

A One-Year Prospective Study on the Impact of Digital Screen Exposure on Sleep Quality and Cognitive Performance among Adults in Western Gujarat, India

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Abstract

Background: In the digital age, excessive screen exposure from smartphones, computers, and televisions has become commonplace, particularly among young adults in urbanizing regions. Prolonged digital screen time is suspected to disrupt circadian rhythms through blue light emission, suppress melatonin production, and impair cognitive functions such as attention, memory, and reaction time. While global studies highlight these concerns, region-specific data from India, especially longitudinal observations in Gujarat's population, remain limited. This one-year prospective study aimed to evaluate the effects of varying levels of daily digital screen exposure on sleep quality and cognitive performance among adults in western Gujarat.

Material and Methods: This study was conducted at a tertiary care teaching hospital in western Gujarat over one year. A total of 250 healthy adults aged 18-45 years were recruited through convenient sampling from community and institutional settings and followed up at baseline, 6 months, and 12 months. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), while cognitive performance was evaluated with standardized tests. Screen exposure time (SET) was self-reported via validated questionnaires and corroborated with device usage logs where possible. Ethical approval was obtained from the institutional ethics committee.

Results: Participants with high screen exposure (>4 hours/day) exhibited significantly poorer sleep quality (mean PSQI 7.8 ± 2.1 vs. 4.2 ± 1.5 in low exposure group, $p < 0.001$) and prolonged sleep latency. Cognitive assessments revealed slower reaction times (increased by ~25-30 ms), reduced attention scores, and lower memory performance in the high-exposure group. These differences persisted and slightly worsened over the one-year follow-up, with evening screen use showing stronger associations.

Conclusion: The findings demonstrated a notable negative impact of prolonged digital screen exposure on both sleep architecture and cognitive efficiency in the western Gujarat population. Targeted interventions promoting screen hygiene are warranted to mitigate these effects in young adults.

Keywords: Digital Screen Exposure, Sleep Quality, Cognitive Performance, PSQI, Reaction Time, Blue Light.

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Introduction

The rapid proliferation of digital devices has transformed daily life, bringing convenience but also raising health concerns related to prolonged screen time. In India, smartphone penetration has surged, with young adults in semi-urban and urban areas of Gujarat spending increasing hours on screens for work, education, and entertainment.

Blue light emitted from LED screens is known to interfere with the suprachiasmatic nucleus, delaying melatonin onset and altering sleep-wake cycles. [1,2] Previous research has linked excessive screen exposure to fragmented sleep, daytime

somnolence, and diminished cognitive abilities. International studies, such as those from Norway and the US, report increased insomnia risk and shorter sleep duration with bedtime screen use. In India, cross-sectional surveys among students and office workers in West Bengal and other regions have shown similar patterns of elevated PSQI scores and impaired attention with higher screen time.

Locally, in western Gujarat, lifestyle shifts due to economic growth and digital adoption have amplified exposure, yet longitudinal data specific

to this population's physiological responses are scarce. Factors like occupational screen demands and cultural evening device use may exacerbate risks. [3,4] This study was undertaken to fill this gap by prospectively examining the effect of digital screen exposure on sleep parameters and cognitive performance over one year in adults. The justification lies in providing evidence-based insights for public health strategies tailored to regional needs, ultimately supporting better physiological well-being amid digital dependency.

Material and Methods

This prospective observational study was carried out over one year in the Department of Physiology at a medical college in western Gujarat, India. The research protocol received approval from the Institutional Ethics Committee, and all procedures adhered to the Declaration of Helsinki. Written informed consent was obtained from every participant after a thorough explanation of the study objectives, potential risks, and benefits. Confidentiality of data was strictly maintained.

Inclusion criteria encompassed healthy adults aged 18-45 years residing in western Gujarat for at least one year, with no major comorbidities. Exclusion

criteria included diagnosed sleep disorders, neurological conditions, psychiatric illnesses, shift workers, or those on medications affecting sleep or cognition. Participants with baseline excessive alcohol or tobacco use were also excluded to minimize confounding.

Data collection involved structured questionnaires for socio-demographics and screen time habits (categorized as low: <2h/day, moderate: 2-4h/day, high: >4h/day), PSQI for sleep quality, and objective cognitive tests (ruler drop for reaction time, letter cancellation for attention, and standardized word recall for memory). Follow-ups at 6 and 12 months assessed changes. Statistical analysis was performed using SPSS v26. Descriptive statistics, chi-square tests, ANOVA, Pearson correlations, and repeated measures analysis were applied. A p-value <0.05 was considered statistically significant.

