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Nighttime Smartphone Blue Light Exposure, Sleep Quality, and Metabolic Health in Adolescents and Young Adults

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Abstract

Nighttime smartphone use has become very common among adolescents in recent years, and this may affect both sleep quality and metabolic health. However, the specific effect of smartphone-emitted blue light is difficult to separate from behavioral forms of smartphone-related sleep disruption, especially when looking at adolescents. Smartphone-emitted blue light can disrupt circadian rhythms and melatonin secretion. This can potentially affect glucose regulation and insulin sensitivity, leading to specific metabolic outcomes in adolescents. However, other forms of sleep disruption (stress, room temperature, physical discomfort, and bedtime delay) can also contribute to these outcomes. This paper looks at the association between sleep quality and nighttime smartphone-emitted blue light, compared with other forms of sleep disruption, and metabolic outcomes in adolescents. This study uses a literature review and survey to analyze whether blue light has a specific role in these relationships. 70 individuals responded to the survey. Greater smartphone use after getting into bed was associated with poorer self-reported sleep quality (ρ = –0.284, p = 0.017). Difficulty stopping smartphone use before bed was also associated with more frequent bedtime delay (ρ = 0.392, p = 0.001). However, blue-light-reduction feature use was not significantly associated with sleep quality (ρ = 0.176, p = 0.144). Blue-light-specific associations were weaker in the survey, while the literature showed stronger evidence of blue light affecting sleep and metabolic regulation. This difference suggests that other behavioral, psychological, and environmental forms of sleep disruption may also contribute to these outcomes alongside blue-light exposure.

Email address or other contact information, if relevant

Introduction

Adolescence is the developmental stage that starts with puberty, between the ages of 8–14, and ends in the mid-20s [1]. Over 95% of adolescents in the US have access to smartphones [2], and more than 70% use their phones within 30 minutes of falling asleep [3]. With this increase in screen time comes an increase in exposure to blue light. Blue light affects the body's circadian rhythm by suppressing melatonin secretion and increasing alertness and cortisol levels. These responses are more evident in adolescents [4]. Sleep can be disrupted by photic factors (light-related factors such as nighttime blue-light exposure) and non-photic factors (factors unrelated to light, such as stress, room temperature, physical discomfort, and bedtime delay). However, the association between blue-light exposure and insulin sensitivity and glucose levels has not been fully covered, especially in adolescents and when comparing these effects with other forms of sleep disruption. This study aims to understand the association between sleep quality and nighttime exposure to smartphone-emitted blue light, as opposed to other forms of sleep disruption, with measures of insulin sensitivity and glucose regulation in adolescents.

Methods

For the literature review, papers or studies were identified via PubMed and Google Scholar by searching for keywords related to the research question, including adolescent sleep quality, smartphone-emitted blue light, insulin sensitivity, glucose regulation, circadian rhythm, photic sleep disruption, non-photic sleep disruption, and metabolic health.

A cross-sectional survey was conducted in Lebanon and Spain via Google Forms. The inclusion criteria required participants to be between the ages of 13 and s old and 24 years. The questionnaire was divided into three sections: (1) sleep habits and sleep quality, (2) nighttime smartphone use and screen exposure, and (3) blue light exposure and metabolic health indicators.

Survey responses were exported to Google Sheets and analyzed using Python in Google Colab. Spearman's correlation was used to analyze relationships between variables. Mann–Whitney U tests were used to compare two groups. Kruskal–Wallis tests were used to compare three or more groups. Statistical significance was set at $p < 0.05$.

Ethical considerations

Participation in the survey was voluntary and anonymous. No personal information was collected.

