

The Association Between Smartphone Use and Headache / Migraine in Young Adults: Current Evidence, Biological Mechanisms, and Future Perspectives

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Abstract: Smartphones have become indispensable in modern society, particularly among young adults, where they play a central role in education, communication, entertainment, and professional activities. Although these devices have improved access to information and digital connectivity, the substantial increase in daily screen time has raised concerns regarding their potential impact on neurological health. Among the reported health consequences, headache and migraine have emerged as common complaints associated with prolonged smartphone use. This review critically examines the current evidence on the relationship between smartphone screen time and headache disorders in young adults. Recent observational studies, systematic reviews, and meta-analyses suggest that extended smartphone use is associated with an increased frequency and severity of headaches, particularly migraine. Several biological and behavioural mechanisms have been proposed, including digital eye strain, reduced blink rate, prolonged accommodation, blue light exposure, cervical musculoskeletal strain, sleep disruption, psychological stress, and altered pain modulation. While these mechanisms provide biologically plausible explanations, the available evidence remains largely observational, and causal inferences are limited by methodological heterogeneity and the presence of multiple confounding factors. Current findings support the promotion of healthy digital habits, ergonomic smartphone use, adequate sleep hygiene, and regular screen breaks as practical strategies to reduce headache burden among young adults. Nevertheless, large prospective cohort studies and randomized interventional trials incorporating objective measures of smartphone use are required to clarify the long-term neurological effects of excessive screen exposure. Improved understanding of these associations will help clinicians provide evidence-based recommendations and guide future public health policies addressing digital health. **Objective:** This review aims to critically evaluate current evidence regarding the association between smartphone screen exposure and headache or migraine among young adults, while discussing possible biological mechanisms and future research directions. **Methods:** A structured literature search was conducted using PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar databases. Studies published between 2015 and 2025 evaluating smartphone use, screen exposure, headache, or migraine among young adults were reviewed. Relevant observational studies, systematic reviews, and meta-analyses were considered. **Result:** Available evidence indicates that prolonged smartphone use, particularly exceeding four to six hours daily, is associated with increased headache frequency and migraine symptoms. Proposed mechanisms include digital eye strain, sleep disruption, cervical musculoskeletal stress, psychological factors, and altered pain sensitivity. However, most available studies are observational, limiting causal interpretation. **Conclusion:** Excessive smartphone screen exposure may represent a modifiable behavioural risk factor for headache and migraine among young adults. Future longitudinal and interventional studies using objective smartphone usage measurements are required to establish causal relationships.

Keywords: Smartphone, Screen Time, Migraine, Headache, Young Adults, Digital Eye Strain, Blue Light, Sleep Disturbance, Digital Health

1. Introduction

Over the past decade, smartphones have transformed the way individuals communicate, learn, work, and access healthcare. Rapid technological advances, combined with affordable internet connectivity and widespread availability of mobile applications, have resulted in an unprecedented increase in smartphone use across all age groups. Young adults represent the most intensive users of this technology, frequently spending several hours each day on smartphones for academic activities, professional responsibilities, social networking, entertainment, and online communication [1,2].

Although smartphones provide considerable educational, occupational, and social benefits, prolonged daily screen exposure has generated growing concern regarding its potential effects on physical and neurological health. Excessive smartphone use has been associated with digital eye strain, sleep disturbances, cervical musculoskeletal discomfort, reduced physical activity, anxiety, depression,

and impaired psychological well-being [3–5]. Among these health concerns, recurrent headache and migraine have attracted increasing attention because of their high prevalence among young adults and their significant impact on daily functioning.

Headache disorders are among the leading causes of disability worldwide. According to the Global Burden of Disease Study, migraine remains one of the most disabling neurological disorders, particularly in individuals younger than 50 years of age, affecting educational achievement, workplace productivity, and overall quality of life [6,7]. Migraine is characterized by recurrent episodes of moderate-to-severe headache, often accompanied by nausea, photophobia, phonophobia, and functional impairment. Even tension-type headaches, although generally less severe, contribute substantially to reduced concentration, absenteeism, and diminished quality of life.

