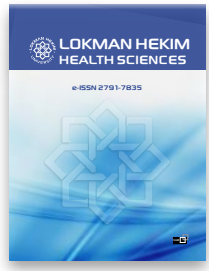
LOKMAN HEKIM HEALTH SCIENCES

DOI: 10.14744/lhhs.2026.64270
Lokman Hekim Health Sci 2026;6(3):424–430



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ORIGINAL ARTICLE

The Silent Saboteur: The Impact of Headaches on Sleep Quality, Central Sensitization, Depression, Anxiety, and Stress

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Abstract

Introduction: This study aimed to investigate the impacts of primary headaches on sleep quality, central sensitization (CS), and psychological factors, including depression, anxiety, and stress, to provide insights for an integrated management approach in patients with headaches. Headache is a common public health problem. Understanding the multifaceted impact of these conditions on various health aspects is essential for comprehensive headache management.

Methods: This descriptive observational study included individuals with primary headaches and asymptomatic controls. Participants were categorized into two groups based on the presence of headaches: A headache group and a headache-free group. Assessments were conducted in a sequential manner to evaluate sleep quality, CS, and emotional well-being, using the Pittsburgh Sleep Quality Index, CS inventory, and Depression, Anxiety, and Stress Scale-21, respectively. Group differences were analyzed using independent t-tests.

Results: The study included 78 individuals with primary headaches and 54 asymptomatic controls. The headache group showed significantly poorer sleep quality ($p<0.001$), increased CS ($p<0.001$), and higher levels of psychological distress, including depression ($p=0.008$), anxiety ($p<0.001$), and stress ($p<0.001$), compared to the headache-free group.

Discussion and Conclusion: These findings emphasize the compounded impact of headaches on both physical and psychological health parameters. The observed differences in sleep quality, CS, and psychological distress between the headache and headache-free groups highlight the need for a multidisciplinary approach to headache management. Addressing these interconnected aspects may enable improvement in therapeutic outcomes and quality of life in individuals with headaches.

Keywords: Central nervous system sensitization; Depression; Headache; Migraine disorders; Sleep

According to the Global Burden of Disease study, "headache disorders are among the most prevalent and disabling conditions worldwide", with various types significantly diminishing individuals' quality of life. Headaches can occur in a wide range from temporary discomfort to chronic problems and can negatively affect individuals' work performance, social life, and general health.[1] In recent years, complaints of headaches have been increasing in society. Therefore, investigating headaches and the factors that affect will provide a solid foundation for treatment algorithms.

Within the framework of the biopsychosocial model, headache disorders should be understood as conditions resulting from the complex interaction between biological,

Cite this article as: *Acet N. The Silent Saboteur: The Impact of Headaches on Sleep Quality, Central Sensitization, Depression, Anxiety, and Stress. Lokman Hekim Health Sci 2026;6(3):424–430.*

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E-mail: nagihan.acet@atilim.edu.tr **Submitted:** 14.08.2025 **Revised:** 23.12.2025 **Accepted:** 30.12.2025 **Available Online:** 06.08.2026

psychological, and social processes.[2] This model emphasizes that pain is not solely a neurophysiological experience, but is also shaped by behavioral patterns, emotional responses, and environmental factors. In the context of primary headaches, neurobiological mechanisms, such as central sensitization (CS) may amplify pain transmission, while disturbances in sleep quality and psychological distress (including depression, anxiety, and stress) can further exacerbate pain perception and disability. Considering these interrelated dimensions together provides a more comprehensive understanding of the pathophysiology of headaches and supports a multidisciplinary approach in both research and clinical management.

Sleep quality may be one of the factors most significantly impacted by primary headaches. Sleep disorders consist of various conditions that disrupt normal sleep patterns.[3] Inadequate or non-restful sleep may interfere with the normal course of physical, mental, social, and emotional functions.[3] Impaired sleep quality inhibits the body's process of self-repair and regeneration, which can lead to more serious health problems in the long term. Establishing the relationship between sleep and headache can make a significant contribution to the management of headaches.

