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Exploring the Relationship Between Screen Exposure, Digital Fatigue, Blue Light Exposure, and Sleep Quality in College Students

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ABSTRACT

Background: The increasing use of digital devices among college students has raised concerns about its impact on digital fatigue, blue light exposure, and sleep quality. This study is grounded in Cognitive Load Theory and Arousal Theory. According to Cognitive Load Theory, excessive screen exposure increases mental workload, leading to cognitive exertion and digital fatigue. Arousal Theory suggests that exposure to artificial blue light, particularly during nighttime, suppresses melatonin secretion, increases physiological arousal, disrupts circadian rhythms, and impairs sleep quality. Previous research has highlighted links between prolonged screen use, eye strain, and sleep disturbances, though evidence on the independent effects of blue light and digital fatigue on sleep quality remains mixed.

Aim: The present study aimed to assess levels of screen exposure, digital fatigue, blue light exposure, and sleep quality among college students, examine their interrelationships, and investigate predictors of digital fatigue.

Methods: A cross-sectional correlational design was employed. A convenience sample of 123 college students aged 18-25 years participated. Data were collected through an online survey administered via Google Forms. Screen exposure was assessed using the Computer Vision Syndrome Questionnaire, digital fatigue with the Screen Fatigue Scale), blue light exposure using a custom 3-item self-report measure, and sleep quality using the PROMIS Sleep Disturbance Short Form (8 items). Descriptive statistics, Pearson correlations, and multiple linear regression were performed using SPSS.

Results: Mean scores were: screen exposure, M = 70.90 (SD = 15.70); digital fatigue, M = 3.90 (SD = 2.74); blue light exposure, M = 8.11 (SD = 2.56); sleep quality, M = 26.49 (SD = 4.67).

Screen exposure was positively correlated with digital fatigue ($r = 0.480$, $p < 0.01$). No significant associations were observed between blue light exposure and sleep quality ($r = -0.046$, $p = 0.610$) or between digital fatigue and sleep quality ($r = 0.021$, $p =$

0.814). Multiple regression indicated that screen exposure, blue light exposure, and sleep quality together predicted digital fatigue, explaining 23.6% of variance (R^2 = 0.236, $p < 0.001$).

Conclusions: Digital fatigue among college students appears to be primarily influenced by screen exposure, with secondary contributions from sleep patterns and blue light exposure. These findings highlight the need for interventions promoting screen hygiene, digital well-being, and healthy sleep behaviors among students.

Keywords: digital fatigue, digital mindfulness, blue light exposure, sleep quality

INTRODUCTION

The proliferation of blue light-emitting devices such as smartphones, tablets, and laptops has surged dramatically over the past decade. These technologies have catalyzed profound social transformations, embedding themselves into daily routines, work, education, and leisure, and becoming indispensable tools for communication, productivity, and entertainment. When used judiciously, they offer unparalleled convenience: instant access to information, seamless connectivity, and innovative applications that enhance quality of life. However, their widespread accessibility and portability have led to overuse, particularly in the hours leading up to bedtime, raising significant concerns about their impact on sleep health (Heo et al., 2017; Chinoy et al., 2018; Yoshimura & Kitazawa, 2017).

This unchecked integration into evening habits stems from design features that prioritize engagement vibrant screens, notifications, and endless content streams making devices lightweight and ever-present. Consequently, exposure to blue light from these screens at night disrupts the body's natural circadian rhythms, delaying sleep onset, reducing sleep quality, and impairing next-day alertness. Impaired sleep cascades into broader health consequences, including obesity, mood disorders, cognitive deficits, and heightened accident risk. For instance, chronic sleep disruption has been linked to metabolic dysregulation, where shortened sleep duration correlates with increased caloric intake and weight gain. In adolescents and young adults, these effects are particularly alarming, as insufficient sleep exacerbates developmental vulnerabilities, contributing to academic underperformance, mental health issues, and risky behaviors. Thus, fostering appropriate behavioral and environmental strategies is essential to safeguard sleep hygiene amid this technological revolution (Heo et al., 2017; Chinoy et al., 2018; Grønli & Byrkjedal, 2016).

Sleep itself is a complex physiological state characterized by reduced awareness and responsiveness to external stimuli, regulated by homeostatic and circadian processes. Humans spend nearly one-third of their lives asleep, underscoring its evolutionary primacy. Far from mere rest, sleep orchestrates critical functions: it consolidates learning and memory, facilitates physical restoration, removes cellular toxins via the glymphatic system, bolsters immune function, and prevents chronic diseases (Curcio et al., 2006; Davies et al., 2014; Cappuccio et al., 2010). In children and adolescents, adequate sleep is paramount for neurodevelopment, growth hormone release, and emotional regulation. The National Sleep Foundation recommends 9-11 hours for school-aged children and 8-10 hours for teenagers, yet global surveys reveal widespread shortfalls. Sleep deprivation studies illuminate these imperatives; even moderate restrictions impair attention, decision-making, and metabolic homeostasis, mimicking the effects of alcohol intoxication.