The increasing prevalence of prolonged smartphone use has prompted researchers to investigate whether excessive screen

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exposure contributes to headache occurrence or exacerbates pre-existing migraine disorders. Several physiological mechanisms have been proposed to explain this relationship. Continuous visual concentration on small digital displays increases accommodative demand and decreases blink frequency, resulting in ocular surface dryness and digital eye strain [8]. Simultaneously, prolonged exposure to short-wavelength blue light, particularly during evening hours, may suppress melatonin secretion, disrupt circadian rhythm, and impair sleep quality, a well-recognized trigger for migraine attacks [9].

Beyond visual mechanisms, smartphone use is frequently associated with sustained neck flexion and poor ergonomic posture, commonly referred to as "text neck syndrome." Prolonged cervical muscle contraction may increase mechanical stress on the cervical spine and surrounding soft tissues, potentially contributing to tension-type headache and worsening migraine symptoms [10]. Excessive smartphone use has also been linked to increased psychological stress, smartphone dependency, anxiety, and emotional exhaustion, all of which may lower the threshold for headache generation through activation of neuroendocrine and central pain-processing pathways [11,12].

Despite the growing number of published studies, the available evidence remains heterogeneous. Differences in study design, methods used to measure smartphone exposure, headache classification, participant characteristics, and adjustment for confounding variables have resulted in inconsistent findings across studies [13–15]. Moreover, lifestyle factors such as inadequate sleep, caffeine consumption, hydration status, academic workload, mental health conditions, and physical inactivity may independently influence headache frequency, making it difficult to establish a direct causal relationship between smartphone use and headache disorders.

Nevertheless, the consistency of observational findings across different populations suggests that excessive smartphone screen time should be regarded as an important modifiable lifestyle factor during the clinical assessment of patients with recurrent headaches or migraine. Identifying potentially reversible behavioural risk factors may facilitate the development of preventive strategies that improve neurological health without limiting the practical benefits offered by digital technology.

In recent years, the concept of digital health has expanded beyond the benefits of technology to include potential health consequences associated with excessive device exposure. Understanding the relationship between smartphone use and headache disorders is therefore important for clinicians, researchers, and public health professionals because smartphone usage is a modifiable behavioural factor.

The primary objective of this review is to critically evaluate the current evidence regarding the association between smartphone screen time and headache or migraine among young adults. In addition to summarizing findings from contemporary observational studies and systematic reviews, this article discusses the biological mechanisms underlying this relationship, evaluates the strengths and limitations of the

available evidence, and highlights important priorities for future research. A comprehensive understanding of these interactions may contribute to evidence-based clinical recommendations and support the development of healthier digital practices among young adults.

2. Literature Search Strategy and Methodology

Literature Search Strategy

"This narrative review was conducted using a structured literature search approach. The methodology was guided by principles of transparency and reproducibility; however, this article was not designed as a systematic review or meta-analysis."

A comprehensive electronic search was performed in four major biomedical databases: PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar. Articles published between January 2015 and December 2025 were considered to capture the most recent evidence reflecting changes in smartphone technology and digital behaviour. Additional relevant studies were identified through manual screening of the reference lists of eligible review articles and original research papers.

The search strategy combined Medical Subject Headings (MeSH) and free-text keywords using Boolean operators. The primary search terms included:

"Smartphone" AND "Headache"
"Smartphone" AND "Migraine"
"Screen Time" AND "Headache"

Database-specific search filters were applied where appropriate to improve retrieval of peer-reviewed literature. Only studies published in English were considered for inclusion.

Eligibility Criteria

Inclusion Criteria

- Studies were included if they fulfilled the following criteria:
- Published in peer-reviewed scientific journals.
- Written in English.
- Included participants aged 18–35 years or reported subgroup analyses for young adults.
- Evaluated smartphone screen time, mobile phone use, or smartphone dependency as the primary exposure.

Exclusion Criteria

- Studies were excluded if they met one or more of the following criteria:
- Conference abstracts lacking a full-text publication.
- Editorials, commentaries, expert opinions, letters to the editor, or narrative reports without original data.

Study Selection

Titles and abstracts retrieved from the database search were screened for relevance. Potentially eligible studies underwent full-text assessment to determine whether they met the predefined inclusion criteria. When uncertainty existed regarding eligibility, the complete article was reviewed before the final decision was made.

