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SMARTPHONE ADDICTION AND SLEEP ONSET LATENCY

The Role of Bedtime Procrastination Among Undergraduate Students in Bengaluru, India

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Abstract: Smartphones play a central role in students' academic, social, and recreational lives; however, excessive use has been increasingly associated with adverse sleep outcomes. The present study examined the relationships among smartphone addiction, bedtime procrastination, and sleep onset latency among undergraduate students in Bengaluru, India. A cross-sectional design was employed using standardized self-report measures of smartphone addiction and bedtime procrastination, along with self-reported sleep onset latency. Descriptive statistics indicated moderate levels of smartphone addiction (M = 28.80, SD = 10.38), bedtime procrastination (M = 22.04, SD = 4.87), and sleep onset latency (M = 22.31 minutes, SD = 24.42). Pearson correlation analysis revealed no significant association between smartphone addiction and bedtime procrastination ($r = -.06$, $p = .55$), while a small-to-moderate significant positive association was observed between smartphone addiction and sleep onset latency ($r = .28$, $p = .004$). The relationship between bedtime procrastination and sleep onset latency was marginally non-significant ($r = .18$, $p = .053$). These findings suggest that smartphone addiction may influence sleep onset latency through direct physiological and cognitive activation mechanisms rather than through behavioural delay. The absence of support for a mediation pathway highlights the need to reconsider commonly assumed mechanisms linking technology use and sleep. The study has implications for digital well-being interventions and sleep hygiene education and underscores the need for future research using larger samples and objective sleep measures.

Keywords: *Smartphone addiction; Bedtime procrastination; Sleep onset latency; Undergraduate students; Sleep behaviour; Digital well-being*

1. INTRODUCTION

As per DataReportal, by the end of 2025, India had around 1.06 billion active mobile phone connections, which accounted for 72.5% of the country's population. This indicates widespread penetration of mobile technology nationwide. (DataReportal, 2026). These statistics not only prove the prevalence of mobile technologies but also reveal how integral handheld devices have become in everyday life, education, entertainment, and communication. (Zhao et al., 2022). For university students, smartphones have transcended their status as mere accessories. They function as entertainment centers, portable classrooms, social networks, alarm clocks, cameras, and tools for emotional support, all combined into a single device.

The convenience of smartphones, however, creates a paradox. The same device that allows students to access lecture materials, communicate with peers, and manage tasks also encourages constant availability, repeated checking, and extended nighttime engagement. (Gupta et al., 2016). Researchers have increasingly conceptualized problematic or addictive smartphone use as a behavioural pattern characterized by loss of control, excessive preoccupation, withdrawal-like discomfort, and persistence despite negative consequences (Kwon et al., 2013). Although smartphone addiction is not a formal diagnosis in major psychiatric classification systems, the construct has substantial research utility because it captures compulsive, dysregulated, and impairing patterns of use that resemble broader behavioural addictions. University students are specifically susceptible to such behaviours. This developmental phase includes sense of identity establishment, fostering friendships, navigate the academic obstacles, and gaining more autonomy in self-regulation. Psychologically, students may use smartphones not only for practical reasons, they might use for coping up with feelings of boredom, loneliness, stress, and the fear of missing out. (Shi et al., 2025). Environmentally, smartphones are deeply embedded in routines of students through learning portals and platforms, social media platforms, apps used for messaging, video streaming services, gaming, and short-form video. (Xu, 2024). Altogether, these influences make prolonged and smartphone excessive usage both easy and widely accepted. These combined influences make sustained and excessive use both easy and socially normalized. One of the most significant core areas affected by excessive smartphone use is sleep. Sleep constitutes an essential, physiological process conserved which supports attention, emotional regulation, memory consolidation, physical restoration, and learning. (Lee et al., 2020).

