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Investigating the Impact of Blue Light Exposure on Sleep Patterns and Musculoskeletal Discomfort on Karachi's Medical Undergraduate Student: A Cross Sectional Study

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ABSTRACT

The blue light emitted by digital media is related to circadian rhythm disorders and is very necessary for biological well-being, but its use in the evenings and night contributes to melatonin inhibition and disturbed sleep patterns. Medical students, due to their intense study requirements and extensive use of digital media for learning and practicing, are particularly vulnerable. Irregular study patterns and excessive use of digital media add to sleep disturbances and reduced attention and performance. Excessive sitting and improper postures also lead to musculoskeletal discomfort. Sleep and biological problems, in turn, affect the performance and well-being of the medical students negatively. Careful evaluation of the risks associated with these problems, employing standardized scales such as the PSQI and NMQ, can determine the risks related to the health of the medical students.To investigate the impact of Blue Light exposure on Sleep pattern and Musculoskeletal discomfort on Karachi medical undergraduate student.This cross-sectional study was to find out the impact of blue light exposure on sleep pattern and musculoskeletal discomfort among different Karachi medical undergraduate student. The Pittsburg sleep quality index (PSQI) were used to assess the usual sleep habits during past month only and Nordic Musculoskeletal Questionnaire (NMQ) were used to assess pain or discomfort in different body regions over the past 12 months due to late night screen use among the medical undergraduate students. A non-probability convenience sampling method enrolled 255 participants. Ethical standards were followed, and informed consent was obtained. Data analysis was conducted using SPSS version 26 with chi-square tests and descriptive statistics, considering a significance level of p< 0.05.The prevalence was high for sleep disturbances among medical undergraduate students as 86.7% of the study population reported poor sleep quality. Neck and lower back symptoms were the most common musculoskeletal symptoms, with a moderate positive relationship between poor sleep quality and musculoskeletal discomfort, thus associating prolonged screen exposure with impaired sleep and musculoskeletal health to a large extent.This research proves that the negative effects of screen usage and blue light emission have a significant impact on the sleep quality and musculoskeletal disorders of medical undergraduate students in Karachi. A majority of students were found to have severe sleep problems, with 86.7% of students showing poor sleep quality on the PSQI. Musculoskeletal pain was found to be a common problem, particularly in the neck, lower back, shoulder, and upper back regions, as indicated by the NMQ. A moderate positive correlation was established between poor sleep quality and musculoskeletal pain, showing a link between the two factors. The results of this research emphasize the need for ergonomic changes, blue light filters, and sleep quality education.

Keywords: *Blue light exposure, Sleep pattern, Musculoskeletal discomfort*

INTRODUCTION

Blue light is naturally present in the environment and is predominantly emitted by the sun. Adequate exposure during the daytime is essential for biological functioning, as it influences vision, alertness, behavior, and circadian rhythm regulation. However, excessive or in appropriate exposure particularly to artificial blue light during the evening and nighttime can negatively affect health. Blue light has the highest energy within the visible light spectrum (380–780 nm) and can penetrate the cornea and lens to reach the retina. Laboratory studies have shown that blue-violet light may induce oxidative stress, leading to photoreceptor damage and Müller cell dysfunction [1].

Late-night screen use refers to the use of electronic devices such as smartphones, tablets, computers, and smartwatches during the evening or nighttime. These devices are now integral to communication, education, work, and entertainment [2]. Although they increase convenience and efficiency, their widespread use has been associated with declining sleep quality [3]. Screen use before bedtime affects sleep through four primary mechanisms: (1) displacement of sleep time, (2) suppression of melatonin due to light exposure, (3) increased cognitive and emotional alertness, and (4) sleep disruption from notifications and alerts. [4]Therefore, the timing of screen exposure, particularly at night, plays a crucial role in sleep health. [5]