Studies investigating multiple digital devices were included only when smartphone-specific results were presented separately. Articles with insufficient methodological detail or incomplete outcome reporting were excluded from qualitative synthesis.

Data Extraction

- Relevant information was extracted systematically from each eligible study using a standardized data collection approach. The following variables were recorded:
- First author and publication year
- Country of study
- Study design
- Sample size
- Participant characteristics
- Mean or median age
- Average daily smartphone screen time
- Method used to assess smartphone exposure
- Headache or migraine diagnostic criteria
- Primary outcomes
- Major findings
- Reported limitations
- The extracted data were compared across studies to identify recurring trends, methodological differences, and potential sources of heterogeneity.

3. Review of Current Evidence

3.1 Global Increase in Smartphone Use Among Young Adults

The rapid expansion of smartphone technology has fundamentally transformed daily life, making mobile devices indispensable for communication, education, healthcare, entertainment, banking, and professional activities. Over the past decade, smartphone ownership has increased dramatically, particularly among young adults, who represent the most digitally connected segment of the global population. The widespread availability of high-speed internet, social media platforms, online learning environments, and digital health applications has further increased the average daily duration of smartphone use [1-3].

Recent international surveys indicate that many young adults spend 4-8 hours per day using smartphones, with some exceeding this duration because of academic commitments, remote work, streaming services, gaming, and social networking [4,5]. The COVID-19 pandemic further accelerated this trend, as educational institutions and workplaces shifted to virtual platforms, substantially increasing reliance on smartphones for both personal and professional purposes [6].

Although smartphones provide undeniable social and educational advantages, prolonged daily exposure has raised important public health concerns. Extended screen time has been associated with multiple adverse outcomes, including digital eye strain, sleep disturbances, reduced physical activity, musculoskeletal discomfort, psychological stress, and impaired cognitive performance [7-9]. Among these consequences, recurrent headache and migraine have emerged as common neurological complaints, particularly among university students and young professionals.

Several epidemiological studies have reported that individuals with prolonged smartphone use are more likely to experience frequent headaches compared with those reporting shorter daily screen exposure. However, the observed association appears to be influenced by multiple lifestyle and behavioural factors, emphasizing the multifactorial nature of headache disorders [10-12].

3.2 Digital Eye Strain and Headache

Digital Eye Strain (DES), also referred to as Computer Vision Syndrome, is one of the most frequently proposed mechanisms linking prolonged smartphone use with headache. Unlike printed text, digital displays require continuous visual accommodation because of screen brightness, glare, contrast variation, and constantly changing visual content. Prolonged focusing on a smartphone display places sustained demand on the accommodative and vergence systems of the eye, leading to ocular fatigue [13].

Extended smartphone use also reduces spontaneous blinking by up to 50%, resulting in tear film instability, ocular surface dryness, and visual discomfort. Common manifestations of digital eye strain include:

- Eye fatigue
- Dry or burning eyes
- Blurred vision
- Difficulty focusing
- Increased light sensitivity
- Frontal or peri-orbital headache

These symptoms become more pronounced during uninterrupted smartphone use exceeding two to three hours, particularly in environments with inadequate lighting or poor viewing ergonomics. Persistent visual fatigue may activate trigeminal nociceptive pathways, which play a central role in migraine pathophysiology [14,15].

Multiple observational studies have demonstrated a significant relationship between digital eye strain and recurrent headache among university students and office workers. Individuals reporting moderate-to-severe ocular discomfort consistently demonstrate a higher prevalence of both tension-type headache and migraine. Although most studies rely on subjective symptom assessment, the consistency of findings across different populations supports digital eye strain as an important contributing factor rather than an isolated symptom [15].

Nevertheless, digital eye strain alone cannot fully explain headache occurrence, as individual susceptibility, environmental conditions, refractive errors, and duration of screen exposure may substantially influence symptom development.

3.3 Blue Light Exposure and Circadian Rhythm Disruption

Modern smartphones emit substantial amounts of short-wavelength blue light, which has become an important area of neurological research because of its influence on circadian rhythm regulation. Specialized retinal ganglion cells containing melanopsin are particularly sensitive to blue light

and communicate directly with the suprachiasmatic nucleus, the primary biological clock regulating sleep-wake cycles.

