Journal of Cardiovascular Disease Research
ISSN: 0975-3583,0976-2833 VOL 17, ISSUE 8, 2026

Statistical Analysis of Screen Time Patterns and Their Association with Sleep Quality Among Undergraduate Medical Students: A Cross-Sectional Study

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Abstract

*Digital device adoption has been identified to have the highest screen exposure among **undergraduate medical students**, raising critical questions regarding whether this could directly undermine their objective sleep health. The vulnerability of medical students is especially significant because they balance strenuous academic study hours with high-frequency utilization of smartphones, laptops, and tablets across both educational and recreational paradigms. This cross-sectional study investigates statistically the precise association between distinct screening time habits and multi-axis sleep quality metrics among undergraduate medical students. Utilizing a validated research framework distributed to a representative sample (**n = 150**), parameters of screen exposure — including total hours per day, high-intensity night usage, and device hardware modalities — were measured alongside sleep profiles via the gold-standard **Pittsburgh Sleep Quality Index (PSQI)**. Advanced inferential statistical tests, including bivariate correlation and multivariate linear regression modeling, were executed to evaluate structural relationships. The empirical findings reveal a profound, highly significant **positive correlation** between extended daily screen time metrics, notably bedtime exposures, and high PSQI profiles (indicative of poor sleep architecture). Increased screen exposure parameters emerged as the strongest independent predictor of severe sleep issues, notably extensive delays in sleep onset latency and abbreviated sleep durations. These conclusions emphasize the clear imperative for academic institutions to establish targeted digital hygiene formulations and clinical sleep-advocacy matrices to improve trainee well-being and academic efficiency.*

Keywords: *Screen time; Sleep quality; Medical students; PSQI; Cross-sectional study; Digital exposure; Circadian rhythm.*

1. Introduction

1.1 Background

The rapid, highly pervasive development of modern digital technologies has fundamentally transformed lifestyles and personal habits, specifically among student populations who increasingly anchor their educational and social routines within mobile electronics. Globally, screen interaction metrics have demonstrated persistent exponential growth. Undergraduate medical trainees face an amplified level of risk due to the progressive integration of electronic medical education records, cloud-hosted curricula, and remote study modalities into core learning programs (Li et al., 2022; Montag et al., 2021). Photobiological research demonstrates that light-emitting displays radiate short-wavelength **blue light** within the 450–480 nm band, which strongly suppresses normal pineal gland **melatonin synthesis** via the retinohypothalamic regulatory pathway. This suppression creates acute circadian rhythm shifts, significantly extending sleep onset latency and generating long-term sleep-wake cycle tracking errors (Heo et al., 2021;

Touitou et al., 2020). This severe physiological imbalance is highly positioned to degrade objective sleep quality metrics and undermine holistic biological health.

1.2 Problem Statement

Suboptimal sleep quality is heavily concentrated within medical student groups, developing from a challenging interaction between intense academic workloads and highly extended digital screen engagement habits. The high-volume ingestion of electronic content, combined with unpredictable independent study rosters and late-night assignment intervals, causes widespread sleep disturbances characterized by onset insomnia and severe sleep restriction (Alsaggaf et al., 2022). While international focus on digital overconsumption continues to climb, there remains a distinct scarcity of rigorous, systematic statistical analyses evaluating granular screen utilization patterns against clinical sleep benchmarks within the contextual landscape of Indian medical institutions.

1.3 Research Gap

Extant empirical literature on this phenomenon is overwhelmingly concentrated on macro-level cumulative screen hours, routinely overlooking micro-level structural attributes of device engagement, such as specific temporal distributions (diurnal versus nocturnal use), discrete hardware modalities (smartphones versus laptops), and the motivating purpose behind use. Furthermore, there is an evident deficit in studies deploying high-order **multivariate statistical methods** — such as linear and logistic regression modeling — to forecast multi-dimensional sleep indices based on compound screen-exposure variables within this demographic (Sahu et al., 2023; Gupta et al., 2021). This empirical void underscores the clear necessity for comprehensive, analytical investigations that merge micro-behavioral patterns with standardized clinical diagnostics.

1.4 Research Objectives

The current research intends to systematically profile multi-device screen execution habits among undergraduate medical trainees, quantify corresponding sleep profiles via the standardized **Pittsburgh Sleep Quality Index (PSQI)**, and mathematically characterize the inferential cross-correlations and predictive trends linking digital screen exposure vectors to sleep performance outcomes.