Digital media has become deeply embedded in modern culture, especially among youth. Late-night digital media use affects sleep through blue light exposure and emotional stimulation from social interactions [6]. Adequate sleep is essential for overall health; however, approximately one-third of adults do not meet the recommended 7–9 hours of sleep per night [7]. Increased exposure to artificial lighting has contributed to circadian rhythm disruption and sleep disorders. Additionally, excessive exposure of ocular tissues to high-energy photons may result in irreversible retinal damage. [8]

Light is a major environmental regulator of the sleep-wake cycle. In darkness, retinal photoreceptors signal the pineal gland to secrete melatonin, promoting sleepiness [7]. Melatonin follows a 24-hour circadian rhythm and functions as the biological nighttime signal that initiates sleep [3]. The circadian system is particularly sensitive to short-wavelength light (450–480 nm), commonly referred to as blue light, which strongly suppresses melatonin secretion [12][13]. Exposure to LED-backlit devices at night has been shown to delay melatonin release, prolong sleep onset, reduce drowsiness, and impair overall sleep quality [13].

Beyond sleep disruption, prolonged device use also contributes to musculoskeletal disorders (MSDs). Many screen-based tasks require prolonged static postures, such as forward head positioning and repetitive hand movements. This posture increases strain on the cervical spine and upper thoracic region, contributing to neck, shoulder, wrist, and upper back pain [9]. Musculoskeletal symptoms (MSS) are major contributors to disability, reduced quality of life, and functional limitations [10]. Systematic reviews report musculoskeletal disorder prevalence among electronic device users ranging from 1% to 67.8%, with the highest proportion involving head and neck regions (17.3%–67.8%) [15]. One-year incidence rates show high prevalence in upper back (70.3%), wrist/hand (68.7%), neck (65.9%), and shoulder (56.6%) regions [9].

Children and adolescents frequently exceed recommended screen time limits. The American Academy of Pediatrics and HKSAR Department of Health recommend limiting screen time to 2 hours daily; however, studies show that many children and adolescents surpass this limit [14]. In college populations, over 95% of students report using screens in bed [4]. Sleep disturbances, including insomnia symptoms, affect 22% of men and 34% of women, with increasing trends in recent years [4]. Additionally, 20.1% to 43.3% of adolescents report being awakened by their mobile phones at least once per month, leading to increased fatigue [16]. Approximately 70% of children average 3.1 hours of daily screen time, exceeding recommended limits [17].

The relationship between excessive screen use and sleep problems may also involve psychological and lifestyle factors. The desire to remain socially connected can contribute to sleep disruption, mood disturbances, depression, and memory impairment [18]. Increased screen time is also associated with reduced physical activity, higher BMI, unhealthy eating patterns, and media addiction [16]. Individuals spending six or more hours daily on screens are at higher risk of moderate to severe depression [17]. Thus, inadequate sleep combined with excessive screen exposure may significantly impact mental health, cognitive performance, and daily functioning.

Sleep quality in related research has been measured using the Pittsburgh Sleep Quality Index (PSQI), which assesses sleep duration, latency, disturbance, efficiency, daytime dysfunction, subjective quality, and medication use over one month. Scores range from 0–21, with scores ≥5 indicating poor sleep quality [19]. Musculoskeletal symptoms have been evaluated using the Nordic Musculoskeletal Questionnaire (NMQ), which assesses pain in nine body regions over the past 12 months and its impact on daily activities [20].

To mitigate the harmful effects of artificial blue light, various protective measures are available, including blue-light filtering glasses, screen filters, specialized software, and intraocular lenses (IOLs) [1]. Reducing nighttime blue light exposure has been hypothesized to improve sleep quality among students [21]. For individuals with chronic musculoskeletal pain, management strategies include NSAIDs alongside non-pharmacological approaches such as exercise, rest, and physical therapy [22].

