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Comparison of visual-evoked potential parameters and prevalence of eye strain symptoms among electronic device users with varying screen time

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ABSTRACT

Objectives: To evaluate the impact of varying screen time durations on visual-evoked potential (VEP) parameters and the prevalence of eye strain symptoms in young adults using electronic devices.

Materials and Methods: A cross-sectional comparative study was conducted on 60 healthy participants aged 18–25 years at Netaji Subhash Chandra Bose Medical College, Jabalpur. Based on self-reported daily screen time, participants were divided into three groups: Group A (<4 h/day), Group B (4–7 h/day) and Group C (>7 h/day). Pattern reversal VEPs were recorded monocularly, and latencies of N75, P100 and N145 components were measured. Eye strain symptoms and screen usage details were collected through structured interviews. Statistical analysis was performed using the Statistical Package for the Social Sciences v26.0, with $P < 0.05$ considered significant.

Results: A significant increase in P100 latency was observed with prolonged screen time. Mean P100 latency in the left eye increased from 109.68 ± 8.46 ms in Group A to 122.13 ± 9.98 ms in Group C ($P = 0.0044$), and in the right eye from 110.89 ± 8.55 ms to 120.24 ± 9.75 ms ($P = 0.016$). N145 latency showed a non-significant upward trend across groups. Eye strain symptoms such as dryness, headache and visual discomfort were reported by 88.3% of participants. Those with symptoms reported significantly longer screen time ($P = 0.0071$) compared to asymptomatic individuals.

Conclusion: Prolonged screen exposure is associated with prolonged P100 latency and more frequent eye strain symptoms in healthy young adults. These findings suggest the need for early electrophysiological screening and public health measures to raise awareness about the visual impacts of excessive screen use.

Keywords: Digital eye strain, Electrophysiology, Pattern reversal visual-evoked potential, Screen time, Visual evoked potential

INTRODUCTION

In our modern world, illuminated by artificial light sources, exposure to light is constant. This is especially evident with the widespread use of electronic devices such as smartphones, laptops and tablets. These light-emitting diode-based screens have become an integral part of daily life, with professional as well as recreational activities revolving around their use. As established in earlier research, prolonged exposure to screen time is associated with a range of physical and mental health consequences, including obesity, sleep disturbances and psychological stress.[1]

Previous studies have also highlighted the potential photochemical damage caused by mobile phone usage[2] and the anatomy of the eye makes it vulnerable to such damage.[3,4] The American Macular Degeneration Foundation cautions that cumulative exposure to ultraviolet and blue light may accelerate age-related macular degeneration progression.[5] Experimental studies in rat models have demonstrated that exposure to diffuse blue light can trigger retinal cell apoptosis, leading to macular degeneration.[6] Prolonged use of these devices, such as mobile phones and laptops, can result in eye strain symptoms such as headaches, dry eye and ocular discomfort, among others.[7]

Visual-evoked potential (VEP) serves as a non-invasive and objective electrophysiological tool to evaluate the functional integrity of the visual pathway.[8] It assesses the response of the occipital cortex to visual stimuli through surface electrodes placed on the scalp.[9] Among the various waveform components, P100 latency is considered the most consistent and with the least variable peak.[10] It is believed to be generated by the pyramidal cells in Layer IV of Area 17 of the visual cortex.[11] Prolongation of P100 latency has been widely accepted as an indicator of demyelination or conduction delay in the optic pathway and may reflect subclinical visual dysfunction.[12,13]

Despite the growing dependence on digital devices, the subtle impacts on visual health are often under-recognised and under-assessed. Many individuals experience symptoms such as eye strain, dryness and blurred vision, yet rarely seek clinical evaluation. Furthermore, objective tools like VEP are not routinely used in assessing screen-related visual stress. This study, therefore, addresses a critical and timely gap by linking screen exposure with both subjective symptoms and objective functional changes in the visual pathway.

MATERIALS AND METHODS

This cross-sectional comparative study was conducted in the electrophysiology laboratory of Netaji Subhash Chandra Bose Medical College, Jabalpur, using the RMS NCV/VEP machine, between July 2024 and September 2024, after obtaining clearance from the Institutional Ethical Committee.