Normal sleep onset latency in healthy adults is defined as the time taken to fall asleep after attempting sleep. Typically falls around 10 to 20 minutes. A prolonged latency to sleep onset is suggestive of physiological arousal, cognitive hyperactivation, sleep timing irregularity, poor sleep hygiene, or external environmental interference. (Sleep Foundation, 2025). Exposure to light-emitting devices during the evening has been demonstrated to cause circadian misalignment, specifically by delaying melatonin suppression and extending the time required to initiate sleep (Chang et al., 2015). Consequently, when students engage with smartphones late at night, the onset of sleep may be postponed through both behavioral and biological mechanisms. (Cemei et al., 2024)

A second construct relevant to this process is bedtime procrastination. Bedtime procrastination study as unnecessary and voluntarily delaying going to bed while no external circumstances prevent a person from doing so.(Kroese et al.,2016). The concept is important because it shifts the conversation from purely biological sleep disturbances to self-regulation failures in pre-sleep behaviour. Students often report intending to sleep at a certain time yet continue scrolling, chatting, watching videos, or engaging in other low-priority activities. In this sense, bedtime procrastination is not merely a scheduling issue; it reflects a gap between intention and action. (Mao et al., 2022)

From a theoretical perspective, smartphone addiction and bedtime procrastination may be closely linked. Problematic smartphone use increases exposure to rewarding, novelty-rich, and socially reinforcing content during hours when students should disengage and prepare for sleep. At the same time, poor self-regulation may make it difficult to stop using the device despite awareness of the next-day consequences (Zhu et al., 2019). This pattern can push bedtime later and may also increase sleep onset latency through heightened stimulation, rumination, and disrupted sleep readiness. (Cemei et al., 2024) Therefore, bedtime procrastination can be understood as a plausible behavioural pathway through which smartphone addiction affects sleep outcomes.

This study focuses on undergraduate students in Bengaluru. The city's strong digital infrastructure, widespread smartphone access, and high reliance on technology for education make it an especially relevant context for examining the relationships among smartphone use, self-regulation, and sleep behavior. (DataReportal, 2025). Although international research has increasingly documented associations between problematic smartphone use, bedtime procrastination, and poor sleep, Indian evidence, especially using sleep onset latency as a specific outcome remains comparatively limited. This study addresses this gap by presenting a research article on these variables among undergraduates in Bengaluru.

The core purpose of this study is threefold: first, to describe the levels of smartphone addiction, bedtime procrastination, and sleep onset latency in the sample; second, to examine the bivariate relationships among these variables; and third, to discuss whether bedtime procrastination may operate as a meaningful explanatory mechanism in the relationship between smartphone addiction and delayed sleep initiation. By integrating behavioural addiction research with sleep psychology and self-regulation theory, this study contributes to a growing understanding of how digital habits shape everyday health behaviours in student populations.

To understand these relationships more clearly, the relevant literature on smartphone addiction, bedtime procrastination, and sleep onset latency is reviewed below.

Hypotheses

Based on prior literature, the study proposed the following hypotheses: **H1:** smartphone addiction would be positively related to bedtime procrastination; **H2:** smartphone addiction would be positively related to sleep onset latency; **H3:** bedtime procrastination would be positively related to sleep onset latency; and **H4:** bedtime procrastination would mediate the relationship between smartphone addiction and sleep onset latency. These hypotheses were grounded in a self-regulation account in which late-night smartphone use increases difficulty disengaging from stimulating activities, thereby delaying bedtime and increasing the time required to fall asleep.

2. LITERATURE REVIEW

2.1 Smartphone Addiction as a Behavioural Construct

The literature on smartphone addiction has expanded significantly over the past decade, with researchers increasingly conceptualizing problematic smartphone use as a behavioural addiction. The Smartphone Addiction Scale (SAS) developed by Kwon et al. (2013) framed smartphone addiction as a multidimensional construct encompassing daily life disturbance, withdrawal, tolerance, cyberspace-oriented relationships, and overuse. This scale has been widely used to empirically capture maladaptive smartphone behaviours.

From a theoretical perspective, a behavioural addiction framework provides a useful lens to understand excessive smartphone use. Such use is characterized by compulsive engagement, loss of control, and persistence despite negative consequences (Griffiths, 2005; Billieux, 2012). These behaviours are often driven by reinforcement mechanisms and emotional regulation needs (Elhai et al., 2017). Additionally, impulsivity and poor self-control have been identified as key contributors to excessive smartphone use, particularly during late-night hours (Kim et al., 2016; Panova & Carbonell, 2018).

