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