Among myriad sleep disruptors caffeine, stress, irregular schedules electronic device use has emerged as a dominant culprit, especially in adolescence. A large population-based study of Norwegian youth found that frequent bedtime media use doubled the odds of sleep disturbances, independent of other factors. The smartphone

revolution amplifies this: over 95% of teens own one, with average daily screen time exceeding 7 hours, much of it nocturnal. Smartphones enable immersive activities social media scrolling, video streaming, gaming, and instant messaging that foster cognitive hyperarousal, delaying melatonin onset and prolonging sleep latency. This behavioral addiction, prevalent in 20-30% of young users, manifests as compulsive checking and FOMO (fear of missing out), further eroding sleep boundaries (Cappuccio et al., 2010; Sahin et al., 2013; Shechter et al., 2018).

Central to this disruption is blue light, a short-wavelength emission (460-480 nm) from LED screens that mimics daylight. Unlike warmer lights, blue light potently suppresses melatonin synthesis in the pineal gland, the hormone orchestrating the sleep-wake cycle. Melatonin's suppression shifts circadian phase, delaying bedtime by 1-2 hours and fragmenting sleep architecture. Randomized trials confirm this: evening tablet use postponed self-selected bedtimes and desynchronized rhythms, while blue-light filters mitigated effects. Spectral tuning experiments show blue-enriched light heightens alertness but at the cost of sleep inertia the next day. In adolescents, whose circadian clocks naturally delay during puberty, this exogenous zeitgeber exacerbates "social jetlag," misaligning biological and social clocks (Heo et al., 2017; Chinoy et al., 2018; Grønli & Byrkjedal, 2016).

Cognitive and emotional dimensions compound physiological insults. Screen brightness and content stimulate the brain's arousal networks, increasing beta waves and heart rate variability akin to stress responses. Reading on e-readers like iPads reduced slow-wave sleep and REM, impairing memory consolidation compared to printed books. Smartphone proximity alone via vibrations or mere presence triggers anticipatory arousal, even if unused. Viewing distance matters too; closer scrutiny (under 30 cm) intensifies blue light flux to the retina. Population data link >3 hours of pre-bed screen time to 50% higher insomnia risk in teens (Heo et al., 2017; Chinoy et al., 2018; Grønli & Byrkjedal, 2016).

Health ramifications extend beyond sleep. Metabolomic profiling reveals sleep loss reprograms lipid and amino acid pathways, fostering insulin resistance and inflammation. Meta-analyses associate short sleep (<6 hours) with 12% higher all-cause mortality, driven by cardiovascular and neoplastic risks. In youth, chronic deficits predict obesity (via ghrelin/leptin imbalance), depression (odds ratio 2.5), and accidents (e.g., drowsy driving). Digital fatigue from blue light may induce eyestrain and circadian desynchrony, mirroring shift-work disorders. Emerging evidence ties nocturnal exposure to neuroinflammation, potentially accelerating neurodegeneration long-term (Heo et al., 2017).

Adolescent vulnerability amplifies these threats. Pubertal delays in melatonin onset (by 2-3 hours) clash with early school schedules, compounding device-induced shifts. A vicious cycle ensues: sleep loss begets irritability and poor impulse control, fuelling more media use for escapism. Cross-cultural studies report 70-80% of teens using devices in bed, with addiction scales correlating inversely with sleep quality. Interventions like blue-light blockers show promise reducing melatonin suppression by 50% and improving sleep efficiency yet adoption lags due to unawareness (Touitou et al., 2016; Brown, 2012; Webb & Friel, 1970).

This dual assault physiological (blue light/melatonin) and behavioral (addiction/arousal) demands urgent scrutiny. While lab studies elucidate mechanisms, real-world patterns in emerging adults (18-25 years) remain underexplored, particularly in diverse cultural contexts like India, where smartphone penetration hit 800 million by 2025 amid rising sleep complaints. Prior work overlooks viewing habits, addiction interplay, and longitudinal health trajectories. Our study addresses this gap by examining nocturnal smartphone use, blue light exposure, sleep metrics, and

psychosocial outcomes in Bengaluru youth, hypothesizing dose-dependent disruptions amenable to targeted interventions (Heo et al., 2017; Chinoy et al., 2018; Grønli & Byrkjedal, 2016).

Therefore, blue light devices permeate bedtime sanctuaries, their circadian toll threatens public health. Heightened awareness, policy (e.g., screen curfews), and tech innovations (e.g., night modes) are imperative. This research illuminates pathways to reclaim sleep in the digital age.

Objectives and Hypotheses

The present study was conducted with certain objectives in mind based on the review of literature, which were to examine the relationships between screen exposure, blue light exposure, digital fatigue, and sleep quality among college students, and to assess the collective predictive value of these factors in explaining variance in digital fatigue. The study was guided by the following hypotheses:

H1a: There will be a significant positive relationship between screen exposure and digital fatigue among college students.

H1b: There will be a significant positive relationship between blue light exposure and sleep quality among college students.

H1c: There will be a significant negative relationship between digital fatigue and sleep quality among college students.

