Effect of Smartphone Screen Exposure before Sleep on Morning Heart Rate and Blood Pressure

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ABSTRACT

Background: Widespread smartphone use during the pre-sleep period has raised concerns regarding its potential effects on sleep physiology and cardiovascular regulation. Exposure to screen light and cognitive stimulation before bedtime may alter autonomic balance, leading to measurable changes in morning cardiovascular parameters. This study aimed to evaluate the effect of smartphone screen exposure before sleep on morning heart rate and blood pressure in healthy young adults.

Material and methods: A prospective observational study was conducted among 80 healthy adults aged 18–35 years. Participants were grouped based on smartphone screen exposure during the 60 minutes preceding sleep into a high-exposure group (≥30 minutes) and a low-exposure group (<10 minutes). Pre-sleep smartphone use was objectively recorded using built-in screen-time tracking applications over seven consecutive nights. Morning resting heart rate and blood pressure were measured under standardized conditions using a validated automated sphygmomanometer. Data were analyzed using appropriate parametric or non-parametric tests, with statistical significance set at $p < 0.05$.

Results: Baseline characteristics were comparable between groups, although the high-exposure group had a shorter mean sleep duration ($p = 0.01$). Morning resting heart rate was significantly higher in the high-exposure group compared to the low-exposure group (76.8 ± 6.9 vs 71.3 ± 6.1 beats/min; $p < 0.001$). Both systolic (121.6 ± 7.4 vs 116.2 ± 6.8 mmHg; $p = 0.002$) and diastolic blood pressure (78.4 ± 5.9 vs 74.9 ± 5.6 mmHg; $p = 0.01$) were also significantly elevated. Duration of pre-sleep smartphone use showed a moderate positive correlation with morning heart rate ($r = 0.46$) and systolic ($r = 0.41$) and diastolic blood pressure ($r = 0.33$) (all $p < 0.01$).

Conclusion: Prolonged smartphone screen exposure before sleep is associated with higher morning heart rate and blood pressure in young adults, suggesting a potential adverse effect on cardiovascular regulation.

Key words: Smartphone use; Screen exposure; Heart rate; Blood pressure; Sleep hygiene

INTRODUCTION

Smartphone use during the pre-sleep period has become a routine behavior across age groups, raising concerns about downstream effects on sleep and cardiometabolic physiology. An updated systematic review and meta-analysis (55 studies; >41,000 participants) reported that electronic media use is consistently associated with poorer sleep outcomes, with a comparatively strong association noted for general smartphone use and sleep problems in subgroup analyses [1]. Because sleep quantity and quality influence autonomic balance and vascular tone, bedtime screen exposure may plausibly translate into measurable differences in next-morning cardiovascular parameters.

Mechanistically, light emitted by screens—particularly short-wavelength (blue) light—can shift circadian timing and suppress melatonin, while also increasing neurophysiologic arousal. Controlled experimental work has shown that evening reading on a light-emitting eReader, compared with a printed book, prolongs sleep onset, reduces evening sleepiness, suppresses melatonin, delays circadian phase, and decreases alertness the following morning [2]. Similarly, unrestricted evening use of light-emitting tablet computers delays self-selected bedtime, suppresses melatonin timing, and is associated with reduced alertness in the first hour after waking [3]. Complementary laboratory evidence demonstrates that two hours of evening exposure to computer-screen light can disrupt sleep continuity and architecture, dampen melatonin secretion, and negatively affect morning attention performance, with wavelength effects being particularly important [4]. Interventions that reduce blue-wavelength exposure (eg, blue-light–blocking amber lenses worn before bedtime) have been shown to improve sleep-related outcomes in randomized crossover designs, indirectly supporting a causal role of blue light in sleep disruption [5].

Beyond sleep, smartphone-related exposures have been linked to markers of autonomic regulation relevant to resting heart rate and blood pressure. In a case-control study using 24-hour Holter monitoring, longer daily mobile phone use was associated with heart rate variability changes indicating a shift in sympathovagal balance toward higher sympathetic activity [6]. Observational evidence also suggests a relationship between cumulative screen time and elevated blood pressure among young adults; for example, a cross-sectional study from North India reported higher odds of elevated blood pressure at higher screen-time thresholds [7]. However, much of the existing literature focuses on sleep endpoints or longer-term exposure patterns, and comparatively fewer

studies have examined whether screen exposure specifically in the immediate pre-sleep window is associated with next-morning resting heart rate and blood pressure, which are clinically interpretable, easily measurable outcomes.