Exposure to blue light during evening or nighttime hours suppresses melatonin secretion, delays sleep onset, reduces sleep efficiency, and shortens total sleep duration. Poor sleep quality is a well-established trigger for migraine attacks and contributes to increased pain sensitivity through alterations in central nervous system excitability.

Several observational studies have demonstrated that young adults using smartphones immediately before bedtime report poorer sleep quality and a higher frequency of headaches compared with individuals limiting nighttime screen exposure. Sleep deprivation may lower the threshold for cortical spreading depolarization, a neurophysiological process strongly implicated in migraine pathogenesis.

Experimental evidence has also suggested that blue light may increase cortical excitability and photophobia among individuals with migraine, although clinical findings remain inconsistent. While blue-light filtering glasses and smartphone night-mode settings have gained popularity, current evidence regarding their effectiveness in preventing headache remains limited and inconclusive. Large randomized controlled trials are still required before these interventions can be routinely recommended in clinical practice.

3.4 Smartphone Use and Migraine Frequency

Migraine is a chronic neurological disorder characterized by recurrent attacks of moderate-to-severe headache accompanied by nausea, vomiting, photophobia, phonophobia, and varying degrees of functional impairment. It affects approximately one billion people worldwide and represents one of the leading causes of disability among young adults [6].

Growing evidence suggests that prolonged smartphone use may contribute to increased migraine frequency and symptom severity through several interacting mechanisms rather than through a single direct pathway. Cross-sectional studies conducted among university students have consistently reported that individuals using smartphones for more than four to six hours daily experience:

- Increased migraine frequency
- Greater headache intensity
- Longer attack duration
- Higher disability scores
- Reduced academic productivity
- Poorer health-related quality of life

Several behavioural factors may explain these findings. Extended screen exposure promotes continuous visual stimulation, poor posture, inadequate sleep, increased psychological stress, and reduced physical activity, each of which has independently been associated with migraine exacerbation [10-15].

However, an important limitation of the current literature is the inability to establish temporality. Because most available studies are cross-sectional, it remains uncertain whether

prolonged smartphone use contributes to migraine development or whether individuals with chronic migraine naturally spend more time using smartphones because of lifestyle modifications or reduced outdoor activity. Consequently, smartphone use should currently be considered a modifiable aggravating factor rather than a proven primary cause of migraine.

3.5 Current Evidence from Recent Clinical Studies

The overall body of evidence demonstrates a consistent association between prolonged smartphone screen time and headache disorders, although the magnitude of this relationship varies across studies. Differences in participant characteristics, definitions of excessive smartphone use, methods used to assess screen exposure, and diagnostic criteria for headache contribute to considerable heterogeneity in published findings.

Recent systematic reviews have concluded that excessive digital screen exposure is associated with an increased prevalence of headache symptoms, particularly migraine, among adolescents and young adults. Nevertheless, these reviews also emphasize that smartphone use rarely acts in isolation. Instead, headache development appears to result from the interaction of several modifiable risk factors, including:

- Sleep deprivation
- Digital eye strain
- Poor ergonomic posture
- Psychological stress
- Anxiety and depression
- Physical inactivity
- Inadequate hydration
- Excessive caffeine intake

Studies incorporating multivariable statistical adjustment generally report a weaker, but still significant, association between prolonged smartphone use and headache frequency, suggesting that smartphone exposure remains an independent contributor after accounting for common confounding variables [12-15].

Overall, the available evidence supports the hypothesis that excessive smartphone screen time is an important lifestyle factor associated with recurrent headache and migraine among young adults. However, the predominance of observational research limits causal inference. Future prospective cohort studies and randomized intervention trials incorporating objective smartphone usage data are needed to establish dose-response relationships and determine whether reducing screen time leads to measurable improvements in headache outcomes.

Summary of Proposed Mechanisms

Current evidence indicates that smartphone-associated headache is multifactorial rather than attributable to a single pathological process. Digital eye strain, circadian rhythm disruption, cervical musculoskeletal stress, psychological factors, and sleep disturbances appear to interact synergistically, increasing vulnerability to headache and migraine in susceptible individuals.

