Original Research

THE RELATIONSHIP BETWEEN DIGITAL SCREEN EXPOSURE AND MIGRAINE ATTACK FREQUENCY: A CLINICAL STUDY

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ABSTRACT

Background: Digital Screen exposure has become a common activity in the contemporary society. There are reports that excessive screen exposures have contributed to increased frequency of migraines. Prolonged use of digital devices in evening hours may interfere with sleep, increase the severity of the visual strains, and increase the frequency and recurrence of migraines. The current study was aimed to determine the relationship between exposure to digital screens and the pattern of migraine attacks among adults.

Methods: The total sample size of the study was 60 they were selected by convenience sampling method with patients diagnosed with migraine. Total of n=48(80) of these were female and remaining n=12(20%) were males. The mean age group of the cohort was 35.2 ± 9.8 years. The respondents were requested to keep a 4-week daily screen time and headache attack frequency. Baseline demographics, migraine characteristics and questionnaire scores (MIDAS, HIT-6, PSQI, PSS-10, and CVS-Q) were measured. The association between migraine outcomes and screen time was determined using spearman correlations and multivariate negative binomial regressions.

Results: The overall mean total daily screen time of 7.8 ± 2.5 hours with smartphone (4.1 ± 1.8 h) and computers/laptops (3.2 ± 2.4 h) were the major sources. Average evening screen time was 1.9 ± 0.8 h. During the study, patients experienced a mean monthly migraine attack frequency of 6.2 ± 2.4 and 8.5 ± 3.1 monthly headache days. Bivariate analysis showed that the total screen time (ρ=0.42), evening screen time (ρ=0.48), CVS-Q score (ρ= 0.51) and frequency of migraine attack ($p<0.01$) had significant positive correlations. Regression analysis proved evening screen time (IRR 1.24; 95% CI 1.111.39 and p=0.001) and total screen time (IRR 1.09; 95% CI 1.021.16 and p=0.008) as independent predictors of migraine frequency on the condition of the covariants such as sleep quality and baseline attack frequency.

Conclusions: Excessive digital screen time, particularly during the evening hours, is independently linked with an increase in the frequency of migraine attacks. The results also put emphasis on digital screen hygiene and behavioral strategies, e.g., reducing the evening screen time, and prevention strategies, including blue-light filters and frequent breaks, which can reduce the frequency of migraine attacks.

Keywords: Migraine, Digital Screen Exposure, Screen Time, Evening Screen Use, Computer Vision Syndrome, Sleep Quality.

INTRODUCTION

Migraine is a commonly prevalent disabling primary headache disorder. It is associated with recurrent attacks of moderate or severe headaches along with photophobia, phonophobia, nausea, and sensory hypersensitivity.

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Migraine is one of the leading causes of disability in adults, especially females, which highlights the importance of modifiable triggers that can increase the disease burden [1]. Among the recent triggering factors, the use of digital devices such as smartphones, tablets, computers, and televisions has become universal, which raises clinical questions regarding their role in precipitating or increasing the frequency of migraine attacks. Multiple neurobiological mechanisms are likely to have an association with exposure to digital screens and the chronicity of migraine and frequency of attacks. To start with, photophobia is a cardinal migraine