Smartphones are uniquely potent in sustaining such behaviours because they integrate multiple sources of reinforcement, including social interaction, entertainment, and information. Their constant accessibility and personalized nature, combined with variable reward systems such as notifications and endless content streams, promote habitual checking and difficulty disengaging (Alter, 2017; Eyal, 2014; Oulasvirta et al., 2012).

2.2 Smartphone Use and Sleep Outcomes

A substantial body of research has documented the negative impact of excessive smartphone use on sleep. Exposure to light-emitting screens in the evening has been shown to delay circadian rhythms, suppress melatonin secretion, prolong sleep onset latency, and impair next-morning alertness (Cain & Gradisar, 2010; Chang et al., 2015; Czeisler et al., 2011; Exelmans & Van den Bulck, 2016; de Zwart et al., 2018).

Although some early studies focused on eReaders, the underlying mechanisms are highly applicable to smartphones, which also emit short-wavelength light and are widely used before bedtime. Consequently, pre-sleep device use has been associated with shorter sleep duration, poorer sleep quality, fragmented sleep, and delayed sleep initiation (Kheirinejad et al., 2022).

Further evidence indicates that bedtime technology use is significantly associated with increased sleep onset latency. AlShareef et al. (2022) found that individuals using smartphones and tablets before sleep were more likely to take longer than 30 minutes to fall asleep. This is particularly important because sleep onset latency serves as a specific and interpretable indicator of sleep disturbance (Exelmans et al., 2018). Unlike general measures of sleep quality, sleep onset latency directly reflects the transition into sleep and captures the influence of behavioural activation, cognitive arousal, and physiological stimulation.

2.3 Bedtime Procrastination as a Self-Regulation Failure

Bedtime procrastination has emerged as a significant construct in understanding sleep-related behaviours. Kroese et al. (2014) defined bedtime procrastination as the unnecessary and voluntary delay of bedtime despite the absence of external constraints. Their work highlighted that many individuals postpone sleep even when they intend to go to bed earlier, resulting in insufficient sleep.

Importantly, bedtime procrastination is conceptually distinct from insomnia. Individuals with insomnia may go to bed on time but struggle to fall asleep, whereas those with bedtime procrastination delay going to bed itself. This distinction has important implications for understanding underlying mechanisms and designing interventions (Uygur & Bahar, 2023).

Subsequent research has linked bedtime procrastination to low self-control, poor planning, stress, and increased engagement with digital media during the evening (Krzywoszanski, 2019). It is widely conceptualized as a form of self-regulation failure in which immediate gratification is prioritized over long-term well-being. Among students, the tendency to continue engaging in activities such as social media use, video consumption, or online interactions often overrides intended sleep schedules, leading to habitual sleep delay.

2.4 Interplay Between Smartphone Addiction, Bedtime Procrastination, and Sleep

Recent research has increasingly examined the combined relationships among smartphone addiction, bedtime procrastination, and sleep outcomes. Studies have suggested that bedtime procrastination may act as a behavioural pathway linking excessive smartphone use to poor sleep.

For instance, Correa-Iriarte et al. (2023) reported significant associations among problematic smartphone use, bedtime procrastination, and sleep quality, indicating that delayed bedtime behaviour may explain how digital over-engagement leads to sleep disturbances. Similarly, Huang et al. (2023) found that mobile phone dependency, fear of missing out, and bedtime procrastination were interconnected, with bedtime procrastination playing a mediating role in sleep outcomes among college students.

Further support for this pathway comes from Bozkurt et al. (2024), who demonstrated that bedtime procrastination mediated the relationship between problematic smartphone use and sleep quality in adolescents. These findings suggest that smartphone addiction may influence sleep not only directly but also indirectly by altering bedtime routines and weakening behavioural control. Such patterns may increase pre-sleep cognitive and physiological activation, ultimately delaying sleep onset (Thangaraj et al., 2025).

2.5 Indian Context and Research Gap

The relationship between smartphone use and sleep is particularly relevant in the Indian context. Indian college students operate within environments characterized by intense academic demands, widespread digital learning, prolonged commuting, and strong reliance on smartphones for social connectivity. These factors can blur the boundaries between academic activities, leisure, and sleep.