Although observational studies consistently support these mechanisms, prospective longitudinal studies and randomized intervention trials are still needed to establish causality and determine the relative contribution of each pathway. A better understanding of these mechanisms will help clinicians identify modifiable risk factors and develop comprehensive preventive strategies for patients experiencing recurrent headaches associated with excessive smartphone use.

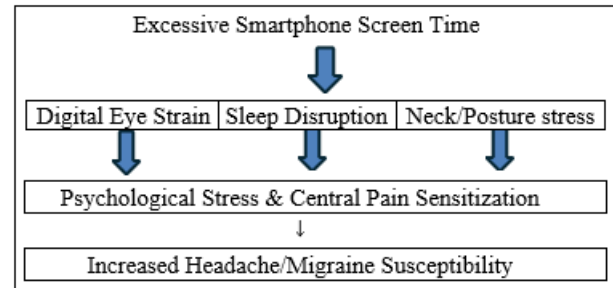


Figure 1: Proposed biological and behavioural pathways through which prolonged smartphone exposure may contribute to headache and migraine symptoms

Table 1: Summary of Selected Studies Evaluating Smartphone Use and Headache/Migraine

Study	Year	Design	Population	Major Findings
Montagni et al.	2016	Cross-sectional	Young adults	Higher screen exposure associated with increased headache symptoms
Wang et al.	2017	Systematic review/meta-analysis	Multiple populations	Mobile phone exposure showed association with headache risk
Al-Hadidi et al.	2019	Cross-sectional	University students	Smartphone overuse associated with migraine symptoms
Lee et al.	2021	Observational study	University students	Increased smartphone use linked with poor sleep and headache
Ahmed et al.	2022	Cross-sectional	Students	Screen exposure associated with headache prevalence

4. Critical Discussion

The findings summarized in this review indicate a consistent association between prolonged smartphone screen time and an increased prevalence of headache and migraine among young adults. Although the available evidence generally supports this relationship, it should be interpreted cautiously because most published studies are observational in nature and cannot establish a direct causal association [8,12,15].

One of the most consistent observations across the literature is that individuals reporting prolonged smartphone use—particularly more than four to six hours per day—experience headaches more frequently than those with lower daily screen exposure. This trend has been observed among university students, healthcare professionals, office workers, and community-based populations across different geographical regions. Such consistency strengthens the hypothesis that excessive smartphone use may represent an important lifestyle-related risk factor for recurrent headache disorders [4,9].

However, several methodological limitations reduce the certainty of current evidence. The majority of studies rely on self-reported estimates of smartphone use and headache frequency, making them vulnerable to recall bias and reporting inaccuracies. Participants often underestimate or overestimate their actual daily screen time, while headache severity and frequency are also subject to subjective interpretation. Future investigations should utilize objective smartphone usage data obtained from digital monitoring applications to improve measurement accuracy.

Another important limitation is the predominance of cross-sectional study designs. Because exposure and outcome are measured simultaneously, these studies cannot determine whether prolonged smartphone use contributes to headache development or whether individuals with recurrent headaches engage in different smartphone usage patterns because of

lifestyle changes or reduced physical activity. Prospective cohort studies are therefore essential to establish temporal relationships and better understand causality.

The relationship between smartphone uses and headache is further complicated by the presence of numerous confounding variables. Sleep quality, anxiety, depression, academic stress, caffeine intake, hydration status, physical inactivity, visual impairment, and poor ergonomic posture have all been independently associated with headache disorders. Although many studies attempted to adjust for these factors statistically, residual confounding remains a significant concern. Consequently, smartphone screen time should be considered one component of a broader behavioural and environmental framework influencing headache susceptibility rather than an isolated etiological factor [10,13].

Despite these limitations, the biological plausibility supporting this association is considerable. Evidence from ophthalmology, neurology, sleep medicine, and musculoskeletal research demonstrates that prolonged smartphone use may simultaneously induce digital eye strain, disturb circadian rhythm, increase cervical muscle tension, and promote psychological stress. These interacting mechanisms are well-recognized contributors to headache generation and migraine exacerbation, reinforcing the clinical relevance of excessive smartphone use [11,14].

Overall, the current body of evidence suggests that prolonged smartphone screen time should be regarded as a modifiable behavioural risk factor that may increase headache susceptibility, particularly among individuals with underlying migraine predisposition. Nevertheless, stronger longitudinal and interventional studies are required before definitive causal conclusions can be drawn.