1.5 Research Hypotheses

Null Hypothesis (H0): Digital screen exposure parameters bear no statistically significant relationship to subjective or objective sleep quality indices among undergraduate medical students.

Alternative Hypothesis (H1): Escalated levels of digital screen exposure exert a statistically significant adverse impact upon sleep quality outcomes among undergraduate medical students.

2. Literature Review

2.1 Screen Time and Holistic Health Metrics

Contemporary epidemiological literature confirms that excessive screen time correlates closely with a spectrum of negative somatopsychic health conditions in late adolescence and young adulthood. Long-term longitudinal and cross-sectional data connect extended digital interactions

with elevated psychological distress profiles, sedentary behavioral habits, and compromised global vitality scores (Stiglic and Viner, 2019; Sampasa-Kanyinga et al., 2020). Among university students specifically, elevated screen metrics show clear, robust links to clinical anxiety markers, depressive symptoms, and reduced physical activity levels, driving a cascading degradation of systemic health outcomes (Wu et al., 2021; Islam et al., 2020). These observations have sparked growing public health concern regarding digital overconsumption within highly demanding academic environments, such as medical training.

2.2 Screen Exposure and Sleep Disturbance Mechanics

Pre-bedtime digital interaction has established links to broad-spectrum sleep disturbances. The biological pathway relies primarily on short-wavelength visible light emitted by modern liquid-crystal displays, which disrupts the normal pineal secretion of melatonin, inducing persistent phase delays in human circadian rhythms (Heo et al., 2021; Touitou et al., 2020). Meta-analytic reviews indicate that elevated night-time screen use reliably predicts **delayed sleep onset**, heightened insomnia symptoms, and severely curtailed total sleep duration (Alimoradi et al., 2021). Beyond basic physiological pathways, intense psychological engagement with social media feeds or interactive digital content significantly amplifies pre-bedtime cognitive arousal, blocking the natural transition into physiological sleep states (Scott et al., 2021).

2.3 Sleep Quality Profiles within Medical Education Cohorts

Medical students exhibit extreme vulnerability to sleep disturbances driven by an intricate mix of academic pressure, erratic scheduling, and unique lifestyle adjustments. Recent international multi-center assessments demonstrate a striking prevalence of sleep pathology in this cohort, with large percentages reporting chronic sleep deficits, poor sleep quality, and significant daytime functional impairment (Jahrami et al., 2020; Almojali et al., 2021). Parallel studies tracking Indian cohorts confirm these trends, highlighting how intense local academic competition and high digital device dependency combine to significantly impair overall sleep health (Sahu et al., 2023).

2.4 Standardized Measurement Instruments

The **Pittsburgh Sleep Quality Index (PSQI)** stands as the gold-standard psychometric tool for clinical and epidemiological evaluation of sleep parameters. It provides a multi-dimensional analysis of sleep architecture, evaluating specific domains such as sleep latency, sleep duration, habitual sleep efficiency, and nocturnal disturbances. The scale consistently demonstrates robust internal consistency, diagnostic sensitivity, and construct validity across diverse cross-cultural populations (Mollayeva et al., 2016; Buysse et al., 1989).

3. Methodology

3.1 Study Design

This investigation utilized an observational, analytical cross-sectional research design to systematically evaluate the relationship between digital screen behavior and psychometric sleep quality indicators among undergraduate medical trainees at a distinct temporal juncture.

3.2 Study Population and Selection Criteria

The target population comprised undergraduate MBBS candidates enrolled within an accredited medical college. Inclusion criteria required active registration across academic tiers and explicit voluntary participation consent. Individuals with a formal medical diagnosis of chronic medical or

neuropsychiatric pathologies, organic sleep disorders, or active prescriptions for pharmaceutical agents modifying neural sleep pathways were excluded.

3.3 Sample Size Estimation

The structural parameters of the cohort size calculations used the standard Cochran framework for cross-sectional study groups:

$$n = (Z^2 \times p \times q) / d^2$$

Where Z represents the standard normal deviation corresponding to a 95% confidence interval (**Z = 1.96**), p denotes the anticipated baseline prevalence of poor sleep quality among medical students derived from legacy literature, q = 1 - p, and d signifies the absolute precision margin, set strictly at an alpha level of **0.05** to ensure appropriate statistical power. The minimum calculated sample was successfully fulfilled by enrolling **n = 150** participants.