Emerging Indian research has reported associations between problematic smartphone use and sleep difficulties among students (Uniyal & Tiwari, 2020). However, there remains limited research specifically examining bedtime procrastination and sleep onset latency as distinct yet related constructs. Additionally, mediation models exploring the role of bedtime procrastination in the relationship between smartphone addiction and sleep outcomes are still underdeveloped in Indian samples.

2.6 Theoretical Mechanisms Linking Smartphone Use and Sleep

The literature identifies multiple mechanisms through which smartphone use may influence sleep. The behavioural displacement hypothesis suggests that time spent on smartphones reduces the time available for sleep (Cain & Gradisar, 2010). The physiological activation pathway posits that exposure to screen light and stimulating content delays circadian rhythms and biological readiness for sleep (Chang et al., 2015). The cognitive-emotional arousal mechanism highlights that engaging with emotionally stimulating or socially interactive content increases mental activation, thereby prolonging sleep onset (Levenson et al., 2017). Finally, the self-regulation failure perspective suggests that individuals struggle to disengage from smartphone use despite intending to sleep (Kroese et al., 2014).

Bedtime procrastination aligns most closely with the self-regulation failure mechanism; however, these pathways are not mutually exclusive and may operate simultaneously.

2.7 Summary and Research Gap

Despite the growing body of research, several gaps remain. First, many studies focus on general sleep quality rather than the more specific construct of sleep onset latency. Second, mediation models involving bedtime procrastination remain underexplored, particularly in Indian contexts. Third, much of the existing evidence is derived from non-Indian populations, limiting contextual applicability.

The present study addresses these gaps by examining smartphone addiction, bedtime procrastination, and sleep onset latency among undergraduate students in Bengaluru and by evaluating the plausibility of a mediation pathway linking these constructs.

3. RESEARCH METHODOLOGY

The present investigation adopted a quantitative, cross-sectional, correlational research design. A cross-sectional design was considered appropriate because the primary purpose was to examine the current pattern of associations among smartphone addiction, bedtime procrastination, and sleep onset latency within a defined student sample. The study did not involve experimental manipulation; rather, it sought to identify naturally occurring relationships among variables that are highly relevant to student daily life.

The sample comprised 103 undergraduate students from Bengaluru. Participants were selected through a non-probability approach. Undergraduate students were chosen because they represent a population with frequent smartphone engagement, flexible bedtime patterns, and high exposure to academic and social demands that may influence sleep behaviour.

The variables were operationalized as follows. Smartphone addiction was defined as a pattern of excessive and difficult-to-control smartphone use that interferes with daily functioning (Kwon et al., 2013). Bedtime procrastination referred to the voluntary delay of going to bed despite the absence of external constraints and the intention to sleep earlier (Kroese et al., 2014). Sleep onset latency was defined as the self-reported number of minutes required to fall asleep after attempting sleep (Buysse et al., 1989).

Data were collected using a structured questionnaire packet that included a standardized smartphone addiction measure, the Bedtime Procrastination Scale, and a self-report item or measure assessing sleep onset latency in minutes. The use of standardized psychometric measures increased comparability with

previous research and improved the conceptual clarity of the constructs. Participants provided responses in a confidential format intended to reduce social desirability pressure.

After data collection, the dataset was cleaned and analyzed statistically. Descriptive statistics were calculated to summarize the central tendency and dispersion of the variables. Pearson's product–moment correlation was used to examine bivariate relationships among smartphone addiction, bedtime procrastination, and sleep onset latency. The study also considered the possibility of mediation by bedtime procrastination. A full mediation test ideally requires regression-based indirect effect analysis with bootstrapped confidence intervals; however, the correlational pattern itself can still provide preliminary insight into whether a mediation pathway is plausible.

3.1.Population and Sample

The study population comprised undergraduate students in Bengaluru, India, a group characterized by high smartphone use and flexible sleep patterns. The sample included 103 undergraduate students, selected using a convenience sampling method. Participants were active smartphone users within the typical undergraduate age range (18–25 years). While the sampling approach limits generalizability, it is appropriate for examining correlational relationships among the study variables.