Headaches can also serve as a significant trigger for the development of increased central nervous system sensitivity. CS is "a neurophysiological phenomenon that is adaptive, activity-dependent, and dynamic."[4] This process entails neurobiological alterations in the neurons located in the dorsal horn of the spinal cord.[4] These changes involve an increase in excitability, a boost in synaptic transmission, and a reduction in inhibition.[4] In summary, CS represents a condition in which the nervous system exhibits heightened sensitivity, resulting in an exaggerated perception of pain. Particularly in individuals with chronic headache, CS can develop due to persistent stimulation of the central nervous system, potentially leading to a lowered pain threshold and an amplified perception of pain.[5] In individuals with chronic headaches, the increase in central nervous system sensitivity may reduce quality of life and significantly complicate the treatment process.

The psychological impact of primary headaches should not be overlooked. Primary headaches, such as migraine and tension-type headaches (TTH), may lead to increased levels of psychological distress, including depression, anxiety, and stress.[6] When pain becomes a constant source of anxiety, it makes it difficult to perform daily activities and negatively affects the general mood of the person.[7] Depression and anxiety may increase the severity of headaches, and headaches may trigger these psychological conditions. Stress may be both a cause and a consequence of headache; especially TTHs are closely related to stress. Therefore, it is important to consider the psychological status in the treatment of primary headaches.

The presence of headaches may affect numerous physical and psychological factors. A comprehensive assessment of these factors together may contribute to more effective headache management strategies. Although previous studies have independently investigated the associations between headaches and sleep quality, psychological distress, or CS, no studies have comprehensively examined these factors simultaneously within a single conceptual framework. Moreover, there is a lack of studies addressing this issue among university students in Türkiye, a population with increasing vulnerability to stress and irregular sleep patterns. Therefore, this study was designed to provide a holistic evaluation of sleep quality, CS, and psychological factors in individuals with and without headaches, within the context of the biopsychosocial model of pain.

Considering the multidimensional interaction between biological, behavioral, and psychological mechanisms within the biopsychosocial model, this study aimed to examine how primary headaches influence sleep quality, CS, and psychological distress. It was hypothesized that individuals with primary headaches would exhibit poorer sleep quality, higher levels of CS, and greater psychological distress (depression, anxiety, and stress) compared to asymptomatic controls.

Materials and Methods

Study Place and Design

The study was carried out at the Atılım University between October 2024 and January 2025.

This study was designed as a descriptive observational study and reported in adherence with the strengthening the reporting of observational studies in epidemiology guidelines. The study was registered with ClinicalTrials.gov (NCT 06603493).

Ethical Statement

Approval for this study was obtained from the Atılım University Ethics Committee (Date: 25.09.2024, Decision no: 606.01.02.268), and the study was conducted in accordance with the Declaration of Helsinki. All participants were informed about the purpose and procedures of the study and provided written informed consent before participation.

Participants

Participants were recruited from the Atılım University campus using a convenience sampling method. Participants were recruited through a convenience sampling method using an announcement poster on the university website and notice boards. Participation was voluntary. Participants who responded to the invitation completed an online screening form to confirm eligibility criteria. Eligible participants were then contacted and scheduled for assessment sessions. The included subjects were allocated into two groups: A headache group and a headache-free group. Individuals diagnosed with migraine and TTHs according to the International Classification of Headache Disorders (International Classification of Headache Disorders, 3rd edition), were placed in the headache group, while other participants were assigned to the headache-free group. Each participant was assessed in a one-time, face-to-face evaluation.

Inclusion Criteria

Individuals aged 18–65 who were located on the university campus were included.

Exclusion Criteria

Exclusion criteria included neurological disorders, musculoskeletal diseases, chronic pain conditions, and psychiatric disorders.

One hundred and forty-four participants were evaluated for eligibility. Twelve participants were excluded due to the exclusion criteria. A total of 132 participants took part in the study. Seventy-eight individuals diagnosed with either migraine or TTH comprised the headache group, whereas the headache-free group included 54 participants. Of the 78 participants in the headache group, 68 were diagnosed with TTH and 10 with migraine.

Data Collection

Assessment of Sleep Quality

Sleep quality was assessed using the Turkish version of the Pittsburgh Sleep Quality Index (PSQI) developed by Buysse et al. (1989).[8] The Turkish validity and reliability study was conducted by Ağargün et al. (1996; good internal consistency).[9] It is a 19-item questionnaire designed and consists of 7 components: (1) Subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) habitual sleep efficiency, (5) sleep disturbances, (6) use of sleep medication, and (7) daytime dysfunction, (8) each component is scored between 0 and 3, yielding a global score ranging from 0 to 21. Higher scores indicate poorer sleep quality, and a global score >5 reflects clinically significant sleep disturbance.[8]