Results

A total of 70 participants between the ages of 13 and 24 completed the survey. Survey responses indicated a negative association between smartphone use after getting into bed and self-reported sleep quality (ρ = −0.284, p = 0.017). Blue-light reduction feature use was not significantly associated with sleep quality (ρ = 0.176, p = 0.144). Higher nighttime smartphone light exposure was also not significantly associated with sleep quality (p = 0.290). Stress or anxiety was the most commonly reported sleep disruptor (n = 45), followed by room temperature (n = 41) and smartphone use before bed (n = 40). Difficulty stopping smartphone use before bed was positively correlated with bedtime delay (ρ = 0.392, p = 0.001). Frequent nighttime smartphone users reported significantly higher high-calorie cravings (p = 0.038), unusual tiredness (p = 0.045), and mental fog (p = 0.041).

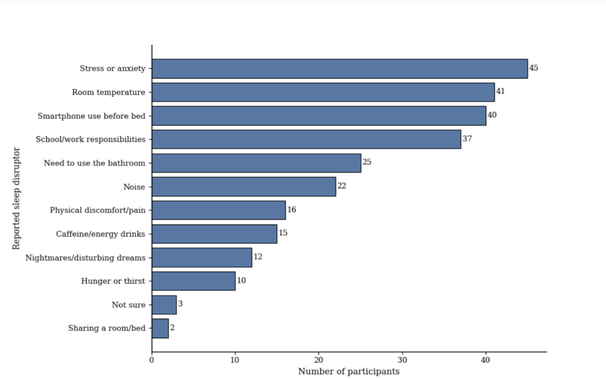

Figure 8: Reported factors contributing to sleep disruption among survey participants.

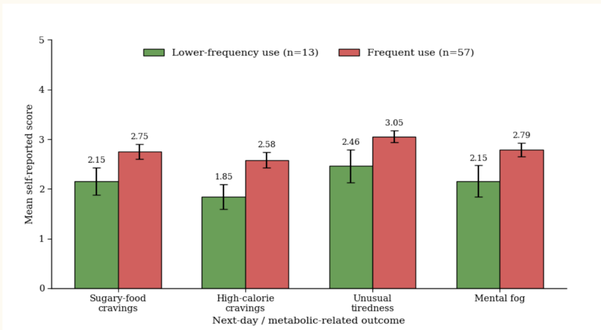

Figure 11: Comparison of next-day metabolic-related outcomes between participants with lower-frequency and higher frequency nighttime smartphone use.

Discussion

The survey findings were consistent with current studies as described in the literature review. Both show an association between nighttime smartphone use and poorer sleep quality. The data found no direct relationship between blue-light exposure and sleep quality. These results suggest that blue light alone may not fully explain the relationship between nighttime smartphone use and poorer sleep. The survey also shows that smartphone use may disrupt sleep through other behavioral factors, not only blue-light exposure. This suggests that smartphones may disrupt sleep not only through light exposure, but also by keeping the participants engaged through social media, gaming, streaming apps and time spent on them. ants. Frequent nighttime smartphone users reported greater sugary-food cravings, high-calorie cravings, unusual tiredness, and mental fog than lower-frequency users. These findings support the possibility that blue light is not the only pathway connecting sleep disruption with metabolic outcomes.

Conclusion

The findings suggest that blue light may contribute to sleep and metabolic disruption, but it is one of several factors affecting these outcomes. Instead of working alone, blue light sets a delay that becomes much worse when paired with late-night mental stimulation that is a part of smart phone use. The behavioral mechanisms and effects of smartphone use can outweigh, or be more strongly associated with the effects of smartphone-emitted blue light, as there is a shift from a physical stimulus to a cognitive one, which can have a more significant effect on metabolic health. The study relied on self-reported data, which may be affected by recall or reporting bias. The survey did not directly measure glucose, insulin, HOMA-IR, or OGTT responses. The cross-sectional study shows associations, but cannot establish causation. Future research should directly measure blue-light exposure, melatonin, glucose, and insulin sensitivity, while also looking at specific measures of nonphotic sleep disruption, to better determine the specific metabolic effects of nighttime smartphone-emitted blue light in adolescents.

References

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