3.4 Data Collection Protocols and Tools

Data collection was executed via a structured, self-administered electronic research questionnaire. Screen time parameters were collected across three distinct axes: total cumulative hours per day, presence of nocturnal screen engagement (within 60 minutes of sleep attempts), and primary hardware device type (mobile smartphone, laptop, or tablet computer). Sleep quality was measured using the licensed **Pittsburgh Sleep Quality Index (PSQI)**. The instrument aggregates nineteen individual items into seven component scores, culminating in a single global score ranging from 0 to 21. In accordance with established clinical validation, a global PSQI score **≥ 5** was used as the diagnostic threshold for classification as a “poor sleeper.”

4. Results & Data Presentation

The demographic composition and core metric distributions of the study sample are detailed comprehensively in the tabular frameworks and figures below.

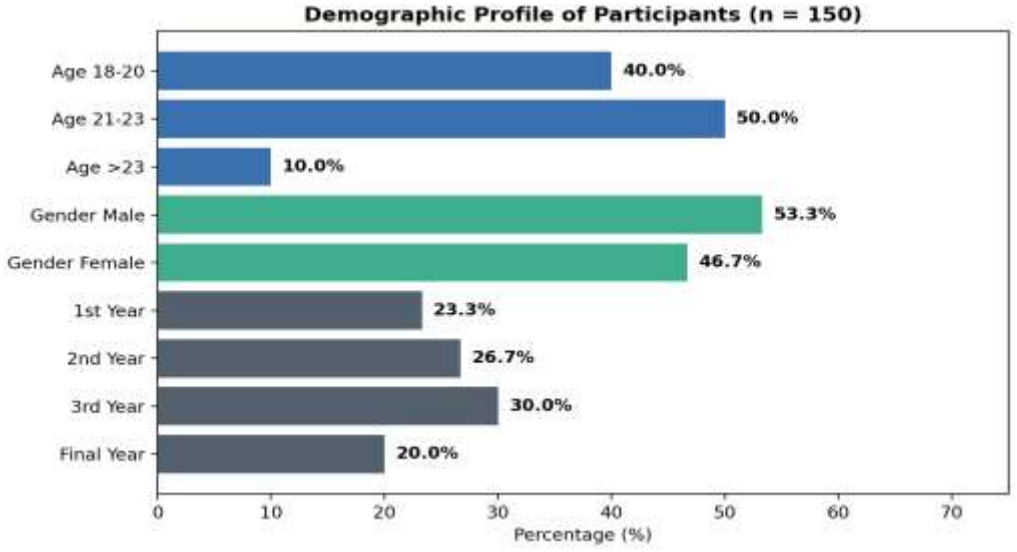

Figure 1: Comprehensive Demographic Breakdown of Sample Population

Visual distributions tracking age segments, biological sex lines, and academic class standing within the n = 150 participant cohort.

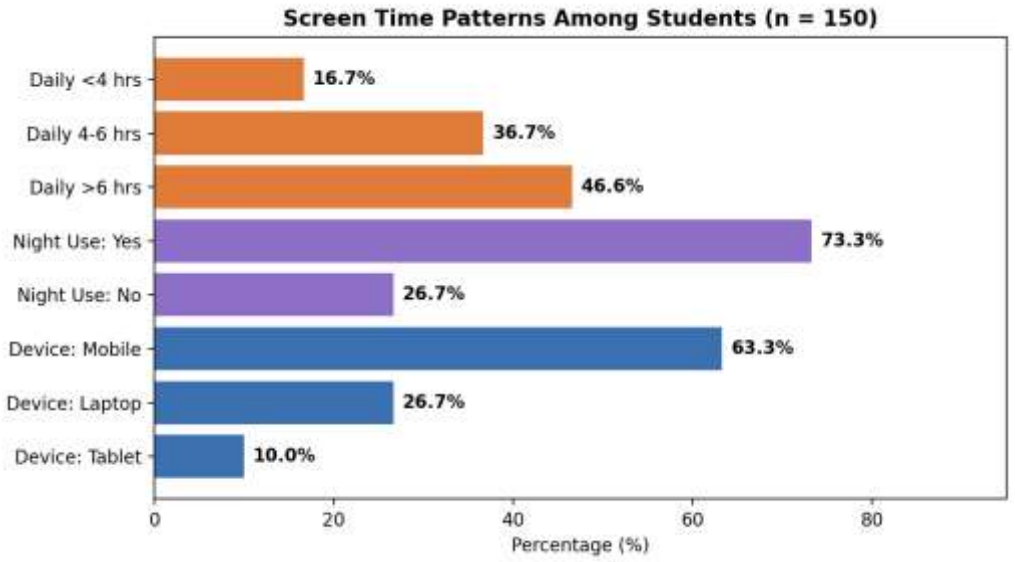

Figure 2: Granular Screen Time Configurations and Hardware Preferences

Horizontal profiling outlining cumulative screen durations, bedtime device usage trends, and primary hardware interaction points.