Assessment of CS

CS was assessed using the CS inventory (CSI), developed by Mayer et al. (2012).[10] The Turkish version was validated by Keleş et al.[11] (2018 Cronbach's α=0.92, intraclass correlation coefficient=0.93). The CSI includes 25 items evaluating symptoms, such as sensitivity to bright light, pain all over the body, fatigue, poor concentration, and unrefreshing sleep.[10] Each item is scored from 0 ("never") to 4 ("always"), with total scores ranging from 0 to 100. A score of 40 or higher indicates the presence of CS.[10]

Assessment of Psychological Factors

Psychological distress (depression, anxiety, and stress) was measured using the depression anxiety stress scale (DASS-21), developed by Lovibond and Lovibond (1995).[12] Depression, anxiety, and stress levels were assessed using the Turkish version of the DASS-21 validated by Yıldırım et al. (2017; Cronbach's α=0.87).[13] It consists of three subscales - depression, anxiety, and stress-, each with 7 questions, evaluating emotional and physiological symptoms.[12] A maximum of 42 points can be obtained for each component (the first score is multiplied by two).[12] Higher scores indicate the severity of the respective disorder.

Power Analysis

A post hoc power analysis was conducted using G*Power 3.1.9.7 to determine the achieved power of the study based on the comparison of sleep quality (PSQI) between the headache and headache-free groups. With an effect size of d=0.64, an alpha level of 0.05, and group sample sizes of 78 and 54, the achieved power (1–β error probability) was calculated as 0.948. This indicates that the study had a high statistical power (94.8%) to detect significant differences between the groups.

Statistical Analysis

All statistical analyses were performed using IBM Statistical Package for the Social Sciences Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Categorical variables were presented with frequencies and percentages, while continuous variables were summarized as mean, standard deviation, minimum, and maximum values. The normality of distribution for continuous variables within

Table 1. The number, percentage, and gender distribution of the participants according to headache status

Presence of headache	Gender	Frequency	Percent	χ^2	p[a]
No pain	Female	38	70.4	2.818	0.244
	Male	16	29.6		
	Total	54	100.0		
Tension type headache	Female	40	58.8		
	Male	28	41.2		
	Total	68	100.0		
Migraine	Female	8	80.0		
	Male	2	20.0		
	Total	10	100.0		

[a]: p-value calculated by Pearson Chi-square test.

each group was assessed using the Kolmogorov-Smirnov test and skewness and kurtosis values. A skewness and kurtosis range of ±2 was considered acceptable for normal distribution.[14] Between-group comparisons for continuous variables were conducted using Independent Samples t-test. For categorical variables, such as gender distribution among headache groups, the Pearson Chi-square test was applied. Effect sizes were reported using Cohen's d for t-tests. Statistical significance was set at $p<0.05$.

Results

The study included 78 individuals with primary headaches and 54 asymptomatic controls. As shown in Table 1, among the 132 participants, 54 reported no headache, 68 had TTH, and 10 had migraine. The proportion of females varied across groups: 70.4% in the no-pain group, 58.8% in the TTH group, and 80.0% in the migraine group. Although female participants were predominant in all groups, a Pearson Chi-square test revealed that the difference in gender distribution among headache types was not statistically significant ($\chi^2=2.818$, $p=0.244$), indicating comparable gender distribution across groups.

Demographic characteristics of the participants in both groups were similar in terms of age, height, weight, and body mass index ($p>0.05$). Comparisons of the demographic characteristics of the participants are shown in Table 2.

In the intergroup comparison, the headache group had significantly higher levels of sleep disturbance, CS, depression, anxiety, and stress than the headache-free group. Comparisons between groups were presented in Table 3 ($p<0.05$).

Table 2. Demographic characteristics of the participants

Variables	Headache Group mean±SD (min;max) (n=78)	Control group mean±SD (min;max) (n=54)	Mean difference	t	Cohen's d	p[t]	95% CI of the difference	
							Lower	Upper
Age (year)	23.07±2.01 (20; 30)	22.65±0.92 (21; 25)	-0.44	-1.52	-0.26	0.480	-1.02	0.13
Height (cm)	1.71±0.83 (1.56; 1.90)	1.69±0.09 (1.54 ; 1.92)	-0.01	-0.91	-0.16	0.543	-0.04	0.01
Weight (kg)	68.14±13.63 (42; 964)	66.96±12.38 (49; 93)	-0.51	-0.21	-0.39	0.694	-5.14	4.12
BMI (kg/m^2)	23.02±3.23 (16.82; 29.07)	23.08±3.02 (17.3; 29.3)	0.05	0.10	0.01	0.387	-1.06	1.16

n: Number of participants; BMI: Body mass index; SD: Standard deviation; CI: Confidence interval; cm: centimeter; kg: kilogram; kg/m^2: kilogram/meter^2; t: Independent samples t-test.