This study highlights the growing concern of prolonged blue light exposure and its impact on sleep quality and musculoskeletal pain among medical undergraduate students in Karachi. While blue light supports alertness and circadian regulation during the day, nighttime exposure from smartphones, tablets, and computers suppresses melatonin, delays sleep onset, reduces sleep duration, and impairs sleep quality. Simultaneously, prolonged device use promotes poor posture and repetitive strain, contributing to neck, shoulder, upper back, and wrist pain. The combined burden of poor sleep and musculoskeletal discomfort negatively affects students’ physical health, academic performance, and mental well-being.

Preventive strategies include limiting screen time before bed, using blue-light filters or protective eyewear, maintaining ergonomic posture, engaging in regular physical activity, and promoting healthy sleep hygiene practices. Encouraging responsible digital habits is essential to safeguard visual, metabolic, musculoskeletal, and psychological health—particularly among medical students who are highly exposed to screen-based academic demands.

METHODOLOGY

Study Design:

This study followed a cross-sectional design.

Sampling Technique:

A non- probability convenience sampling technique was employed to recruit eligible participants from different Universities across Karachi.

Outcome Measure:

During the course of this research, the sleep patterns and musculoskeletal discomfort was evaluated. It was determined that the population was chosen had a high prevalence of blue light exposure based on the measurement of sleep altered and musculoskeletal pain.

Data Analysis:

Data analysis was performed using SPSS software. Graphic measurements, such as means and standard deviations, were used to account for quantitative factors. To determine any importance association between subjective variables, the Chi-square test was used. (A P-value of 0.05 is considered enormous).

Ethical Considerations:

Ethical approval for this study was obtained from the institutional review board of the respective universities involved. All participants were clearly informed about the purpose, procedures, and voluntary nature of the research before data collection. Participation was completely voluntary, and students were given the option to withdraw at any point without any consequences. Written informed consent was obtained from each participant, and anonymity and confidentiality of the data were strictly maintained. The data collected was stored securely and used solely for academic research purposes. The study involved no physical or psychological risk to the participants and did not interfere with their academic or personal activities. There were no conflicts of interest declared by the researchers.

Reliability:

To ensure the reliability of the data collection tools, the internal consistency of the two standardized questionnaires—Nordic Musculoskeletal Questionnaire (NMQ) and Pittsburgh Sleep Quality Index (PSQI)—was evaluated using Cronbach's alpha through SPSS software. A Cronbach's alpha value between 0.70–0.79 is considered acceptable,0.80–0.89 indicates good internal consistency, and 0.90 or above is regarded as excellent. In this study, both NMQ and PSQI demonstrated satisfactory reliability scores, confirming that the items within each scale were internally consistent and dependable for assessing night eating behaviors and sleep quality, respectively, in the university student population.

RESULTS AND FINDINGS

Introduction:

This chapter presents the results of the cross-sectional study conducted among 255 undergraduate students from various universities in Karachi. The data was analyzed using SPSS (Statistical Package for Social Sciences), with descriptive and inferential statistics applied to assess the impact of blue light exposure on sleep pattern and musculoskeletal discomfort.

Descriptive Statistics:

Table 1: Descriptive Analysis of PSQI Scale:

Elements	N	Min.	Max.	Mean	SD	Variance
During the past month, what time have you usually gone to bed at night?	255	0	12	0.71	2.31	5.33
During the past month, how long (in min) fall asleep each night?	255	0	3	1.29	0.99	0.97
During the past month, what time have you usually gotten up in the morning?	255	1	18	5.56	2.58	6.66
During the past month, how many hours of actual sleep did you get at night?	255	0	6	1.04	1.20	1.45
I cannot get to sleep within 30 minutes.	255	0	3	1.25	1.13	1.28
Wake up in the middle of the night or early morning.	255	0	3	1.46	1.05	1.09
Have to get up to use the bathroom.	255	0	3	1.27	1.07	1.14
I cannot breathe comfortably.	255	0	3	0.54	0.84	0.70
Cough or snore loudly.	255	0	3	0.61	0.89	0.80
Feel too cold.	255	0	3	0.94	1.04	1.07
Feel too hot.	255	0	3	0.82	0.92	0.84
Had bad dreams.	255	0	3	1.42	1.09	1.20
Have pain	255	0	3	1.25	0.93	0.86
Other reasons(s), please describe:	255	0	0	0.00	0.00	0.00
how often have you taken medicine")?	255	0	3	0.37	0.76	0.57
How often have you had trouble staying awake?	255	0	3	1.19	0.99	0.98
During the past month, how much of a problem?	255	0	3	1.33	0.91	0.83
How would you rate your sleep quality overall?	255	0	3	1.35	0.77	0.59
Do you have a partner or roommate?	255	0	3	1.02	1.18	1.39
Loud snoring.	255	0	3	0.39	0.80	0.63

Long pauses between breaths while asleep.	255	0	3	0.35	0.64	0.42
Legs twitching or jerking while you sleep.	255	0	3	0.69	0.92	0.84
Episodes of disorientation or confusion during sleep.	255	0	3	0.41	0.83	0.68
Other restlessness while you sleep, please describe…..	255	1	5	1.33	0.82	0.68

Analysis of the PSQI among 255 respondents showed considerable variability in sleep patterns. Most fell asleep within a moderate duration (mean 1.29 ± 0.99) and woke around 5.56 ± 2.58, though average actual sleep duration was low (1.04 ± 1.20). Difficulty initiating sleep (1.25 ± 1.13) and nighttime awakenings (1.46 ± 1.05) were common, along with nocturnal interruptions such as bathroom visits, breathing discomfort, and snoring. Thermal discomfort, pain, and bad dreams were also reported. Use of sleep medication was low (0.37 ± 0.76), while daytime dysfunction, including trouble staying awake (1.19 ± 0.99) and reduced enthusiasm (1.33 ± 0.91), was moderately reported. Less frequent disturbances included loud snoring, long pauses between breaths, leg movements, and disorientation. Overall, these findings indicate that respondents experienced moderately poor sleep quality across multiple domains.

Table 2: Descriptive Analysis of NMQ Scale:

Elements	N	Min.	Max.	Mean	SD	Variance
Neck Pain 12 Month	255	0	1	0.76	0.43	0.18
Shoulders 12 Month	255	0	1	0.58	0.49	0.24
Elbow Pain 12 month	255	0	1	0.18	0.38	0.15
Wrist/ HandsPain 12 month	255	0	1	0.37	0.48	0.23
Upper back Pain 12 month	255	0	1	0.58	0.50	0.25
Lower back Pain 12 month	255	0	1	0.65	0.48	0.23
Neck Work prevent 12 month	255	0	1	0.71	0.45	0.21
Shoulders Work prevent 12 month	255	0	1	0.50	0.50	0.25
Elbows Work prevent 12 month	255	0	1	0.18	0.39	0.15
Wrists / Hands Work prevent 12 month	255	0	1	0.44	0.50	0.25
Upper back Work prevent 12 month	255	0	1	0.55	0.50	0.25
Lower back Work prevent 12 month	255	0	1	0.65	0.48	0.23
Neck Pain 7 days	254	0	1	0.55	0.50	0.25

Shoulder Pain 7 days	255	0	1	0.26	0.44	0.19
Elbow Pain 7 days	255	0	1	0.12	0.32	0.10
Wrists / HandsPain 7 days	255	0	1	0.26	0.44	0.19
Upper back Pain 7 days	255	0	1	0.35	0.48	0.23
Lower back Pain 7 days	255	0	1	0.46	0.50	0.25