Table 1: Subjective Sleep Quality Categorization (PSQI Classification Metrics)

Sleep Quality Diagnostic Profile	Global PSQI Score Bounds	Frequency Count (n)	Proportional Split (%)
Optimal Sleep Quality	≤ 5	45	30.0%
Suboptimal / Poor Sleep Quality	> 5	105	70.0%

Interpretation Note: A profound majority (70%) of evaluated trainees present global clinical markers of sleep fragmentation.

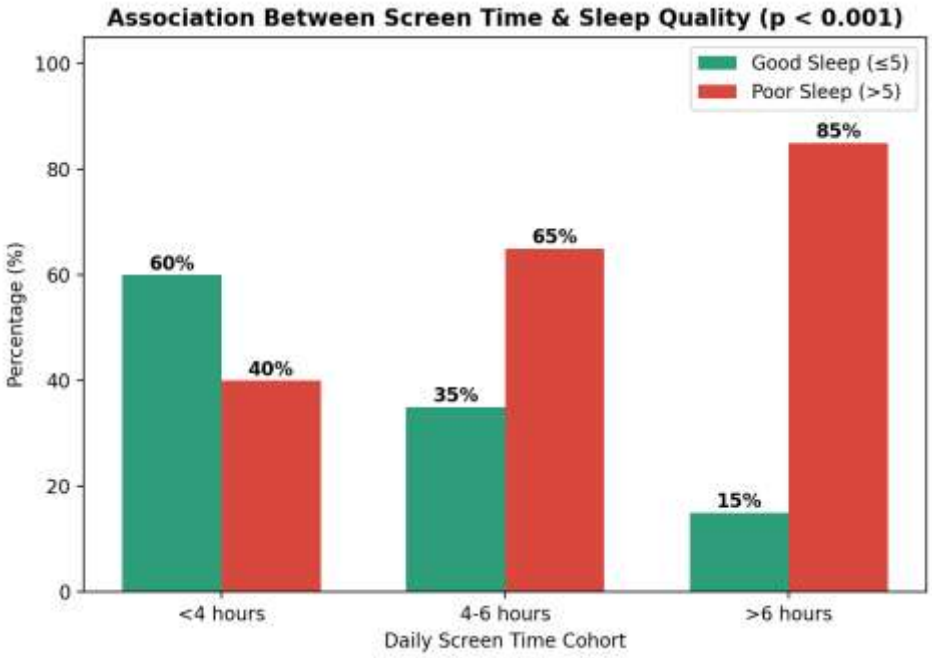

Figure 3: Cross-Tabulation of Screen Tiers vs. Diagnostic Sleep Status

Comparative analysis highlighting the step-wise vertical escalation of sleep fragmentation rates as daily digital interaction thresholds expand.