symptom, and light may increase pain even between attacks in certain patients. This concept has evolved from experimental and clinical evidence that point to intrinsically photosensitive retinal ganglion cells (ipRGCs) that express melanopsin, which conveys luminance information to thalamic and brainstem nuclei engaged in nociception, reinforcing trigeminovascular activation in migraine [2–4]. The blue-enriched light (short wavelength) emitted by LED displays seems especially provocative, in line with the spectral sensitivity of melanopsin [3, 4]. Second, the visual cortical hyperexcitability can be induced by temporal light modulation (flicker) and high contrast patterns in susceptible persons, and this may reduce the minimum threshold needed to start an attack [5]. In addition to photic effects, the frequency of migraine can be indirectly affected by the utilisation of digital screens via the extra-visual pathways. Close-up work adds to digital eye strain that has symptoms of asthenopia and dry eye that can also serve as headache triggers or increase prodrome discomfort [6]. Neck flexion, improper viewing distances, and immobility are examples of screen-related ergonomics that may trigger myofascial loading and convergent cervicogenic input into trigeminal pathways, thus supporting the onset of migraine attacks in people at risk [7]. Another pathway in these cases is sleep disruption: evening blue-enriched light exposure inhibits melatonin, delays circadian rhythm, and impairs sleep quality, which can all be related to elevated migraine frequency and diminished responsiveness to prevention interventions [8, 9]. Furthermore, cognitive-emotional stresses related to constant connectivity (notifications, multitasking, and task switching) can enhance stress reactiveness, a confirmed migraine trigger via hypothalamic and brainstem pathways that mediate the entry of nociceptive information [10]. Clinically, higher daily screen time and heavy computer use have been associated with increased occurrence of headache and migraine symptoms in students, office workers, and general populations, with varying effect sizes and confounding (e.g., by stress, posture, sleep) being frequent [13]. These data, along with the mechanistic understandings, reinforce the necessity of subtractive clinical analysis to decouple photic (wavelength, luminance, flicker), behavioral (duration, breaks), ergonomic (posture, viewing angle), and chronobiological (timing of exposure) data that might have a role in the frequency of attacks. These analyses can also guide real-world, non-pharmacological interventions, which include structured screen breaks, luminance and contrast maximization, temporal modulation reduction, spectral filtering of blue-enriched light in the evening, ergonomic corrections, and sleep hygiene that can be used in combination with existing preventative pharmacotherapies against the calcitonin gene-related peptide (CGRP) pathway [14]. Based on this background, the current study was designed to analyze the relationship between digital screen exposure and migraine attack frequency. The results of this study can be utilized for targeted behavioural prescription and to optimize comprehensive migraine management.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of General Medicine, Rajiv Gandhi Institute of Medical Sciences (RIMS), Adilabad, Telangana. Institutional Ethical approval was obtained for the study. Written consent was taken from all the participants of the study after explaining the nature of the study in the vernacular language.

Inclusion Criteria

- ICHD-3 migraine diagnosis ≥ 1 year
- Daily use of digital screen devices such as smartphones, tablets, computers, or televisions.
- Willing to participate in the study voluntarily.

Exclusion Criteria

- Headaches other than migraine
- Uncorrected refractive error or active ocular disease
- Neurological or psychiatric disorders
- Pregnant females
- Shift-work sleep disorders

At baseline, demographics, migraine characteristics (subtype, disease duration, baseline monthly attack frequency over the prior 3 months), medication history, caffeine intake, and comorbidities were recorded. Participants completed validated questionnaires: Migraine Disability Assessment (MIDAS), Headache Impact Test (HIT-6), Pittsburgh Sleep Quality Index (PSQI), Perceived Stress Scale (PSS-10), and the Computer Vision Syndrome Questionnaire (CVS-Q). A brief ergonomic assessment (seated posture, screen distance/height) was documented.

Exposure assessment: digital screen exposure was captured using a structured approach

1. **Self-Report Log (Baseline):** The daily screen time by device category (smartphone, computer, tablet, TV), typical evening screen time (last 2 hours before bedtime), use of blue-light filtering/night-mode, and average break frequency (adherence to “20-20-20” rule).
2. **Four-Week Electronic Diary:** participants recorded, once daily, (a) total screen time (hours), (b) evening screen time (hours within 2 hours pre-sleep), (c) predominant task type (reading/text, video, gaming, interactive work), and (d) use of blue-light filter that day (yes/no).
3. **Objective Spot Checks:** at baseline, the primary device’s display luminance (cd/m²) and color temperature (K) were measured using a calibrated external light meter and colorimeter in the clinic; ambient workstation illuminance

(lux) was recorded for participants who brought laptops.

Primary exposure variables were averaged over the diary period: mean daily total screen time (hours/day), mean evening screen time (hours/day), proportion of days using blue-light filters, and baseline device luminance. Secondary exposure variables included task type distribution and break frequency.