3.2.Theoretical Framework

The study is grounded in a **self-regulation framework**, supported by behavioural addiction theory and sleep science. Smartphone addiction reflects excessive, hard-to-control use driven by reinforcement and poor impulse regulation. Bedtime procrastination represents a failure of self-regulation, where individuals delay sleep despite intending to sleep earlier.

Sleep science further explains that smartphone use may delay sleep through physiological activation (e.g., melatonin suppression) and cognitive arousal. Accordingly, the study proposes that smartphone addiction influences sleep onset latency both directly and indirectly via bedtime procrastination.

From an ethical perspective, the study involved minimal risk. Participation was voluntary, responses were used for academic research purposes, and confidentiality was maintained. Because the constructs concern everyday behaviors rather than invasive procedures, the study was suitable for a non-clinical undergraduate population. Nevertheless, care was taken to present items respectfully and to interpret findings without pathologizing all smartphone use.

3.3.Research Objectives

The study was guided by the following objectives:

(1) to assess the level of smartphone addiction among undergraduate students in Bengaluru; (2) to assess the level of bedtime procrastination among the same students; (3) to estimate self-reported sleep onset latency; (4) to examine the relationships among smartphone addiction, bedtime procrastination, and sleep onset latency; and (5) to explore whether bedtime procrastination may function as a mediating mechanism in the relationship between smartphone addiction and sleep onset latency.

3.4. Instruments

Smartphone addiction was assessed using the Smartphone Addiction Scale–Short Version (SAS-SV; Kwon et al., 2013), a 10-item measure with good reliability ($\alpha > .80$). Bedtime procrastination was measured using the Bedtime Procrastination Scale (BPS; Kroese et al., 2014), a 9-item scale with acceptable reliability ($\alpha \approx .70–.80$). Sleep onset latency was assessed using a self-reported estimate of the average time (in minutes) taken to fall asleep.

4. RESULTS

The present study examined the relationships among smartphone addiction, bedtime procrastination, and sleep onset latency among undergraduate students in Bengaluru. Descriptive statistics, correlation analysis, regression analysis, and mediation analysis were conducted to address the study objectives.

- **Descriptive Statistics**

Table 1 presents the descriptive statistics for the three core variables. The mean smartphone addiction score was 28.80 (SD = 10.38), the mean bedtime procrastination score was 22.04 (SD = 4.87), and the mean sleep onset latency was 22.31 minutes (SD = 24.42).

The variability observed in sleep onset latency indicates differences in the time taken by participants to fall asleep.

table 1

descriptive statistics of study variables (n = 103)

Variable	Mean (M)	Standard Deviation (SD)
Smartphone Addiction	28.8	10.38
Bedtime Procrastination	22.04	4.87
Sleep Onset Latency (mins)	22.31	24.42

Sleep onset latency showed high variability (SD = 24.42), indicating substantial individual differences
Note. Sleep onset latency is measured in minutes.

- **Correlation Analysis**

Pearson correlation analysis was conducted to examine the relationships among the variables (see Table 2).

Smartphone addiction showed a negligible negative association with bedtime procrastination (r = −.06, p = .55), indicating no statistically significant relationship.

A significant small-to-moderate positive association was observed between smartphone addiction and sleep onset latency (r = .28, p = .004).

The relationship between bedtime procrastination and sleep onset latency was not statistically significant (r = .18, p = .053) and may be interpreted as a marginally non-significant trend.

table 2

pearson correlations among study variables

Variable	1	2	3
1. Smartphone Addiction	—		
2. Bedtime Procrastination	−.06 (p=0.55)	—	
3. Sleep Onset Latency	.28** (p = .004)	.18 (p = .053)	—

Note. N = 103. *p < .05, **p < .01.
Correlation between bedtime procrastination and sleep onset latency: p = .053 (marginally non-significant).

- **Regression Analysis**

A multiple regression analysis was conducted with sleep onset latency as the outcome variable (see Table 3).

Smartphone addiction significantly predicted sleep onset latency (β = .28, p = .004). Bedtime procrastination did not significantly predict sleep onset latency (β = .18, p = .053).