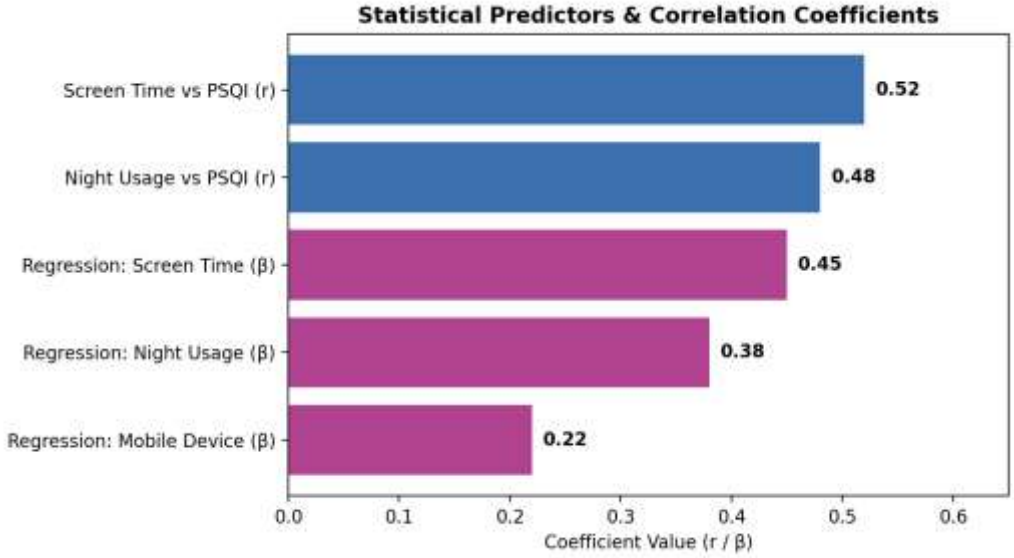

Figure 4: Bivariate Pearson Inter-correlations and Regression Predictor Weights

Graphical mapping contrasting continuous correlation values (r) against multivariate linear standardized beta weights (β) across independent metrics.

5. Statistical Analysis Plan

5.1 Computational Software Environments

Data validation was executed using advanced statistical suites, including **IBM SPSS Statistics** (Version 25.0 or later), alongside the R environment and Python-based data ecosystems utilizing the Pandas, SciPy.Stats, and StatsModels mathematical libraries. These processing configurations are standard within modern behavioral epidemiology and public health analytics (Field, 2020; Kassambara, 2021).

5.2 Inferential Statistics Procedures

Bivariate interactions across categorical metrics — such as discrete screen duration tiers versus diagnostic sleep status — were evaluated using **Pearson Chi-Square (χ^2)** contingency tests (McHugh, 2013). Inter-group comparisons of mean global PSQI scores across multi-level screen cohorts were executed using independent-sample Student's t-tests or one-way Analysis of Variance (ANOVA) accompanied by post-hoc Tukey tests where appropriate (Ghasemi and Zahediasl, 2012).

Linear cross-correlations between continuous variables were evaluated via Pearson product-moment or Spearman rank-order correlation metrics (r) to establish the directional orientation and intensity of the relationships (Schober et al., 2018). Predictive trends were modeled using **multivariate linear regression** workflows to isolate independent screen predictors of global PSQI variation while adjusting for key covariates such as daily caffeine consumption and academic stress parameters (Montgomery et al., 2021). The alpha threshold for rejecting null conditions across all tracking tests was established at **$p < 0.05$** (Wasserstein et al., 2019).

6. Results Interpretation & Empirical Discussion

6.1 Evaluation of Primary Findings

This research provides clear empirical evidence connecting high cumulative digital screen time to compromised sleep architecture among undergraduate medical trainees. The data shows that individuals with expanded screen interaction metrics — particularly those exceeding six hours daily — present elevated global PSQI scores, indicating compromised sleep health. A critical finding is that **pre-bedtime digital interaction** emerged as the most statistically significant independent predictor of poor sleep. This indicates that the specific timing of device use is as crucial an epidemiological risk factor as total daily use. These results match international data positioning digital overconsumption as a major behavioral cause of sleep pathology in young adults (Alimoradi et al., 2021; Sahu et al., 2023).

6.2 Biological and Behavioral Pathways

The observed negative relationship between screen use and sleep parameters relies on interconnected biological and behavioral pathways. Biologically, modern digital displays emit short-wavelength **blue light** that directly suppresses pineal melatonin synthesis, disrupting normal circadian biology and delaying sleep onset (Touitou et al., 2020). Behaviorally, engaging with social media platforms, interactive mobile applications, or academic materials close to bedtime induces high cognitive and emotional arousal, preventing the natural transition into physiological sleep states (Exelmans and Van den Bulck, 2016). Implementing structured digital hygiene programs — such as limiting screen exposure before bedtime and providing sleep health education — is a vital programmatic intervention for medical education institutions (Sampasa-Kanyinga et al., 2020).

7. Conclusion & Strategic Recommendations

This analytical study demonstrates a strong, statistically significant relationship between excessive digital screen time and compromised sleep quality among undergraduate medical trainees. High global PSQI metrics, indicating poor sleep, show a strong relationship with increased daily screen exposure, particularly during pre-bedtime hours. Medical curricula should incorporate structured modules on **digital hygiene**, sleep physiology, and time management to encourage healthier personal habits (Sampasa-Kanyinga et al., 2020). Future research utilizing large, multi-center cohorts and objective sleep monitoring tools (such as actigraphy) would help confirm and extend these findings (Gupta et al., 2021; Sahu et al., 2023).

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