Therefore, the present study was designed to evaluate the effect of smartphone screen exposure in the hour before sleep on next-morning resting heart rate and blood pressure in healthy young adults. We hypothesized that greater pre-sleep smartphone screen exposure would be associated with higher morning heart rate and higher systolic and diastolic blood pressure.

MATERIAL AND METHODS

Study design and setting: This original research was designed as a prospective observational study conducted over a period of three months at a tertiary care teaching institution in India. The study aimed to evaluate the association between smartphone screen exposure during the pre-sleep period and morning cardiovascular parameters, specifically heart rate and blood pressure, in healthy adults.

Study population: Participants were recruited from undergraduate students and hospital staff through voluntary enrollment. Adults aged 18–35 years were considered eligible, as this age group has relatively stable autonomic cardiovascular regulation and high smartphone usage.

Inclusion criteria

- Age between 18 and 35 years
- Daily smartphone use for at least one year
- Regular sleep–wake schedule (self-reported bedtime between 10:00 PM and 12:00 AM)
- Willingness to comply with study instructions and monitoring protocol

Exclusion criteria

- History of hypertension, cardiovascular disease, diabetes mellitus, or sleep disorders
- Use of medications affecting heart rate or blood pressure (e.g., beta-blockers, antihypertensives)
- Shift work or recent trans-meridian travel within the preceding four weeks

- Regular consumption of alcohol, caffeine, or nicotine after 6:00 PM
- Use of wearable sleep-tracking or blue-light–filtering devices during the study period

Sample size estimation: Sample size was determined based on previously published studies reporting modest but clinically relevant differences in morning systolic blood pressure (3–5 mmHg) and resting heart rate (3–6 beats per minute) associated with nocturnal screen exposure. Assuming a moderate effect size (Cohen's $d = 0.5$), a two-tailed alpha of 0.05, and a statistical power of 80%, the minimum required sample size was calculated as 64 participants. To account for potential non-compliance or attrition, 80 participants were enrolled.

Group allocation: Participants were categorized into two groups based on self-reported smartphone use in the 60 minutes preceding sleep for at least five nights per week:

- **High-exposure group:** Smartphone screen use ≥30 minutes before sleep
- **Low-exposure group:** Smartphone screen use <10 minutes or complete avoidance before sleep

Smartphone usage duration was recorded using built-in screen-time tracking applications to reduce recall bias.

Study protocol: Participants were instructed to maintain their usual daily activities and sleep schedules throughout the study period. For seven consecutive nights, smartphone usage during the pre-sleep period was monitored and logged. Participants were advised to avoid vigorous physical activity, caffeine, and emotional stress after 6:00 PM.

On the morning following the seventh night, cardiovascular measurements were obtained between 6:30 AM and 8:00 AM, after at least 7 hours of sleep. Measurements were taken before any physical activity, food intake, or smartphone use.

Measurement of heart rate and blood pressure: Resting heart rate and blood pressure were measured using a validated automated digital sphygmomanometer. Participants were seated comfortably with back support and feet flat on the floor after a rest period of 10 minutes. The cuff was applied to the non-dominant arm at heart level.

Three readings were recorded at one-minute intervals, and the average of the last two readings was used for analysis. Systolic blood pressure, diastolic blood pressure, and resting heart rate were documented.

Outcome variables

- **Primary outcomes:** Morning resting heart rate and systolic blood pressure
- **Secondary outcome:** Morning diastolic blood pressure

Statistical analysis: Data were entered into a spreadsheet and analyzed using standard statistical software. Continuous variables were expressed as mean ± standard deviation. Normality of data distribution was assessed using the Shapiro–Wilk test. Comparisons between groups were performed using the independent *t*-test for normally distributed variables and the Mann–Whitney *U* test for non-parametric data. A p value <0.05 was considered statistically significant.