The overall model was statistically significant and explained 8% of the variance in sleep onset latency (R^2 = .08).

table 3

regression analysis predicting sleep onset latency

Predictor	B	SE	β	t	p
Smartphone Addiction	.64	.21	.28	3.00	.004**
Bedtime Procrastination	.89	.46	.18	1.94	0.053

Note. N = 103. Outcome variable = Sleep Onset Latency. R^2 = .08.
*p < .05, **p < .01

Smartphone addiction emerged as a significant positive predictor, whereas bedtime procrastination did not significantly predict sleep onset latency. The model explained a modest proportion of variance (8%), indicating that other factors also contribute to sleep onset latency

- **Mediation Analysis**

A mediation analysis was conducted to examine whether bedtime procrastination mediated the relationship between smartphone addiction and sleep onset latency. The results did not support mediation because smartphone addiction did not significantly predict bedtime procrastination, and the indirect effect was not statistically significant.

table 4

mediation analysis: indirect effect of smartphone addiction on sleep onset latency through bedtime procrastination

Path	**Effect (B)**	**SE**	**t**	**p**
Path a: SA → BP	−0.06	.10	-0.59	.55
Path b: BP → SOL	.89	0.46	1.94	.053
Direct effect (c'): SA → SOL	.64	0.21	3	.004**
Total effect (c): SA → SOL	.65	0.21	3.02	.004**
Indirect effect (a × b) : Not significant				

Note. SA = Smartphone Addiction; BP = Bedtime Procrastination; SOL = Sleep Onset Latency.
The indirect effect was not statistically significant.
*p < .05, **p < .01

The findings suggest that smartphone addiction may influence sleep onset latency through direct physiological and cognitive activation mechanisms rather than through behavioral delay

- **Summary of key Findings**

Smartphone addiction showed a significant small-to-moderate positive association with sleep onset latency. No significant relationship was observed between smartphone addiction and bedtime procrastination. The association between bedtime procrastination and sleep onset latency was marginally non-significant. These findings suggest that smartphone addiction may influence sleep onset latency more directly rather than through bedtime procrastination.

5. DISCUSSION

The present study examined the relationships among smartphone addiction, bedtime procrastination, and sleep onset latency among undergraduate students in Bengaluru. The findings provide partial support for the proposed hypotheses and offer important insights into the behavioral and psychological mechanisms linking smartphone use and sleep.

- **Smartphone Addiction and Sleep Onset Latency**

A key finding of this study is that smartphone addiction was significantly and positively associated with sleep onset latency, indicating that students with higher levels of problematic smartphone use tend to take longer to fall asleep. This result aligns with a growing body of research demonstrating that excessive smartphone use is linked with sleep disturbances, including delayed sleep initiation, reduced sleep quality, and circadian disruption (Cain & Gradisar, 2010; Chang et al., 2015; Exelmans & Van den Bulck, 2016; Kheirinejad et al., 2022).

Importantly, the observed relationship reflects a small-to-moderate effect size, suggesting that while smartphone addiction is not the sole determinant of sleep delay, it represents a meaningful and practically relevant contributor. This finding can be interpreted through multiple theoretical pathways. From a physiological perspective, exposure to light-emitting screens in the evening is known to suppress melatonin and delay circadian rhythms (Chang et al., 2015; Czeisler et al., 2011). From a cognitive-emotional perspective, engaging with stimulating content, such as social media, messaging, or videos. This may increase mental activation, thereby prolonging the transition into sleep (Levenson et al., 2017; Exelmans & Van den Bulck, 2016). Together, these mechanisms provide a plausible explanation for why smartphone addiction directly influences sleep onset latency.

- **Bedtime Procrastination and Sleep Onset Latency**

Contrary to expectations, bedtime procrastination did not show a statistically significant relationship with sleep onset latency, although the association was in the expected direction and may be interpreted as a marginally non-significant trend. This suggests that while delaying bedtime may contribute to sleep difficulties, it may not be a sufficiently strong or consistent predictor of sleep onset latency in the present sample.

One possible explanation is that bedtime procrastination primarily affects sleep timing (when individuals go to bed) rather than sleep initiation (how quickly they fall asleep once in bed), a distinction highlighted in prior research (Kroese et al., 2014; Uygur & Bahar, 2023). Thus, individuals may delay going to bed but still fall asleep relatively quickly once they attempt to sleep. Alternatively, the variability observed in sleep onset latency may be influenced by additional unmeasured factors such as stress, anxiety, environmental disturbances, or irregular routines, which may dilute the observed relationship (Owens, 2014).