Outcome Assessment: The participants documented migraine attacks in a similar 4-week diary (start time, duration, maximum pain 010, related photophobia, aura, and acute medication). The main outcome was the frequency of the migraine attacks every month (number of separate migraine days within 28 days). Monthly headache days, acute medication days, and maximum pain intensity were the secondary outcomes.

Data Quality and Handling: Diary compliance was assessed with weekly reminders sent, provided that there were ≥2 consecutive missing entries. Missing daily exposure or outcome data were addressed with prespecified rules when 75% of days were complete; missing days were imputed with the individual mean of available days, and the participant would not be included in per-protocol analyses, but in sensitivity analyses.

Statistical Analysis: All the data were uploaded to an MS Excel spreadsheet and analyzed by SPSS version 26 in Windows format. The categorical variables were represented as mean, standard deviation, and percentages, and the continuous variables were calculated by the square test for differences between two groups. Pearson or Spearman correlations as appropriate; t-tests/Mann–Whitney U for dichotomized exposures. Two-sided $p<0.05$ was considered statistically significant. Model diagnostics (dispersion, multicollinearity via VIF, residual plots) were performed. Results are presented as incidence rate ratios (IRR) with 95% confidence intervals.

RESULTS

A total of n=60 cases were included in the study; the baseline characteristics of the cohort are given in Table 1. The mean age of the cohort was 35.2 years, comprised mostly of females (80%). Median duration of migraine was 8.5 years, and 70% of the respondents reported migraine without aura. The mean baseline monthly frequency of attacks was 5.8 and 30 percent in preventive therapy. The scores in disability and impact were found to be with a heavy burden, with a mean of 42.5 in MIDAS and 63.8 in HIT-6. There was a reduction in the quality of sleep (PSQI 8.2) and a moderate increase in the level of stress (PSS-10 19.1). It is important to note that the mean CVS-Q score of 15.7 indicated that there was significant digital eye strain, which denotes that screen-related variables could be linked to the general migraine morbidity in this population.

Table 1: Baseline Characteristics of the Study Cohort (N=60)

Characteristic	Value
Demographics	
Age, years (Mean SD)	35.2 ± 9.8
Sex, n (%) Female	48 (80.0%)
Migraine Characteristics	
Disease Duration, years (Median [IQR])	8.5 [4.0, 15.0]
Migraine Subtype, n (%) Without Aura	42 (70.0%)
Baseline Monthly Attack Frequency (Mean ± SD)	5.8 ± 2.1
On Preventive Therapy, n (%)	18 (30.0%)
Questionnaire Scores (Mean ± SD)	
MIDAS Score	42.5 ± 18.3
HIT-6 score	63.8 ± 5.9
Pittsburgh Sleep Quality Index (PSQI)	8.2 ± 3.5
Perceived Stress Scale (PSS-10)	19.1 ± 6.0
Computer Vision Syndrome (CVS-Q Score)	15.7 ± 4.2

Digital Screen Exposure Patterns in the study subjects are given in Table 2. The mean time spent at the screen was 7.8 hours/day, with the largest proportions of smartphones (4.1 hours) and computers/laptops (3.2 hours). Television (1.5 hours) and tablets (0.8 hours) were less. Evening television time, 2 hours before bed, was 1.9 hours.

The measures of devices/environment showed medium values of luminance (285 cd/m^2) and workstation illuminance (340 lux in 35 patients). Only 41.7% wore blue-light filters on most days, and 20% engaged in regular visual breaks behaviorally. The results indicate high cumulative exposure and the inability to adopt optimal protective behaviors,

which may increase the risk of migraine due to increased digital device and evening light exposure.