A total of 60 study participants were enrolled in the study. Participants were recruited using a convenience sampling method, considering feasibility and the defined inclusion criteria of the study. The study population consisted of MBBS and paramedical students from the medical college. After obtaining written informed consent, data were collected through personal interviews and history taking. Information recorded included average daily screen time, types of electronic devices used and presence of eye strain symptoms. This was followed by anthropometric measurements and visual acuity testing using Snellen's chart.

Inclusion criteria included young adults aged 18–25 years of both genders,[14,15] with uncorrected visual acuity of 6/6 in both eyes (participants not using spectacles or contact lenses). Exclusion criteria included individuals with known ophthalmic or chronic medical conditions, and those using blue light filter glasses or eye drops.

Participants were divided into three groups based on their average daily screen time (ST):[16]

- Group A: ST < 4 h
- Group B: ST 4–7 h
- Group C: ST > 7 h

Pattern reversal VEPs were recorded. Participants were instructed to report with a clean scalp (no oil applied) on the day of testing. The scalp was prepared using Ten20 conducting paste, and electrodes were placed according to the 10–20 International System at the following sites:

- Recording electrode: Occiput (Oz)
- Reference electrode: Vertex (Cz)
- Ground electrode: Forehead (Fz)[10]

Subjects were seated comfortably at a distance of 100 cm from the stimulus screen and were instructed to fix their gaze on a red dot at the centre of a checkerboard pattern.[17]

Monocular stimulation was performed, testing each eye separately while the other was covered with a patch. The recorded VEP parameters included N75, P100 and N145 latencies, ensuring electrode impedance was maintained below 5 Ω.

Data were analysed using IBM Statistical Package for the Social Sciences software version 26.0. Results were expressed as mean ± standard deviation (SD). The Shapiro–Wilk test was applied to assess normality. Depending on the distribution, analysis of variance or the Kruskal–Wallis test was used to compare groups. $P < 0.05$ was considered statistically significant.

RESULTS

A total of 60 participants (32 males and 28 females), aged between 18 and 25 years, were included in the study. Table 1 presents the demographic and screen exposure characteristics of the participants. The mean age was 21.2 ± 2.4 years. The majority of participants were MBBS students, with a few from other educational backgrounds.

The mean daily screen time was 6.1 ± 2.4 h. A majority of participants (61.7%) reported using only smartphones, while others used smartphones in combination with other devices (35.0%) or other devices alone (3.3%).

Among the 60 participants, 53 (88.3%) reported experiencing symptoms of eye strain, whereas 7 (11.7%) did not. The mean screen time for those with eye strain was significantly higher (6.11 ± 2.25 h/day) compared to those without (3.57 ± 0.75 h/day), with a statistically significant *P*-value (*P* = 0.0071) [Table 2 and Figure 1]. The figure illustrates a clear trend of prolonged latencies in both P100 and N145 components with increasing screen time, in both the right and left eyes. A statistically significant increase in P100 latency was observed with higher screen time exposure. For the left eye, mean P100 latency increased from 109.68 ± 8.46 ms in Group A (<4 h/day) to 122.13 ± 9.98 ms in Group C (>7 h/day), with *P* = 0.0044. For the right eye, latency rose from 110.89 ± 8.55 ms to 120.24 ± 9.75 ms (*P* = 0.016). Although N145 latencies showed an upward trend across the screen time groups, these differences were not statistically significant [Table 3].

Table 1: Demographic and device usage profile of participants (*n*=60).

Variable	Category	*n* (%)
Age (years)	Mean±SD	21.2±2.4
Sex	Male	32 (53.3%)
	Female	28 (46.7%)
Education	12th pass	5 (8.3%)
	Higher secondary	1 (1.7%)
	Bachelor	7 (11.7%)
	MBBS 1st year student	28 (46.7%)
	Pursuing MBBS/MBBS student	14 (23.3%)
	1 Year MBBS/1st Prof/medicos	4 (6.7%)
	Masters	1 (1.7%)
	Undergraduate (non-MBBS)	1 (1.7%)
Screen time (h/day)	Mean±SD	6.1±2.4
Primary device used	Phone/Smartphone only	36 (61.7%)
	Phone/Smartphone+other devices	21 (35.0%)
	Others only	2 (3.3%)

SD: Standard deviation

Table 2: Association between screen time and eye strain (n=60).