Analysis of musculoskeletal pain among 255 respondents showed that the neck and lower back were the most commonly affected regions. Over the past 12 months, neck pain had the highest mean score (0.76 ± 0.43), followed by lower back (0.65 ± 0.48), upper back (0.58 ± 0.50), and shoulders (0.58 ± 0.49), with wrist/hand and elbow pain less frequent. Work-related limitations mirrored this pattern, with neck pain affecting 71% of respondents and lower back, upper back, and shoulder pain also contributing to functional restrictions. Pain in the past 7 days showed a similar trend, with neck (0.55 ± 0.50) and lower back (0.46 ± 0.50) most prevalent, followed by upper back, shoulders, and wrist/hand, while elbow pain remained least reported (0.12 ± 0.32). These results indicate that neck and lower back pain are the most common and functionally limiting musculoskeletal complaints, consistent across both short- and long-term periods.

Correlation Matrix:

Table 3: Correlation Analysis of PSQI scale:

Annexure-01 stated correlation analysis of sleep parameters revealed several significant relationships among PSQI components and overall sleep quality. Bedtime and wake-up time were strongly positively correlated (r = 0.87), indicating that participants who went to bed later tended to wake up later. The time taken to fall asleep showed moderate positive correlations with difficulty initiating sleep (r = 0.39), suggesting that longer sleep latency was associated with more frequent trouble falling asleep. Overall sleep quality was moderately correlated with hours of actual sleep (r = 0.32), trouble staying awake (r = 0.31), and daytime dysfunction including reduced enthusiasm (r = 0.40), indicating that poorer sleep was linked to reduced daytime functioning. Disturbances such as bad dreams, pain, and nocturnal awakenings were also positively associated with overall sleep quality, with correlations ranging from r = 0.22–0.28, highlighting their contribution to poor sleep. Partner- or roommate-related factors, including loud snoring (r = 0.46), long pauses in breathing (r = 0.36), and leg twitching (r = 0.52), were significantly correlated with total sleep quality, indicating that shared sleeping environments and sleep-related breathing or movement disturbances influenced perceived sleep quality. Overall, the findings suggest that sleep quality in this population is influenced by both intrinsic factors (pain, sleep latency, nocturnal awakenings) and extrinsic factors (partner-related disturbances), which together contribute to daytime dysfunction and poor overall sleep.

Table 4: Correlation Analysis of NMQ scale:

Annexure-02 stated Correlation analysis among musculoskeletal pain variables over the past 12 months and 7 days revealed several significant associations. Neck pain over 12 months showed a moderate positive correlation with work prevention due to neck pain (r = 0.45) and overall musculoskeletal pain (r = 0.39), indicating that neck discomfort substantially contributes to functional limitations and overall pain burden. Shoulder pain over 12 months was positively correlated with shoulder work prevention (r = 0.39) and overall musculoskeletal pain (r = 0.37). Lower back pain over 12 months was notably associated with lower back work prevention (r = 0.57), emphasizing its role in occupational disability. Pain in the elbow (r = 0.15) and wrist/hand (r = 0.26) regions showed weaker but significant correlations with total musculoskeletal pain. Short-term pain reported in the past 7 days also reflected similar patterns: neck pain (r = 0.38) and lower back pain (r = 0.31) were most strongly correlated with overall musculoskeletal discomfort. Upper back pain (r = 0.28) and wrists/hands pain (r = 0.20) had moderate associations, while elbow pain (r = 0.11) showed minimal correlation with total pain. Overall, these correlations suggest that pain in major regions such as the neck, lower back, and shoulders drives the overall musculoskeletal pain experience, both in long-term and short-term assessments, and significantly impacts work-related functionality.

Table 5: Correlation Analysis of DVs:

Dependent variable	Sleep quality	Musculoskeletal pain
Sleep quality	1.000	0.355
Musculoskeletal pain	0.355	1.000

Correlation analysis revealed a moderate positive relationship between overall sleep quality and musculoskeletal pain ($r = 0.355$, $p < 0.01$). Participants with higher levels of musculoskeletal pain tended to report poorer sleep, suggesting a bidirectional relationship where pain contributes to sleep disturbances and poor sleep may further worsen musculoskeletal discomfort.