RESULTS

A total of 80 participants were included in the final analysis, with 40 individuals in each exposure group. Baseline demographic characteristics were comparable between the high and low pre-sleep smartphone exposure groups with respect to age, sex distribution, and body mass index (Table 1). Mean age was similar in both groups, and there was no significant difference in gender composition. Body mass index did not differ significantly between groups. However, the high-exposure group demonstrated a significantly shorter mean sleep duration compared with the low-exposure group (6.8 ± 0.6 vs 7.2 ± 0.5 hours; p = 0.01). As expected by group definition, average pre-sleep smartphone use was substantially higher in the high-exposure group than in the low-exposure group (46.5 ± 9.2 vs 6.4 ± 2.1 minutes; p < 0.001).

Morning cardiovascular parameters differed significantly between the two groups (Table 2). Participants with higher pre-sleep smartphone exposure had a greater resting heart rate compared with those with low exposure (76.8 ± 6.9 vs 71.3 ± 6.1 beats/min; p < 0.001). Similarly, mean systolic blood pressure was significantly higher in the high-exposure group (121.6 ± 7.4 mmHg) than in the low-exposure group (116.2 ± 6.8 mmHg; p = 0.002). Diastolic blood pressure was also elevated among participants with higher screen exposure (78.4 ± 5.9 vs 74.9 ± 5.6 mmHg; p = 0.01).

The magnitude of differences in cardiovascular outcomes between exposure groups is summarized in Table 3. High pre-sleep smartphone exposure was associated with an increase of 5.5 beats/min in resting heart rate (95% CI: 2.6–8.4), a 5.4 mmHg increase in systolic blood pressure (95% CI: 2.1–8.7), and a 3.5 mmHg increase in diastolic blood pressure (95% CI: 0.9–6.1), with all differences reaching statistical significance.

Correlation analysis demonstrated a positive association between the duration of pre-sleep smartphone use and morning cardiovascular parameters (Table 4). Pre-sleep screen time showed a moderate positive correlation with resting heart rate ($r = 0.46$; $p < 0.001$) and systolic blood pressure ($r = 0.41$; $p < 0.001$), and a weaker but statistically significant correlation with diastolic blood pressure ($r = 0.33$; $p = 0.003$).

Table 1. Baseline characteristics of study participants

Variable	High screen exposure group (n = 40)	Low screen exposure group (n = 40)	*p* value
Age (years), mean ± SD	23.9 ± 3.8	24.2 ± 3.5	0.71
Male : Female (n)	22 : 18	21 : 19	0.82
Body mass index (kg/m²), mean ± SD	22.6 ± 2.4	22.1 ± 2.2	0.34
Average sleep duration (hours), mean ± SD	6.8 ± 0.6	7.2 ± 0.5	0.01
Pre-sleep smartphone use (minutes), mean ± SD	46.5 ± 9.2	6.4 ± 2.1	<0.001

Table 2. Comparison of morning heart rate and blood pressure between groups

Parameter	High screen exposure group (n = 40)	Low screen exposure group (n = 40)	*p* value
Resting heart rate (beats/min), mean ± SD	76.8 ± 6.9	71.3 ± 6.1	<0.001
Systolic blood pressure (mmHg), mean ± SD	121.6 ± 7.4	116.2 ± 6.8	0.002
Diastolic blood pressure (mmHg), mean ± SD	78.4 ± 5.9	74.9 ± 5.6	0.01

Table 3. Mean difference in cardiovascular parameters between exposure groups

Outcome variable	Mean difference (High – Low)	95% Confidence interval	*p* value
Resting heart rate (beats/min)	+5.5	2.6 to 8.4	<0.001
Systolic blood pressure (mmHg)	+5.4	2.1 to 8.7	0.002
Diastolic blood pressure (mmHg)	+3.5	0.9 to 6.1	0.01

Table 4. Correlation between pre-sleep smartphone use duration and morning cardiovascular parameters (n = 80)

Parameter	Correlation coefficient (r)	*p* value
Resting heart rate	0.46	<0.001
Systolic blood pressure	0.41	<0.001
Diastolic blood pressure	0.33	0.003

DISCUSSION

In this study of healthy young adults, greater smartphone screen exposure in the hour preceding sleep was associated with higher next-morning resting heart rate and higher systolic and diastolic blood pressure. The observed between-group differences (≈5.5 beats/min for heart rate; ≈5.4 mmHg for systolic BP; ≈3.5 mmHg for diastolic BP) are modest but physiologically meaningful, particularly when considered as a potentially recurrent daily exposure.