- **Smartphone Addiction and Bedtime Procrastination**

The study did not find a significant association between smartphone addiction and bedtime procrastination, which contrasts with several prior studies suggesting that problematic smartphone use contributes to delayed bedtime (Huang et al., 2023; Correa-Iriarte et al., 2023). This finding is theoretically important, as it challenges the assumption that smartphone addiction necessarily operates through behavioural delay mechanisms.

One explanation for this pattern is a measurement mismatch between the constructs. Smartphone addiction reflects a broad pattern of excessive and compulsive use across the day, whereas bedtime procrastination is a specific behavioural pattern restricted to the pre-sleep period. As a result, high smartphone use during daytime may elevate addiction scores without necessarily translating into bedtime delay.

Additionally, contextual factors specific to student life in Bengaluru may have influenced the findings. Students may engage in late-night smartphone use for academic or socially normative reasons, which may not be perceived as procrastination. In such cases, smartphone use may extend into bedtime without being experienced as unnecessary delay, thereby weakening the relationship between the two constructs (Mao et al., 2022).

- **Mediation Analysis and Theoretical Implications**

A central objective of the study was to examine whether bedtime procrastination mediates the relationship between smartphone addiction and sleep onset latency. However, the findings did not support this mediation pathway. Specifically, the absence of a significant relationship between smartphone addiction and bedtime procrastination indicates that the necessary conditions for mediation were not met.

This result has important theoretical implications. It suggests that the effect of smartphone addiction on sleep onset latency may operate primarily through direct mechanisms rather than through behavioral delay. In other words, students may go to bed at their intended time but continue engaging with their smartphones in bed, thereby increasing physiological arousal, cognitive stimulation, and exposure to light, all of which delay sleep onset.

This interpretation aligns with emerging research emphasizing in-bed smartphone use as a critical determinant of sleep disruption (Magalhães et al., 2020; Cemei et al., 2024). It also highlights the need to distinguish between bedtime delay and pre-sleep engagement, as these represent conceptually distinct pathways affecting sleep.

- **Practical Implications**

The findings have several practical implications for student well-being and intervention design. First, interventions aimed at improving sleep should not focus solely on encouraging earlier bedtimes but should also address smartphone use during the pre-sleep period. Strategies such as digital curfews, blue-light reduction, and behavioural self-regulation techniques may be particularly beneficial (Cain & Gradisar, 2010; Exelmans & Van den Bulck, 2016).

Second, awareness programs in academic institutions can emphasize the impact of late-night smartphone use on sleep health, even when students do not perceive their behaviour as problematic. Given the high prevalence of smartphone use in student populations, even small improvements in sleep habits may have meaningful cumulative effects on academic performance, mental health, and overall well-being (Owens, 2014; Lee et al., 2020).

- **Limitations and Future Directions**

Several limitations of the study should be acknowledged. First, the cross-sectional design limits the ability to draw causal inferences. Future longitudinal or experimental studies are needed to establish temporal relationships among variables. Second, all measures were based on self-report, which may be subject to recall bias or social desirability effects. The inclusion of objective sleep measures, such as actigraphy, would strengthen future research.

Third, the study focused on a specific student population in Bengaluru, which may limit generalizability to other contexts. Future studies could examine diverse populations and incorporate additional variables such as stress, anxiety, fear of missing out, and sleep hygiene behaviours to better understand the mechanisms underlying sleep disruption.

Finally, although mediation was not supported in the present study, future research using larger samples and bootstrapped mediation models may reveal more nuanced indirect effects or identify alternative mediators.

6. CONCLUSION

In conclusion, the present study demonstrates that smartphone addiction is directly associated with delayed sleep onset latency among undergraduate students. However, bedtime procrastination does not appear to function as a mediating mechanism in this relationship. These findings suggest that the impact of smartphone use on sleep may be driven more by physiological and cognitive activation during pre-sleep periods than by behavioural delay in bedtime. The study contributes to the growing literature on digital behaviour and sleep by highlighting the importance of examining distinct pathways through which technology use affects sleep health.

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