H2: There will be a significant collective predictive relationship between screen exposure, blue light exposure, and sleep quality on digital fatigue among college students.

REVIEW OF LITERATURE

Zhong et al. (2025) investigated how electronic screen use influences sleep duration and sleep timing in adults using a large population-based dataset. The study examined not only total screen time but also the timing of screen exposure across the day. The authors found that individuals who engaged in higher levels of screen use, particularly during evening and nighttime hours, were significantly more likely to experience delayed sleep onset, reduced total sleep duration, and irregular sleep schedules. The authors interpreted these findings using both behavioral and biological explanations. Behaviorally, screen use often displaces sleep time, encouraging individuals to stay awake longer. Biologically, light emitted from screens, especially blue light, interferes with the body's circadian rhythm. The study also suggested that frequent late-night screen use may gradually reshape sleep habits over time, leading to chronic sleep disruption. Although the sample consisted of adults in general, the findings are highly applicable to college students, who frequently engage in prolonged nighttime screen use for academic work, social media, and entertainment. This study provides strong foundational support for the screen exposure-sleep quality link central to the present research. (Zhong et al. ,2025) Pieh et al. (2025) used a randomized controlled trial design to test whether reducing smartphone screen time could directly improve mental health and sleep-related outcomes. Participants were divided into an intervention group, which was instructed to consciously reduce smartphone use, and a control group that maintained usual behavior. After the intervention period, the reduced-use group demonstrated significant improvements in sleep quality, emotional well-being, stress levels, and depressive symptoms. The authors argued that excessive screen exposure contributes to continuous cognitive stimulation, psychological overload, and lack of recovery time, all of which contribute to digital fatigue. What makes this study especially important is its experimental design, which suggests a causal relationship rather than simple correlation. For college students, this research suggests that excessive screen use is not just associated with fatigue and poor sleep, but that modifying digital behavior can meaningfully improve well-being. This provides strong justification for studying screen exposure as a modifiable risk factor in student populations. (Pieh et al., 2025) Kaewpradit et al. (2024) conducted a cross-sectional study specifically among university

students to examine digital screen use patterns and their associations with sleep quality, mental health, and academic performance. The study found that a large proportion of students reported excessive daily screen time, often extending late into the night. Students with higher screen exposure reported greater difficulty falling asleep, more frequent nighttime awakenings, increased daytime sleepiness, and lower perceived sleep quality. In addition, heavy screen users reported higher levels of emotional distress and poorer academic concentration. The authors emphasized that nighttime smartphone use appeared particularly harmful, as it interfered with both sleep timing and sleep duration. This study is directly aligned with the present research topic because it focuses on the same population (college students) and clearly demonstrates how screen exposure simultaneously affects sleep quality, mental well-being, and functioning. (Kaewpradit et al., 2024) He et al. (2025) conducted a systematic review and meta-analysis to provide a comprehensive evaluation of the relationship between screen time and sleep outcomes. By statistically synthesizing data from numerous previous studies, the authors were able to identify consistent global trends. Their findings demonstrated that increased screen exposure is significantly associated with insomnia symptoms, delayed sleep onset, shorter sleep duration, and poor subjective sleep quality. The authors highlighted that adolescents and young adults are among the most vulnerable populations due to their heavy reliance on digital devices for education, communication, and leisure. Importantly, they suggested that the relationship between screen exposure and sleep disturbance may be bidirectional: excessive screen use worsens sleep, while poor sleep may increase reliance on screens. This study provides strong scientific justification for examining screen exposure as a key variable in student sleep research. (He et al. ,2025)

Alam et al. (2024) explored the impact of blue light exposure from electronic devices on circadian rhythm functioning and sleep patterns among adolescents and young adults. The authors explained that blue light has a particularly strong effect on the brain's biological clock because it suppresses the secretion of melatonin, the hormone responsible for initiating sleep. Their findings indicated that individuals who frequently used electronic devices during nighttime experienced delayed sleep onset, reduced sleep duration, poorer sleep quality, and greater daytime fatigue. The study also discussed how repeated exposure to blue light in the evening can gradually shift circadian rhythms, leading to chronic sleep irregularities. This research is highly relevant to the present project because it directly explains the biological mechanism connecting screen exposure, blue light, and sleep disruption in the same age group as college students. (Alam et al., 2024)

Sánchez-Cano et al. (2025) conducted a controlled experimental study to compare the effects of red and blue LED light exposure on melatonin levels in healthy adults. Participants were exposed to specific light conditions for a fixed duration, and melatonin concentrations were measured before and after exposure. The results clearly demonstrated that blue light caused significantly greater suppression of melatonin compared to red light. This finding provides strong physiological evidence explaining why exposure to electronic screens before bedtime disrupts sleep. Unlike survey-based studies, this experimental research directly demonstrates a biological mechanism rather than relying on self-reported associations. The findings strongly support the inclusion of blue light exposure as a key variable in studies examining sleep quality among college students who routinely use screens late at night. (Sánchez-Cano et al., 2025)