Table 3. The comparison of sleep disorders, central sensitization, depression, anxiety, stress between groups

Variables	Headache group (n=78) mean±SD (min; max)	Control group (n=54) mean±SD (min; max)	Mean difference	t	Cohen's d	p[t]	95% CI of the difference	
							Lower	Upper
Sleep quality via PSQI	7.84±3.35 (2; 16)	5.77±3.01 (1; 12)	2.06	-3.62	0.64	<0.001*	0.94	3.19
Central sensitization via CSI	30.46±16.17 (1 ;66)	19.92±17.54 (1; 81)	10.53	-3.55	0.62	<0.001*	4.66	16.4
Depression via DASS-21	7.02±5.89 (0 ;21)	4.25±5.76 (0; 20)	2.76	-2.67	0.47	0.008*	0.72	4.81
Anxiety via DASS-21	6.76±5.61 (0 ;21)	3.59±5.09 (0; 21)	3.17	-3.31	0.58	<0.001*	1.28	5.07
Stress via DASS-21	6.38±5.01 (0 ;17)	3.11±4.31 (0; 18)	3.27	-3.90	0.69	<0.001*	1.31	5.03

*: p<0.05. SD: Standard deviation; CI: Confidence interval; PSQI: Pittsburgh sleep quality index; CSI: Central sensitization inventory; DASS-21: Depression, anxiety, and stress scale-21; n: Number of participants; t: Independent samples t-test.

Discussion

Migraine and TTH are the most common primary headache disorders.[15] While migraine ranks 2nd among neurological disorders causing disability, TTH ranks 28th.[16] When examining the prevalence of these two significant types of headaches, migraine affects 14.4% of the population, whereas the prevalence of TTH ranges from 26.1% to 86.0%.[16,17] The burden posed by these headache disorders remains a major issue globally. Reducing the burden of headache disorders requires a better understanding of the factors that increase headache-related impacts.[18]

In this study, the complex impacts of headache presence on sleep quality, CS, depression, anxiety, and stress were thoroughly investigated. These factors were examined within the framework of the biopsychosocial model of pain, which emphasizes that pain is not merely a physiological phenomenon, but a multidimensional experience shaped by biological, psychological, and social interactions. From this perspective, the present study provides an integrated understanding of how headaches affect multiple interconnected domains rather than focusing on a single physiological outcome. This holistic approach highlights the importance of considering cognitive, emotional, and behavioral aspects in the assessment and management of primary headaches.

The results of the present study demonstrated statistically significant group differences in sleep quality, CS, depression, anxiety, and stress levels ($p<0.001$) for all parameters. In addition, the effect size analysis revealed that these differences were moderate to large in magnitude, indicating that the observed associations are not only statistically but also clinically meaningful. The largest effect size was observed for stress (Cohen's $d=0.69$), followed by sleep quality ($d=0.64$) and CS ($d=0.62$), suggesting that psychological distress, particularly stress, exerts a strong influence in individuals with headaches, alongside biological mechanisms, such as CS. This finding underscores the robust biopsychosocial impact of headache disorders and highlights the need for integrative assessment strategies that address both physiological and psychological domains.

The findings of this study indicate that individuals experiencing headaches demonstrated lower sleep quality. This finding is consistent with previous studies in the literature demonstrating that individuals with both migraine and TTHs have lower sleep quality compared to the headache-free.[19–22]

Clinically, this highlights the importance of evaluating sleep quality in patients with headaches. In headache management, incorporating strategies aimed not only at pain relief but also at improving sleep quality may contribute to more effective symptom control. Clinicians should adopt a multidisciplinary approach to address sleep issues in patients with headaches, thereby reducing headache frequency and severity.