Table 2: Digital Screen Exposure Patterns during the 4-Week Diary Period

Exposure Variable	**Value (Mean ± SD/ n (%)**	
Daily Screen Time (hours/day)	Mean	± SD
Total Screen Time	7.8	2.5
By Device Category		
Smartphone	4.1	1.8
Computer/Laptop	3.2	2.4
Television	1.5	1.0
Tablet	0.8	1.1
Evening Screen Time (last 2 hrs before bed)	1.9	0.8
Device & Environment Metrics		
Primary Device Luminance (cd/m^2)	285	112
Workstation Illuminance (lux) (n=35)	340	155
Behavioral Factors		
Used Blue-Light Filter ≥ 50% of days, n (%)	25 (41.7%)	
Reported Regular Breaks ("20-20-20" rule), n (%)	12 (20.0%)	

Table 3 shows the migraine outcomes in the cases of the study. During the 4-week diary, participants experienced a mean of 6.2 migraine attacks with 8.5 headache days per month, which shows a high frequency of symptomatic burden. Treatment reliance was high, as the average use of acute medication was 5.9 days per month. The highest levels of intense pain were maintained at 7.4/10, which can be used to highlight the fact that clinical severity persisted despite the preventive and acute management plans. These results demonstrate that the study population had a significant migraine morbidity, as the attack days were converted to many days of impaired functionality. Together with high baseline disability scores, these findings underscore the long-term, debilitating quality of migraines and may contribute to the effect of lifestyle elements that can be altered, such as screen exposure.

Table 3: Migraine Outcomes during the 4-Week Study Period

Outcome Measure	**Value (Mean ± SD)**
Primary Outcome	
Monthly Migraine Attack Frequency	6.2 ± 2.4
Monthly Headache Days	8.5 ± 3.1
Secondary Outcomes	
Acute Medication Days	5.9 ± 2.7
Average Peak Pain Intensity (0-10 scale)	7.4 ± 1.6

Table 4 shows the bivariate correlation between screen exposure and migraine outcome analysis of the cohort. Analysis of the table shows that total screen time was associated with frequency of attacks (ρ=0.42) and days with headaches (ρ=0.38). The evening screen time had more significant relations with attack frequency (0.48) and headache days (ρ=0.45). The strongest correlations were found between CVS-Q scores and migraine frequency (ρ=0.51) and pain intensity (ρ=0.39). There were moderate correlations between poor sleep (PSQI) and headache days. These findings indicate that screen exposure overall and evening use alone worsen the burden of migraine, whereas digital eye strain enhances frequency and severity, which is why the multifactorial interaction of lifestyle behaviors and neurological outcomes is significant.

Table 4: Bivariable Correlations (Spearman's ρ) Between Screen Exposure and Migraine Outcomes

Screen Exposure Variable	**Migraine Attack Frequency (p)**	**Monthly Headache Days (p)**	**Peak Pain Intensity (p)**

Total Screen Time (hrs/day)	0.42*	0.38	0.25
Evening Screen Time (hrs/day)	0.48*	0.45*	0.31
CVS-Q Score	0.51*	0.47*	0.39*
PSQI Score (Sleep Quality)	0.37	0.40	0.22
p-value < 0.01 for all marked * correlations			

Multivariable regression analysis of the cohort is given in Table 5. Screen exposure as an independent predictor of migraine attack frequency was confirmed by the negative binomial regression. Increases in total daily screen time by 1-hour increments increased the incidence of attacks 9% (IRR 1.09) and evening screen time by 24% (IRR 1.24). Baseline frequency was also a good predictor (IRR 1.21). A significant contribution was made by poor sleep quality (PSQI) and CVS-Q scores. The predictors of outcomes were not found to be age, sex, migraine subtype, or stress independently. These results highlight the over-representative role of evening screen exposure, digital eye strain, and sleep disruption to migraine chronification, which thus supports behavior-specific interventions to address migraine management.

Table 5: Multivariable Negative Binomial Regression for Monthly Migraine Attack Frequency

Predictor Variable	**Incidence Rate Ratio (IRR)**	**95% Confidence Interval**	**P value**
Primary Exposures			
Total Screen Time (per 1-hour increase)	1.09	(1.02 - 1.16)	0.008*
Evening Screen Time (per 1-hour increase)	1.24	(1.11 - 1.39)	<0.001 *
Covariates			
Age (per I-year increase)	0.99	(0.97 - 1.02)	0.62
Sex (Female vs. Male)	1.32	(0.91 - 1.92)	0.14
Migraine Subtype (With Aura)	1.18	(0.94 - 1.48)	0.15
Baseline Attack Frequency	1.21	(1.10 - 1.33)	<0.001 *
PSQI Score (per 1-point increase)	1.05	(1.00 – 1.10)	0.04*
PSS-10 score (per 1-point increase	1.03	(1.00 – 1.06)	0.07
CVS-Q score (per-1 point increase)	1.01	(1.02 – 1.12)	0.003*
*Significant Model diagnostics: AIC= 345.2, Dispersion θ =1.15 (p=0.21)			