Yosep et al. (2024) examined the phenomenon of screen fatigue among first-year nursing students who were extensively engaged in online learning. The study documented a range of symptoms associated with prolonged screen exposure, including

eye strain, headaches, irritability, reduced attention span, mental exhaustion, and decreased motivation. The authors explained that continuous digital engagement places sustained cognitive demands on students while also creating physical strain due to prolonged visual focus. Importantly, students who experienced higher levels of screen fatigue also reported lower engagement with academic tasks and greater emotional exhaustion. This study is particularly relevant to the present research because it directly addresses digital fatigue as a measurable and meaningful experience among students, supporting its inclusion as a central variable. (Yosep et al., 2024)

Romero-Rodríguez et al. (2023) investigated digital fatigue among university students during the period of extensive online education brought about by the COVID-19 pandemic. The study found that students experienced significant levels of emotional exhaustion, cognitive overload, reduced motivation, and mental disengagement due to prolonged exposure to online learning environments. The authors emphasized that digital fatigue is a multidimensional construct involving emotional, cognitive, and physical components. They also noted that constant exposure to screens without adequate recovery time can lead to long-term academic disengagement and psychological strain. This study is highly relevant to the current project because it reinforces the idea that digital fatigue is not a superficial discomfort but a serious psychological outcome of excessive screen exposure in student populations. (Romero- Rodríguez et al. ,2023)

Beyea et al. (2025) conducted a meta-analysis to explore the causes and effects of videoconferencing fatigue, commonly known as "Zoom fatigue." Instead of focusing on a single sample, the authors analyzed data from multiple studies to find common psychological patterns. Their results showed that long hours of videoconferencing strongly link to emotional exhaustion, mental overload, reduced attention span, and increased cognitive effort. The study noted that constant self-monitoring on camera, fewer non-verbal cues, and continuous close-up engagement heighten mental strain. The authors pointed out that digital fatigue is more than just discomfort; it is a measurable psychological response to too much screen time. This study is relevant to the current research, as many college students spend long hours in online classes, virtual meetings, and video calls, making them vulnerable to similar fatigue. It supports the idea that screen exposure affects sleep not only biologically but also, cognitively and emotionally, contributing to overall exhaustion. (Beyea et al., 2025)

Yglesias-Alva et al. (2025) focused on creating and validating a multidimensional questionnaire to measure digital fatigue among university students. The study included several stages, such as item development, expert validation, pilot testing, and statistical validation on a student sample. The authors defined digital fatigue as a complex issue that includes emotional exhaustion (feeling overwhelmed by digital tasks), cognitive fatigue (difficulty concentrating after extended screen use), and physical fatigue (eye strain, headaches, bodily tiredness). Their findings showed that digital fatigue can be reliably measured and is a genuine psychological issue instead of a vague complaint. This study is important for the present research, as it provides scientific backing for treating digital fatigue as a serious concern. It supports the notion that prolonged screen time among students leads to layered exhaustion, which may worsen sleep quality and overall well-being. (Yglesias-Alva et al., 2025)

Garlock et al. (2025) studied the connection between long screen time, computer vision syndrome (CVS), sleep issues, and fatigue in medical students. The authors looked atsymptoms like eye strain, dry eyes, blurry vision, headaches, and general tiredness, along with sleep quality indicators. Their findings indicated that students using digital devices for many hours were much more likely to face both visual discomfort and sleep problems. The study highlighted that

physical discomfort from screen use does not stay isolated; it adds to overall fatigue and decreases sleep quality. This study reinforces the current research by showing that screen exposure impacts students not only mentally and emotionally but also physically, creating a cumulative burden that can disrupt healthy sleep patterns. (Garlock et al., 2025)

Chaudhry et al. (2022) explored the link between smartphone use and sleep quality among university students. Using standardized sleep assessment tools, the authors found that students with higher smartphone use, especially at night, were much more likely to report poor sleep quality, delayed sleep onset, and daytime sleepiness. The study explained how constant connectivity, notifications, and late-night browsing raise psychological arousal and stop the brain from entering a relaxed state needed for sleep. The authors also indicated that problematic smartphone use might develop into habits that gradually harm sleep hygiene.

This study directly supports the current research by showing that excessive screen time among students has clear and measurable effects on sleep quality. (Chaudhry et al., 2022) Abraham et al. (2023) looked at how too much digital engagement affects student well-being, focusing on academic burnout. The study found that students who spent more hours on online platforms reported higher levels of emotional exhaustion, less academic motivation, and feelings of being mentally drained. The authors argued that constant online engagement creates pressure to stay available and productive, which gradually depletes psychological resources. Although the study centered on burnout, its findings are vital to understanding digital fatigue and sleep disturbances. Emotional exhaustion from excessive screen time may hinder students' ability to relax at night, indirectly causing sleep problems. This study supports the idea that digital exposure impacts the overall mental health of students, not just specific behaviors. (Abraham et al., 2023)