According to the results of the present study, CS was found to be increased in individuals with headaches compared to the headache-free group. The impact of the presence of primary headaches on CS is consistent with previous studies.[5,23,24] CS occurs when there is a functional increase in circuits within nociceptive pathways, leading to abnormal sensitivity. According to the International Association for the Study of Pain, "CS is characterized by an increased sensitivity of nociceptive neurons within the central nervous system to normal or subthreshold afferent stimuli."[25] For example, patients with chronic headaches frequently present with pressure pain hypersensitivity, pericranial muscle tenderness, and cutaneous allodynia - clinical indicators of CS that contribute to pain persistence.[26,27] CS is particularly associated with neurological disorders, such as migraine, which cause important level of disability. In migraine pathogenesis, CS is believed to contribute to the development of cutaneous allodynia and the progression of migraine into a chronic condition.[5] Although genetic predisposition and activation of the trigeminal vasculature are considered the main pathophysiological factors of migraine,[28] CS is believed to contribute to the persistence of pain. Therefore, the management of CS-related pain and symptoms is crucial in primary headaches, such as migraine or TTH. The presence of CS in individuals with headaches may lead to significant functional impairment in their daily lives. In light of the present study's findings, the importance of treatment approaches targeting CS in individuals with headaches is once again emphasized.

In the present study, depression and anxiety levels were statistically higher in individuals with headaches compared to the asymptomatic group. Considering the increased disability caused by chronic headaches, this finding is not surprising. Because of headaches, accompanying symptoms, and comorbidities, headache sufferers experience reduced quality of life and face impediments in daily life activities, including school, work, and family responsibilities.[29,30] Previous studies in the literature have reported that migraineurs suffer from more severe depression than non-migraineurs;[31,32] furthermore, when migraineurs experience depression, their migraine symptoms are more severe than those in migraineurs without depression. In

addition, a "bidirectional comorbidity" has been observed in longitudinal studies, migraineurs had an increased risk of developing depression after an 11-year follow-up,[33] while patients with depression similarly showed an increased risk of developing migraines. In the literature, another study conducted on individuals with TTH reported that 53.4% of these individuals had anxiety and 36.9% had depression.[34] Similarly, another study reported that anxiety and depression were more prevalent in individuals with TTH than in those without headaches.[35]

From a clinical perspective, these results emphasize the need to assess depression in individuals suffering from migraine or TTHs. The bidirectional relationship between depression and migraine highlights the need for a holistic approach in headache management that considers psychosocial factors. For clinicians, evaluating the risk of depression in patients with headaches can play a crucial role in enhancing both pain management and overall quality of life for these patients. This study has some limitations. The descriptive observational design reflects only the state at a particular point in time and does not allow for the observation of changes over time. Therefore, the participants were assessed only once, and no follow-up was conducted. In addition, self-report questionnaires were utilized to assess physical and psychological factors. Since self-reported data may involve recall bias, it is recommended that these parameters be evaluated with objective measurement methods in future studies. Furthermore, due to the limited number of participants with migraine, it was not possible to statistically compare subtypes of primary headache (i.e., migraine and TTH) separately. Finally, as the sample of this study was limited to a single institution (Atılım University), the generalizability of the results may be restricted. Future studies should aim to include larger populations covering multiple institutions, and long-term follow-up is recommended to more comprehensively assess the effects of headaches.

Despite these limitations, the study has several strengths. This study is one of the few to comprehensively examine the multifaceted effects of headache on sleep quality, CS, depression, anxiety, and stress within a single framework. The use of standardized and widely validated measurement tools enhances the reliability of the findings. In addition, the multidisciplinary approach emphasized in this research highlights the importance of addressing both physiological and psychological factors in headache management, offering a holistic perspective that may benefit clinical practice.

Conclusion

The study demonstrated that individuals with headaches experience poorer sleep quality, increased CS, and higher levels of psychological distress compared to headache-free individuals. These results highlight the necessity of addressing headache management through a biopsychosocial and multidisciplinary framework, focusing not only on clinical symptoms but also on improving sleep quality, psychological well-being, and stress regulation. Considering these interconnected domains together may enhance treatment outcomes and overall quality of life for individuals suffering from headaches.

Ethics Committee Approval: The Atılım University Ethics Committee granted approval for this study (date: 25.09.2024, number: 606.01.02.268).

Informed Consent: All participants were informed about the purpose and procedures of the study and provided written informed consent before participation.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

Use of AI for Writing Assistance: Not declared.

Acknowledgments: I would like to express my gratitude to all the participants who contributed their time and effort to this study.

Peer-review: Double blind peer-reviewed.

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