Results

Over the one-year period, 220 participants completed all follow-ups (attrition rate ~12%). Mean age was 28.4 ± 6.2 years, with 58% males. Average daily screen time was 4.7 ± 1.8 hours, predominantly on smartphones (72%).

Table 1: Distribution of Participants by Screen Exposure Categories (Baseline and 12 Months)

Screen Time Category	Baseline n (%)	12 Months n (%)	p-value
Low (<2h/day)	65 (29.5)	52 (23.6)	0.12
Moderate (2-4h)	85 (38.6)	78 (35.5)	-
High (>4h/day)	70 (31.8)	90 (40.9)	0.03

Table 2: Sleep Quality Parameters (PSQI Components) Across Exposure Groups at 12 Months

PSQI Component	Low Exposure (Mean $\pm$ SD)	High Exposure (Mean $\pm$ SD)	p-value
Sleep Latency	1.2 ± 0.8	2.8 ± 1.1	<0.001
Sleep Duration	0.9 ± 0.7	2.1 ± 0.9	<0.001
Daytime Dysfunction	0.8 ± 0.6	2.3 ± 1.0	<0.001
Global PSQI Score	4.2 ± 1.5	7.8 ± 2.1	<0.001

Table 3: Cognitive Performance Measures at Baseline and 12 Months

Test	Low Exposure Change	High Exposure Change	p-value (Group Diff)
Reaction Time (ms)	$+12 \pm 8$	$+28 \pm 15$	<0.001
Attention Score (% accuracy)	-3 ± 4	-12 ± 7	<0.001
Memory Recall (words)	-1.2 ± 1.5	-3.8 ± 2.1	<0.001

Table 4: Correlation of Daily Screen Time with Key Outcomes (Pearson r, at 12 months)

Outcome	Correlation (r)	p-value
Global PSQI	0.68	<0.001
Reaction Time	0.55	<0.001
Attention Score	-0.62	<0.001
Memory Performance	-0.48	<0.001

Discussion

The present one-year study demonstrates a clear association between increased digital screen exposure and adverse effects on sleep quality and cognitive performance in the western Gujarat adult population. These findings align with the broader understanding that excessive screen time,

particularly in evenings, disrupts natural physiological processes governing rest and mental acuity. [5,6]

Our observation of significantly higher PSQI scores and prolonged sleep latency in the high-exposure group (>4h/day) mirrors results from an Indian study on young adults where screen time strongly

correlated with poorer sleep quality, especially latency. Internationally, Norwegian university students showed a 59% increased insomnia risk per additional hour of bedtime screen use, consistent with our data on daytime dysfunction. [7,8]

Regarding sleep duration and efficiency, participants in our high-exposure cohort reported shorter sleep and more disturbances, corroborating West Bengal office worker research where extended SET led to reduced sleep duration (strong correlations $r > 0.87$). Similar patterns emerged in US and Chinese studies linking screen time to insufficient sleep and irregular routines. [9,10]

Cognitive impairments were evident in slower reaction times and reduced attention/memory among high-exposure individuals. This resonates with international findings where night screen time negatively impacted processing speed and working memory on tests like PASAT and MoCA. In India, studies among medical students and adolescents have similarly reported attention deficits and fatigue with prolonged use. [11]

The prospective design over one year allowed us to observe progressive worsening, unlike many cross-sectional studies, strengthening causal inferences.

Evening chronotype susceptibility noted here echoes global chronobiology research. Blue light suppression of melatonin and cognitive arousal from content likely mediate these effects. [12]

Comparisons with regional data from Gujarat college students highlight shared issues like eye strain and mental distress, though our physiological focus adds depth. Overall, the results emphasize the need for awareness in digitally transitioning populations. [13]

The study relied partly on self-reported screen time, which may introduce recall bias, though device logs helped validation. The sample was hospital/community-based and may not fully represent rural extremes. Long-term neuroimaging correlates were not included due to resource constraints.

Conclusion

This one-year study in western Gujarat demonstrates that prolonged digital screen exposure significantly impairs sleep quality and cognitive performance in adults. Higher screen time was associated with poorer sleep quality, longer sleep latency, reduced sleep efficiency, slower reaction time, and impaired attention and memory, particularly with evening use. These findings emphasize the need for public health measures promoting healthy screen habits, sleep hygiene, and digital wellness. Further research should evaluate interventions and include broader age groups to support healthier technology use.

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