Diaconu et al. (2024) provided a thorough review of how blue light affects sleep and overall bodily function. The authors talked about how artificial light, especially the short-wavelength blue light from smartphones, laptops, and LED screens, disrupts the body's internal biological clock. They detailed how blue light lowers melatonin production, delays circadian rhythm timing, and reduces sleep pressure, making it harder to fall asleep and leading to poorer sleep quality. The paper also stressed that ongoing exposure to blue light at night could cause long- lasting sleep disorders and increased daytime fatigue. Importantly, the authors pointed out that young adults and students are particularly at risk due to their heavy reliance on digital devices late at night. This study reinforces the biological basis of the current research by showing how blue light from screens disrupts sleep and highlighting the need to investigate its effects on college students. (Diaconu et al., 2024)

Gonçalves et al. (2021) explored the relationship between screen time and sleep quality, focusing on how modern digital lifestyles impact healthy sleep habits. The authors found that people with long screen exposure, especially at night, experienced poorer sleep quality, trouble falling asleep, and increased daytime tiredness. The study highlighted that using screens before bed often leads to behavioral shifts, where time meant for sleep is instead spent on digital devices. Additionally, the authors mentioned how mental stimulation from social media, entertainment, and academic tasks can raise mental arousal, making it tough for the brain to settle into sleep. This study is highly relevant to the current research since it supports the view that both biological factors (light exposure) and behavioral patterns (late-night usage) contribute to students' sleep problems. (Gonçalves et al. ,2021)

METHODS

Participants

Using a convenience sampling method, the study included college students aged 18-25 years. The final sample comprised 123

participants (N = 123) that is, 56 male and 67 female participants.

Participants were recruited through online dissemination of the survey link administered via Google Forms, which was circulated across student networks and social media platforms. Convenience sampling was employed due to ease of access and feasibility within the study context.

Inclusion Criteria

1. Individuals aged between 18 and 25 years.
2. Students currently enrolled in a college or university.
3. Regular users of digital devices (smartphones, laptops, or tablets).
4. Participants willing and able to provide informed consent for participation.
5. Proficiency in reading and understanding the English language.

Exclusion Criteria

1. Individuals with a diagnosed sleep disorder.
2. Participants currently using medication known to affect sleep or alertness.

Ethical Considerations and Data Collection

The study was conducted in accordance with the ethical principles for research involving human participants. Prior to participation, individuals were provided with information regarding the nature, purpose, and voluntary nature of the study. Participants were assured that their responses would remain confidential and that they held the right to withdraw at any stage without penalty.

Informed consent was obtained from each participant before the commencement of the assessment, either through an electronic form for online respondents or a physical consent page for offline participants.

Measures

1.Computer Vision Syndrome Smart Questionnaire (CVS-Smart) (Iqbal, 2024):

Screen exposure was assessed using the Computer Vision Syndrome Smart Questionnaire (CVS-Smart) developed by Iqbal (2024). The instrument consists of 5 items designed to assess symptoms associated with computer vision syndrome resulting from prolonged screen use. Each item was scored on a 3-point scale (0, 1, 2) with higher scores indicating greater severity of screen-related visual symptoms. The scale demonstrated high internal consistency, with a reported reliability coefficient of $\alpha = .860$. Evidence for face validity indicated that the items were clear, relevant, and appropriate for assessing screen-related visual discomfort. Construct validity was supported through confirmatory factor analysis (CFA), which showed good model fit indices. The CVS-Smart questionnaire has been used as a concise screening tool for assessing screen exposure-related visual strain. (Iqbal, 2024)

2.Screen Fatigue Scale (Ocak et al., 2023):

Digital fatigue was measured using the Screen Fatigue Scale developed by Ocak et al. (2023). The scale comprises 24 items assessing fatigue associated with prolonged screen use across multiple domains, including physical, cognitive, behavioral, and affective symptoms. Responses were recorded on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating greater levels of digital fatigue. The total score was obtained by summing responses across all items. The reliability of the scale was found to be 0.936. The scale was selected due to its multidimensional assessment of screen-related fatigue symptoms. (Ocak et al., 2023)

3.Blue Light Exposure Questionnaire (Self-developed):

Blue light exposure was assessed using a self-developed questionnaire consisting of 3 items focusing on nighttime digital device use, exposure to screens prior to sleep, and the use of blue light filters or night mode settings. The items were designed to reflect behaviors associated with blue light exposure during evening and nighttime hours. Responses to the items were summed to obtain a total blue light exposure score, with higher scores indicating greater exposure. The questionnaire was developed

specifically for the present study and served as a proxy measure of blue light exposure.