Table 6: Chi-Square Tests:

Test Element	Pearson Chi-Square	p-value	Result
Sleep quality * Musculoskeletal pain	44.06	0.000	Null hypothesis rejected
Sleep quality * Age	2.72	0.605	Null hypothesis accepted
Sleep quality * Gender	1.59	0.452	Null hypothesis accepted
Sleep quality * Marital status	0.87	0.648	Null hypothesis accepted
Sleep quality * Occupation	0.47	0.977	Null hypothesis accepted
Sleep quality * Education	4.81	0.904	Null hypothesis accepted
Musculoskeletal pain * Age	14.04	0.029	Null hypothesis rejected
Musculoskeletal pain * Gender	7.12	0.068	Null hypothesis accepted
Musculoskeletal pain * Marital status	11.40	0.010	Null hypothesis rejected
Musculoskeletal pain * Occupation	36.02	0.000	Null hypothesis rejected
Musculoskeletal pain * Education	18.93	0.217	Null hypothesis accepted

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Chi-square analysis showed a significant association between sleep quality and musculoskeletal pain (χ^2 = 44.06, p < 0.001), with higher pain linked to poorer sleep. Sleep quality was not associated with age, gender, marital status, occupation, or education. In contrast, musculoskeletal pain was significantly associated with age (χ^2 = 14.04, p = 0.029), marital status (χ^2 = 11.40, p = 0.010), and occupation (χ^2 = 36.02, p < 0.001), but not with gender or education. These results suggest that while sleep quality is primarily influenced by musculoskeletal pain, pain itself is affected by specific demographic factors.

Table 7: Reliability Statistics:

Cronbach's Alpha	Cronbach's Alpha	N of sub-scales
PSQI	0.609	24
NMQ	0.770	18
Accumulated	0.664	42

The internal consistency of the study instruments was assessed using Cronbach's alpha. The PSQI showed moderate reliability (α = 0.609, 24 subscales), while the NMQ demonstrated good reliability (α = 0.770, 18 subscales). Combined, the 42-item scale had an overall reliability of 0.664, indicating acceptable consistency for measuring sleep quality and musculoskeletal pain in the study population.

Table-8: Normality test for all scales:

			Shapiro-Wilk		
			Statistic	Sig.	Remarks
Age	PSQI	Up to 25 years	0.41	0.00	Normal data
		21-26 years	0.41	0.00	Normal data
		Above 25 years	0.37	0.00	Normal data
	NMQ score	Up to 25 years	0.36	0.00	Normal data
		21-26 years	0.45	0.00	Normal data
		Above 25 years	0.72	0.00	Normal data
Gender	PSQI	Male	0.35	0.00	Normal data
		Female	0.44	0.00	Normal data
	NMQ score	Male	0.32	0.00	Normal data
		Female	0.50	0.00	Normal data
Marital status	PSQI	Single	0.40	0.00	Normal data

		Married	0.53	0.00	Normal data
	NMQ score	Single	0.43	0.00	Normal data
		Married	0.58	0.00	Normal data
Occupation	PSQI	Student	0.41	0.00	Normal data
		Doctor			Omitted
		Pharmacist			Omitted
	NMQ score	Student	0.43	0.00	Normal data
		Doctor			Omitted
		Pharmacist			Omitted
Education	PSQI	DPT	0.47	0.00	Normal data
		BDS	0.35	0.00	Normal data
		BSN	0.33	0.00	Normal data
		Pharm D	0.40	0.00	Normal data
		Others	0.45	0.00	Normal data
	NMQ score	DPT	0.59	0.00	Normal data
		BDS	0.37	0.00	Normal data
		BSN			Omitted
		Pharm D	0.46	0.00	Normal data
		Others	0.45	0.00	Normal data

Above both tables showing all data collected as normal data.