An important consideration is that smartphone exposure represents one component of a complex network of lifestyle

factors influencing headache susceptibility. Future studies should focus on integrated models that evaluate smartphone behaviour alongside sleep patterns, psychological health, physical activity, and environmental factors

Clinical Implications

From a clinical perspective, smartphone use should be considered during assessment of young adults presenting with recurrent headache or migraine. Although smartphone exposure is unlikely to be the sole cause of headache disorders, identifying excessive digital behaviour may provide an opportunity for preventive intervention.

5. Research Gaps and Future Directions

Although interest in smartphone-related health effects has increased substantially during the past decade, several important research questions remain unanswered.

First, most available studies are observational and cannot establish causality. Large prospective cohort studies following participants over extended periods are needed to determine whether prolonged smartphone use precedes headache development or merely coexists with other risk factors.

Second, future research should incorporate objective measures of smartphone exposure. Modern smartphones automatically record daily screen time, application usage, and nighttime device activity. Using these objective digital data would substantially improve exposure assessment compared with self-reported estimates.

Third, considerable uncertainty remains regarding the threshold duration of smartphone use associated with increased headache risk. Future studies should investigate potential dose-response relationships to identify clinically meaningful limits for safe smartphone exposure.

6. Limitations

Several limitations should be acknowledged when interpreting the findings presented in this review.

Most published studies included in the literature are cross-sectional, limiting the ability to establish causal relationships between smartphone exposure and headache disorders. The widespread use of self-reported measures for both smartphone use and headache frequency introduces recall bias and may reduce measurement accuracy.

In addition, many investigations did not adequately adjust for important confounding variables, including sleep quality, psychological stress, caffeine intake, hydration status, physical activity, ergonomic practices, and underlying psychiatric conditions. These factors may independently influence headache occurrence and contribute to the observed associations.

Finally, because digital technology evolves rapidly, findings from earlier studies may not fully reflect current smartphone usage patterns, display technologies, or behavioural trends.

Continuous updating of evidence will therefore remain essential.

7. Conclusion

The widespread adoption of smartphones has transformed modern lifestyles, particularly among young adults, who rely on these devices for education, professional activities, communication, and entertainment. While smartphones provide substantial social and technological benefits, the growing body of scientific evidence suggests that prolonged daily screen time is associated with an increased frequency of headache and migraine. Current literature consistently indicates that excessive smartphone use may contribute to neurological symptoms through multiple interconnected mechanisms, including digital eye strain, prolonged visual accommodation, cervical musculoskeletal stress, circadian rhythm disruption caused by blue-light exposure, sleep disturbance, and psychological stress.

Although observational studies demonstrate a relatively consistent association between prolonged smartphone use and headache disorders, the existing evidence remains insufficient to establish a direct cause-and-effect relationship. Most published investigations are cross-sectional and rely on self-reported estimates of smartphone use, making them susceptible to recall bias and residual confounding. Lifestyle factors such as inadequate sleep, emotional stress, poor posture, reduced physical activity, and caffeine intake may also influence headache occurrence independently of smartphone exposure. Therefore, smartphone screen time should currently be regarded as an important modifiable behavioural risk factor rather than a definitive etiological cause of headache or migraine.

From a clinical perspective, healthcare professionals should routinely assess smartphone usage patterns when evaluating young adults presenting with recurrent headaches or migraine. Patient education focusing on healthy digital behaviours—including limiting unnecessary screen time, practicing ergonomic posture, taking regular visual breaks, maintaining adequate sleep hygiene, and reducing nighttime smartphone use—may represent practical, low-cost interventions that improve neurological health and overall quality of life.

Future research should prioritize large multicentre prospective cohort studies and randomized controlled trials that utilize objective smartphone usage data collected through digital monitoring applications. Such studies are needed to clarify dose-response relationships, identify vulnerable populations, evaluate the effectiveness of preventive interventions, and establish evidence-based recommendations for safe smartphone use. As digital technology continues to evolve, ongoing research will play a crucial role in informing clinical practice and public health policies aimed at minimizing the neurological consequences of excessive screen exposure while preserving the benefits of modern mobile technology.

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