4.PROMIS Sleep Disturbance Scale - Short Form 8a (PROMIS, 2020):

Sleep quality was measured using the PROMIS Sleep Disturbance Scale - Short Form 8a, developed as part of the Patient-Reported Outcomes Measurement Information System (PROMIS) initiative. The scale consists of 8 items assessing perceived sleep quality, sleep depth, and sleep-related difficulties. Items were rated on a 5-point Likert scale. For one item, response options ranged from 1 (very poor) to 5 (very good), while for the remaining items, responses ranged from 1 (not at all) to 5 (very much). Higher scores indicated greater sleep disturbance and poorer sleep quality. The PROMIS Sleep Disturbance scale has demonstrated strong psychometric properties in previous research, including good internal consistency with a Cronbach alpha of .930. It was used in the present study as a standardized measure of subjective sleep disturbance. (Reeve, 2016)

Procedure

Data were collected using an online questionnaire administered through Google Forms. Prior to beginning the survey, participants were provided with a detailed explanation of the study, including its purpose, the nature of participation, and ethical considerations. It was clearly stated that participation was voluntary, that no form of pressure or inducement was involved, and that participants had the right to withdraw at any point without any consequences. Confidentiality and anonymity of responses were assured.

The questionnaire was structured in a fixed sequence. The first section consisted of an informed consent form, which participants were required to read and agree to before proceeding. This was followed by a demographic information section, which collected basic background details such as age, gender, and other relevant characteristics.

Participants completed the Computer Vision Syndrome Smart Questionnaire, which assessed screen exposure-related visual symptoms, followed by the Screen Fatigue Scale, a 24-item measure assessing physical, cognitive, behavioral, and affective aspects of digital fatigue. After completing the fatigue scale, participants responded to a self-developed Blue Light Exposure Questionnaire consisting of three items focusing on nighttime device use and blue light filter practices.

The final section of the questionnaire comprised the PROMIS Sleep Disturbance Scale- Short Form (8 items), which assessed subjective sleep quality and sleep-related difficulties. The overall duration required to complete the questionnaire was approximately 10 minutes.

After data collection was completed, the responses were downloaded and coded and anonymized, with no personally identifiable information retained.

Data analysis was conducted using SPSS to examine relationships among the study variables. The results obtained were interpreted with reference to the research objectives and in comparison, with findings from existing empirical literature in the relevant domain.

RESULTS

Descriptive statistics were computed to examine the levels of screen exposure, digital fatigue, blue light exposure, and sleep quality among college students. The mean score for blue light exposure was 8.11 (SD = 2.56). The mean screen exposure score was 70.90 (SD = 15.70). The mean sleep quality score was 26.49 (SD = 4.67). The mean digital fatigue score was 3.90 (SD = 2.74).

Table 1 Descriptive statistics and Correlation among Blue Light Exposure, Screen Exposure, Sleep Quality, Digital Fatigue

	Mean	Standard Deviation	Blue Light Exposure	Screen Exposure	Sleep Quality	Digital Fatigue
Blue Light Exposure	8.14	2.56	1	-	-.046	-
Screen Exposure	70.90	15.77	-	1	-	.480**
Sleep Quality	26.50	4.68	-.046	-	1	.021
Digital Fatigue	3.93	2.74	-	.480**	.021	1

****Correlation is significant at 0.01 level**

Table 2 Regression Coefficients Predicting Screen Exposure From Blue Light Exposure, Sleep Quality, And Digital Fatigue

Criterion	Predictor	β	p-value
Screen Exposure	Blue Light Exposure	.064	.425
	Sleep Quality	-.037	.643
	Digital Fatigue	.481	<.001
R	.486		
R^2	.236		
$F = 12.252$, $p < .001$			

Pearson product-moment correlation analysis was conducted to examine the relationships among the study variables. A significant positive correlation was observed between screen exposure and digital fatigue ($r = 0.480$, $p < 0.01$), indicating that higher levels of screen exposure were associated with increased digital fatigue.

The association between blue light exposure and sleep quality was also examined using Pearson correlation analysis. The results indicated a very weak negative correlation ($r = -0.046$, $p = 0.610$), suggesting that blue light exposure was not significantly associated with sleep quality in the present sample.

Further analysis examined the relationship between digital fatigue and sleep quality. Pearson correlation results showed a very weak positive correlation ($r = 0.021$, $p = 0.814$), indicating no significant association between digital fatigue and sleep quality.

To examine the predictive contribution of screen exposure, blue light exposure, and sleep quality to digital fatigue, a multiple linear regression analysis was performed. The overall regression model was statistically significant, accounting for 23.6% of the variance in digital fatigue scores ($R^2 = 0.236$, $p < 0.001$). This finding suggests that the combined effect of screen exposure, blue light exposure, and sleep quality significantly predicted levels of digital fatigue among college students.

DISCUSSION

The present study examined the relationships among screen exposure, digital fatigue, blue light exposure, and sleep quality among college students. Overall, the findings indicated that screen exposure was significantly associated with higher levels of digital fatigue, while blue light exposure and digital fatigue showed no meaningful associations with sleep quality. Additionally, screen exposure, blue light exposure, and sleep quality collectively emerged as significant predictors of digital fatigue, highlighting the multifactorial nature of screen-related fatigue in young adults. These findings contribute to the growing body of literature on digital media use and well-being, particularly within the context of increasing screen dependence among college students.