DISCUSSION

This clinical study investigated the relationship between exposure to digital screens and the outcomes of migraine, and how lifestyle elements associated with screen use increase the frequency and the severity of migraine attacks. The results showed that total daily screen time, as well as evening screen exposure, have a significant relationship with a higher number of migraine attacks and headache burden. In particular, exposure to screens in the evening (two hours before sleep) demonstrated the most significant correlation, in support of the importance of circadian disruption and sleep quality in the mechanism of migraine. The study cohort baseline features are in line with the existing migraine epidemiology since most of them were females (80%), and the mean age of the group was 35.2 years, which aligns with the world data on female predominance and highest prevalence rates during the young and middle ages [15]. The long period of disease and elevated scores in MIDAS and HIT-6 indicate that the cohort consisted of patients with a significant migraine-induced disability, which supports the clinical importance of lifestyle triggers in such a group. The smartphone was the most common digital screen device used in our cohort, with exposure to the digital screen being significant in this study, 7.8 hours daily. The past research has demonstrated that the length of the screen time leads to the development of visual strain and causes musculoskeletal stress, and may cause one of the migraine symptoms known as photophobia [6, 16]. This mechanistic relationship is supported in our findings of a high correlation between CVS-Q scores and the results of migraine. Ocular strain, dryness, and headaches are comorbidities that have been identified as the causes of computer vision syndrome, which has been previously recognized as

a comorbidity among migraine patients and likely increases the burden of attacks [17].

Light exposure during the pre-sleep period, especially blue light, turned out to be a major predictor of the occurrence of migraine, which is in line with research that demonstrated that light exposure, especially blue light, during the evening does not help in the secretion of melatonin and circadian rhythms [8]. In our regression analysis, poor sleep quality, as indicated by a high PSQI score, was significantly related to the frequency of attacks. These results are in line with the previous research that has associated sleep disruption with chronification of migraine and the interaction of behavioral elements and neurological vulnerability [9, 18]. The regression analysis in our study also showed that the frequency of migraine attacks increased by 24% with every one-hour rise in evening screen exposure, even after other covariates were held constant. Such an effect size is clinically significant and warrants the prioritization of sleep hygiene and restricting the use of screens in the evening when managing migraine. In addition, the frequency of the baseline attack and the level of stress also contributed to the results, as it means that screen exposure has an interaction with the pre-existing biological and psychosocial vulnerabilities. The stress scores (PSS-10) were borderline related, consistent with the fact that stress is an established migraine trigger that can be aggravated by digital multitasking and constant connectedness [19].

These findings have a clinical management implication. The frequency of migraine could be alleviated through behavioral changes, such as decreasing the number of hours spent watching during the evening, using blue-light filters, and ergonomic behaviors. Notably, two out of five respondents followed the regular screen break, which implies that specific education on the prevention measures could be offered. Past studies have demonstrated the promise of similar behavioral interventions to reduce the frequency and severity of headaches [20]. The small size of the sample and observational character of the study limits this study, as it does not allow the drawing of any causal conclusions. Recall bias may also be introduced by self-reported measures of screen use. However, the findings are validated by the consistent associations of bivariate and multivariate models. The larger samples, objective digital tracking, and interventional designs are required in future studies to develop the causal pathways and effectiveness of screen hygiene interventions.

CONCLUSION

Within the limitations of our study, we found a strong association between screen exposure, especially during the evening, and frequency of migraine attacks. The inclusion of the concept of screen time management and sleep hygiene in migraine management may be a low-cost, modifiable approach to decrease the disease burden.

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