Symptoms of eye strain	Number of subjects	Mean screen time (h/day)
Yes	53	6.11±2.25
No	7	3.57±0.75

DISCUSSION

The present study investigated the impact of daily screen time on VEP among young adults aged 18–25 years. A statistically significant prolongation of P100 latency was observed with increasing screen exposure, indicating delayed conduction along the visual pathways. These findings suggest that excessive use of light-emitting electronic devices may influence the visual pathway, even in individuals with normal visual acuity and no known ophthalmic or neurological conditions.

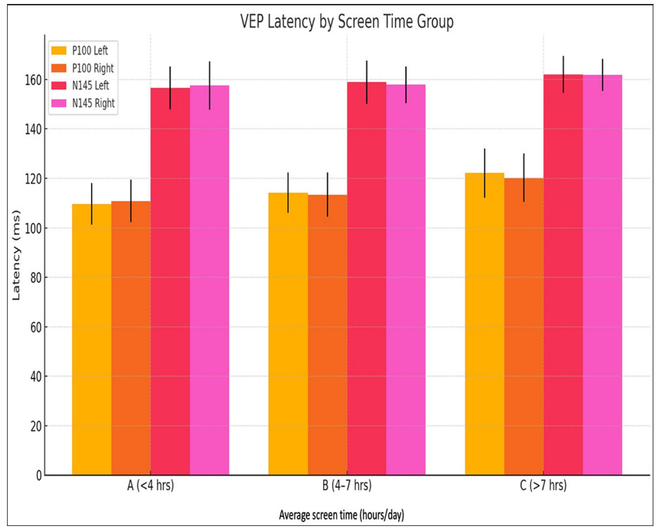

Figure 1: Effect of screen time on visual evoked potential latencies (P100 and N145) in both eyes. The figure illustrates a clear trend of prolonged latencies in both P100 and N145 components with increasing screen time, in both the right and left eyes. VEP: Visual evoked potential

Our findings are consistent with earlier studies that reported increased P100 latency in individuals with prolonged screen exposure among young adults with screen use exceeding 6 h/day.[16] Similarly, another study found that nocturnal use of mobile phones for more than 3 h/day showed prolonged P100 latency.[18] The upward trend in N145 latency in our study, though not statistically significant, is consistent with some other studies[19] that may also suggest concern about prevalent changes in future.

The high prevalence of reported eye strain (88.3%) in this study highlights the increasing burden of digital eye strain among students. The significant association between screen time and eye strain supports existing evidence that visual discomfort and fatigue are common in populations exposed to prolonged near-focus digital tasks.[7]

Chronic exposure to short-wavelength blue light emitted by screens may contribute to and affect cortical excitability, potentially explaining the electrophysiological changes observed in VEP.[20,21] A key strength of this study is its use of objective electrophysiological assessment through pattern reversal VEP, which are sensitive indicators of central visual conduction. The strict inclusion criteria (normal visual acuity, no blue light filter use) and random sampling from

Table 3: VEP latencies (mean±SD) across screen time groups.

Group	P100 Left (ms)	P100 Right (ms)	N145 Left (ms)	N145 Right (ms)
A (<4 h/day)	109.68±8.46	110.89±8.55	156.58±8.75	157.58±9.77
B (4–7 h/day)	114.22±8.20	113.43±8.95	158.96±8.76	157.91±7.40
C (>7 h/day)	122.13±9.98	120.24±9.75	162.11±7.49	161.89±6.49

P-values: P100 Left: *P=0.0044*, P100 Right: *P=0.016*, N145 Left and right: Not statistically significant, SD: Standard deviation, VEP: Visual evoked potential

a homogeneous population further enhance the internal validity of the results.

However, being a cross-sectional study, causal inferences cannot be established. The relatively small sample size, though statistically justified, may limit the generalizability of the findings. Moreover, participants were recruited using convenience sampling, which may further limit generalizability**.** In addition, reliance on self-reported screen time introduces a risk of recall bias. Future longitudinal studies are recommended to explore the in-depth and deep associations of these VEP changes after screen time reduction or blue light mitigation.

CONCLUSION

The study observed an increasing trend in P100 latency and the presence of eye strain symptoms among individuals with higher screen time. These findings suggest potential functional changes in the visual pathways and underscore the importance of awareness regarding digital eye strain among students and young professionals with prolonged screen use. However, further studies including more diverse populations are needed to establish definitive causality.

Ethical approval: The research/study was approved by the Institutional Review Board at Netaji Subhash Chandra Bose Medical College, approval number IEC/2024/4354, dated 9th May 2024.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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