A robust positive relationship between screen exposure and digital fatigue was observed in the present study, indicating that greater time spent using digital devices was associated with higher levels of self-reported

fatigue. This finding aligns with prior research documenting the adverse effects of prolonged screen use on cognitive, visual, and physical functioning. Excessive screen exposure has been linked to multiple symptoms of digital fatigue and strain among young adult populations, including eye discomfort, headaches, and difficulty concentrating, which are hallmark features of digital fatigue (Bagaji & Rao, 2025). Recent cross-sectional research among students and young adults has similarly reported that longer durations of screen engagement correlate with higher levels of self-reported fatigue and computer vision-related symptoms, reinforcing the notion that extended digital engagement may contribute to overload of attentional and visual processing systems (Bagaji & Rao, 2025; Rehman et al., 2024). Several theoretical models also posit that sustained screen engagement without sufficient breaks can tax cognitive resources and increase subjective fatigue through mechanisms such as visual strain, attentional depletion, and musculoskeletal tension. Therefore, the positive correlation observed in this study is consistent with existing literature suggesting that as screen exposure increases, individuals experience greater digital fatigue, underscoring the need for interventions promoting healthy screen habits among college students.

Blue-light exposure in the evening often fails to produce measurable changes in overall sleep quality, suggesting that young adults may have adapted to the pervasive presence of short-wavelength light in their daily environments. In a crossover trial, the use of blue-light-blocking glasses was found to reduce subjective sleep onset latency and nighttime awakenings; however, no significant changes were observed in objective actigraphic indicators such as total sleep time or sleep efficiency, indicating that core physiological sleep parameters may be relatively resistant to short-term blue-light-filtering interventions (Bigalke et al., 2021). Similarly, research examining smartphone night-mode and blue-light-filter applications reported no significant association between filter use and Pittsburgh Sleep Quality Index scores, potentially due to limitations of self-reported usage measures, which may not accurately capture actual retinal exposure, as well as compensatory behaviors such as prolonged screen use (Rabiei et al, 2024). Additionally, experimental studies involving acute blue-light exposure immediately before bedtime have shown reductions in deep sleep and impairments in sustained attention and work efficiency; however, these findings were based on self-reported outcomes and single-night exposure paradigms, limiting conclusions regarding chronic or long-term effects (Uchiumi et al, 2024). Taken together, these findings suggest that habitual exposure and adaptive behaviors may attenuate the observable impact of blue light on subjective sleep quality, that self-report measures may underestimate true exposure levels, and that short-term experimental designs may not adequately capture longer-term adaptations in sleep regulation. This may help explain the non-significant association between blue-light exposure and sleep quality observed in the present study.

The present study found no significant association between digital fatigue and sleep quality, suggesting that screen-related fatigue may not directly translate into poorer perceived sleep among college students. Prior literature indicates that digital fatigue, often conceptualized as digital eye strain or screen fatigue, primarily manifests as visual discomfort, cognitive tiredness, and attentional depletion during waking hours rather than as direct disruption of nocturnal sleep processes (Rosenfield, 2016; Sheppard & Wolffsohn, 2018). Young adults may experience substantial daytime fatigue while maintaining relatively stable subjective sleep quality due to adaptive behaviors, habitual sleep routines, or normalization of tiredness within academic contexts. Additionally, sleep quality in the present study was measured using a self-report instrument, which captures perceived sleep disturbance rather than objective sleep architecture;

individuals experiencing digital fatigue may therefore not interpret their symptoms as sleep-related impairment. This interpretation is supported by research suggesting that subjective fatigue and objective sleep parameters do not always correspond closely in young, healthy populations (Exelmans & Van den Bulck, 2016). Importantly, although digital fatigue was not independently associated with sleep quality, the regression analysis indicated that screen exposure, blue light exposure, and sleep quality together significantly predicted digital fatigue. This finding suggests that digital fatigue may represent a cumulative outcome of prolonged screen engagement and contextual factors rather than a direct consequence of impaired sleep, helping to explain the absence of a simple bivariate relationship between fatigue and sleep quality in the present sample.

The regression analysis in the present study showed that screen exposure, blue light exposure, and sleep quality together significantly predicted digital fatigue, explaining 23.6% of the variance in fatigue scores. This supports the view that digital fatigue is a multidimensional phenomenon, influenced by multiple behavioral and physiological factors rather than a single determinant. Research has documented that digital fatigue encompasses cognitive overload, emotional exhaustion, and demotivation, arising from prolonged engagement with screens, academic demands, and hybrid learning environments (An et al., 2025). The significant combined contribution of screen exposure, blue light exposure, and sleep quality in the regression model suggests that prolonged screen exposure likely plays a dominant role in the development of digital fatigue, while other factors such as sleep patterns and spectral light exposure may interact or contribute indirectly when considered jointly. Additionally, the multidimensional nature of digital fatigue, comprised of physical, cognitive, and emotional dimensions, has been acknowledged in recent work validating multidimensional assessments of digital fatigue in university student populations (Yglesias-Alva et al., 2025). These perspectives highlight that digital fatigue reflects a cumulative outcome of sustained digital demands and contextual strain, aligning with the regression finding that multiple predictors together are more informative than any single factor in isolation. Such an integrated model underscores the complex interplay of screen use behaviors and individual experiences in shaping digital fatigue among college students.