A plausible explanation is that bedtime screen exposure contributes to sleep curtailment and altered autonomic recovery overnight, which can be reflected in morning cardiovascular indices. In our cohort, the high-exposure group also reported a shorter sleep duration, aligning with evidence that insufficient or disrupted sleep can elevate cardiovascular activation. A recent review evaluating experimental studies concluded that acute sleep deprivation is frequently accompanied by rises in blood pressure and autonomic compensatory changes, supporting a short-term effect of sleep loss on BP regulation [8]. Similarly, in an ambulatory sleep-restriction protocol spanning successive nights, daytime heart rate and systolic blood pressure increased and did not fully normalize after limited recovery sleep, suggesting that repeated moderate restriction may sustain sympathetic predominance [9]. Broader epidemiologic literature also supports an association between sleep

disturbances and hypertension risk, including links with short sleep duration and irregular sleep patterns [10]. Taken together, these findings support the possibility that pre-sleep smartphone exposure may act partly through sleep shortening or fragmentation, thereby influencing morning hemodynamics.

Light characteristics and arousal effects may additionally contribute via autonomic modulation independent of sleep duration. A recent systematic review focusing on visible light exposure reported that high-illuminance blue light generally reduces vagally mediated heart rate variability, consistent with increased arousal and reduced parasympathetic tone [11]. Controlled physiologic studies further show that blue-enriched or blue light exposure can shift autonomic indices toward sympathetic predominance, including increases in LF/HF in short-term exposures [12]. Directionally similar effects on autonomic measures have been described with blue-light exposure protocols affecting parasympathetic components of HRV [13]. Such autonomic shifts provide a biologically coherent pathway linking bedtime screen exposure to elevated resting heart rate and higher morning blood pressure in otherwise healthy individuals.

Our findings are also consistent with literature associating screen-related behaviors and smartphone use patterns with cardiovascular endpoints. A dose–response meta-analysis reported higher risk of hypertension with increasing screen time across pediatric and adolescent populations, suggesting that cumulative exposure may have vascular consequences [14]. In a population of medical undergraduates, higher smartphone addiction scores were associated with higher prevalence of hypertension and poorer sleep quality, indicating a clustering of behavioral and physiologic risk markers in heavy users [15]. Importantly, objective behavioral–physiologic coupling has been demonstrated in real-world datasets: a study integrating smartphone use in bed with wearable sleep metrics found that bedtime smartphone use adversely affected sleep latency and wakefulness and was associated with changes in average heart rate and heart rate variability, supporting a link between nocturnal smartphone behavior and autonomic physiology [16]. Although these studies differ in design and outcomes, they strengthen the external plausibility of our observation that heavier pre-sleep screen exposure coincides with higher next-morning cardiovascular measurements.

This study has limitations that should be considered when interpreting the results. First, as an observational design, causality cannot be established and residual confounding may persist despite restrictions (eg, unmeasured stress, dietary sodium intake, or day-to-day physical activity). Second, the study did not include objective sleep staging; therefore, we could not quantify sleep fragmentation or changes in autonomic stress during sleep, which are known to vary with partial sleep restriction and can influence heart rate and HRV [17]. Third, screen exposure was assessed using screen-time tracking, but content type (social media, gaming, academic reading), ambient lighting, and device brightness were not standardized and may modify physiologic effects. Finally, the cohort comprised healthy young adults, limiting generalizability to older populations and individuals with established cardiometabolic disease.

Despite these limitations, the findings suggest that reducing smartphone screen exposure before bedtime may be a simple, low-cost behavioral target to support healthier morning cardiovascular profiles. Future work should incorporate objective sleep measurement (actigraphy/polysomnography), standardized light metrics (illuminance/spectral composition), and repeated morning BP/HR assessments to clarify temporal dynamics and disentangle light-driven autonomic effects from sleep-mediated pathways.

CONCLUSION

The findings of this study indicate that prolonged smartphone screen exposure during the pre-sleep period is associated with a higher morning resting heart rate and elevated systolic and diastolic blood pressure in healthy young adults. Individuals with greater screen exposure before bedtime demonstrated measurable alterations in cardiovascular parameters the following morning, suggesting a possible disruption of normal autonomic regulation. These observations underscore the potential physiological impact of nocturnal smartphone use on cardiovascular function and highlight the importance of limiting screen exposure before sleep as a simple behavioral strategy to promote optimal cardiovascular health.

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