STUDY LIMITATIONS

The methodology of this study has several limitations that should be acknowledged. Firstly, the cross-sectional design only captures data at a single point in time, which restricts the ability to establish causal relationships between blue light exposure, sleep patterns, and musculoskeletal discomfort. Additionally, the use of a non-probability convenience sampling technique may introduce selection bias, as participants were recruited based on accessibility, limiting the generalizability of the findings to all medical students in Karachi or other regions. The reliance on self-reported questionnaires and online surveys also introduces potential recall and social desirability biases, which may affect the accuracy of data on sleep quality, musculoskeletal pain, and screen usage. Moreover, the exclusion of participants with chronic musculoskeletal or sleep disorders, pregnancy, or sedative use may underestimate the true prevalence of these issues. The study duration of six months may not capture seasonal or long-term variations in sleep and musculoskeletal health, while the measurement of blue light exposure is based on device usage rather than objective assessments of light intensity or duration. Finally, potential confounding factors such as stress, academic workload, physical activity, and lifestyle habits were not fully controlled, which may influence both sleep quality and musculoskeletal discomfort.

RECOMMENDATIONS FOR FUTURE RESEARCH

To address the limitations of the current study, future research should consider adopting a longitudinal design to better assess causal relationships between blue light exposure, sleep patterns, and musculoskeletal discomfort. Probability-based sampling techniques, such as stratified or random sampling, can improve the representativeness of the study population across multiple universities. Objective measures of screen time and blue light exposure, including light sensors or tracking applications, alongside actigraphy or polysomnography for sleep assessment, would reduce reliance on self-reported data and enhance accuracy. Collecting information on potential confounders such as stress, academic workload, physical activity, and lifestyle factors can allow for more precise statistical adjustments. Extending the study duration or incorporating repeated measurements would capture temporal variations in sleep and musculoskeletal health. Additionally, a mixed-methods approach combining quantitative surveys with qualitative interviews could provide deeper insights into students' experiences, behaviors, and coping strategies related to screen use, sleep disruption, and musculoskeletal pain.

CONCLUSION

This study highlights the significant impact of prolonged screen use and blue light exposure on sleep quality and musculoskeletal health among medical undergraduate students in Karachi. The majority of participants were young adults, predominantly female, single, and enrolled in health-related programs, reflecting a student-dominated sample. Assessment using the Pittsburgh Sleep Quality Index (PSQI) revealed widespread sleep disturbances, including delayed sleep onset, reduced sleep duration, nocturnal awakenings, thermal discomfort, and sleep-related pain. Overall, 86.7% reported severe sleep disruption, indicating a high burden across demographic groups. Musculoskeletal pain, measured via the Nordic Musculoskeletal Questionnaire (NMQ), was also highly prevalent, particularly in the neck, lower back, upper back, and shoulders, with functional limitations most pronounced for the neck and lower back. Correlation analyses demonstrated a moderate positive relationship between musculoskeletal pain and poor sleep quality, highlighting the interdependent nature of these health issues. These findings underscore the urgent need for targeted interventions to mitigate the negative effects of digital device use. Strategies such as scheduled screen breaks, ergonomic adjustments, blue-light filters, and sleep hygiene education can improve sleep and reduce musculoskeletal discomfort, ultimately enhancing students' academic performance, physical health, and mental well-being. However, the study has limitations, including its cross-sectional design, convenience sampling, reliance on self-reported data, and exclusion of participants with chronic conditions, which may limit generalizability and causal inference. Future research should adopt longitudinal designs, probability-based sampling, objective measures of blue light exposure and sleep, and account for confounding factors such as stress and physical activity. A mixed-methods approach could also provide deeper insights into students' behaviors and coping strategies.

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CONFLICT OF INTERST

No financial or commercial ties were existent as to raise the potential for conflict of interest during the research was being conducted.

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