The findings of this study have several practical applications for promoting healthier technology use among college students. First, encouraging screen hygiene practices, such as taking regular breaks, limiting continuous screen time, and using night-mode or blue-light filters strategically, may help mitigate digital fatigue without necessarily impacting sleep quality directly (Sheppard & Wolffsohn, 2018). Second, psychoeducation initiatives that inform students about the cognitive and physical effects of prolonged screen exposure can enhance awareness and encourage self-regulation of device use (An et al., 2025). Finally, promoting digital well-being, including balanced engagement with online learning, social media, and recreational screen time, can support students in managing fatigue and maintaining overall academic and psychological functioning.

From a clinical and educational perspective, the results highlight the importance of addressing student mental health in relation to digital technology use. Mental health practitioners and university counseling services may consider screening for digital fatigue as part of broader well-being assessments, particularly among students reporting high screen exposure (Rosenfield, 2016). Additionally, structured interventions, such as brief workshops on digital literacy, self-monitoring tools for screen use, or cognitive-behavioral strategies to manage digital strain, could be integrated into academic curricula or wellness programs to reduce fatigue and improve functional outcomes (Yglesias-Alva et al., 2025). By

combining practical guidance with structured educational initiatives, institutions can foster environments that support both digital engagement and healthy cognitive, emotional, and behavioral functioning in students.

The present study provides evidence that digital fatigue among college students is a multidimensional phenomenon, influenced primarily by screen exposure, with additional contributions from blue light exposure and sleep-related factors. While significant associations were observed between screen exposure and digital fatigue, blue light exposure and sleep quality showed limited independent effects, highlighting the complexity of these interactions. These findings emphasize the importance of considering both behavioral and environmental contributors to digital fatigue and support the development of interventions that address screen use, awareness of blue light, and overall digital well-being. Collectively, the results underscore that digital fatigue cannot be fully explained by a single factor, and effective strategies for managing it require a holistic, integrative approach that takes into account the cumulative demands of modern technology use among young adults.

Limitations and Future Directions

Despite providing valuable insights into the relationships among screen exposure, digital fatigue, blue light exposure, and sleep quality, the present study has several limitations. First, the cross-sectional design precludes causal inferences; while regression analyses identify associations, the directionality between screen behaviors and digital fatigue cannot be determined (Salkind, 2023). Second, the study relied exclusively on self-report measures, which may be influenced by recall bias or subjective interpretation, particularly for constructs such as screen time, blue light exposure, and sleep quality (Exelmans & Van den Bulck, 2016). Third, the convenience sample of college students aged 18-25 limits generalizability to other populations with different digital habits or age groups. Future research should address these limitations by incorporating longitudinal or experimental designs to examine causal pathways, using objective measures such as actigraphy, device usage tracking, or photometric sensors to enhance precision, and exploring moderating factors such as chronotype, stress, or environmental lighting (Rosenfield, 2016). Expanding the sample to include diverse populations and testing intervention strategies such as digital well-being programs, psychoeducation on screen hygiene, and adaptive device features may provide actionable guidance to reduce digital fatigue and improve overall student well-being. Together, addressing these limitations and pursuing these directions will strengthen understanding of digital fatigue and inform effective strategies to manage it in high-screen-use populations.

CONCLUSION

The present study examined the relationships among screen exposure, digital fatigue, blue light exposure, and sleep quality among college students, contributing to the growing literature on digital media use and well-being in young adults. The findings indicate that screen exposure is a significant correlate of digital fatigue, supporting prior evidence that prolonged engagement with digital devices is associated with increased cognitive, visual, and subjective fatigue. In contrast, blue light exposure and sleep quality did not demonstrate significant independent associations with sleep quality or digital fatigue at the bivariate level, underscoring the complexity of these relationships. Regression analyses revealed that screen exposure, blue light exposure, and sleep quality collectively predicted digital fatigue, explaining a meaningful proportion of variance in fatigue scores. This finding supports a multidimensional conceptualization of digital fatigue, suggesting that it emerges from the cumulative influence of behavioral and contextual factors rather than from a single causal pathway. While screen exposure

appears to be the primary contributor, blue light exposure and sleep-related factors may exert indirect or interactive effects when considered within an integrated model.

The results suggest that digital fatigue among college students is best understood as a cumulative outcome of sustained digital engagement rather than as a direct consequence of impaired sleep or blue light exposure alone. These findings highlight the importance of adopting comprehensive approaches to digital well-being that address screen use patterns and broader contextual demands of technology use. Future research employing longitudinal and objective methodologies is warranted to clarify causal mechanisms and inform evidence-based interventions aimed at reducing digital fatigue in high screen-use populations.

Use of Generative AI and AI-assisted Technologies

During the writing process of this study, the authors used Gemini (https://gemini.google.com/) for assistance in organizing the structure of the manuscript. After using this tool, the authors carefully reviewed, edited, and verified the content independently and take full responsibility for the final version of the manuscript.

Declaration by Authors

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