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A cross-sectional assessment of smartphone addiction and sleep quality among medical undergraduates

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Abstract: *Introduction:* Smartphone usage among medical students is on the rise due to their vast academic commitment subsequently leading to smart phone addiction. Global studies have demonstrated that smartphone addiction is associated with poor sleep quality. However, regional studies in Eastern India are limited using standardized tools like the Smartphone Addiction Scale – Short Version (SAS-SV) and Pittsburgh Sleep Quality Index (PSQI) together which is used in the present study to unveil the association between smart phone addiction and sleep quality among Indian medical undergraduates. *Aim and Objectives:* To determine the prevalence of smart phone addiction and relationship between smartphone addiction and sleep quality among medical undergraduates. *Materials and Methods:* A cross-sectional observational study was conducted among 205 first and second year undergraduate medical students in a tertiary care hospital Kolkata using Smartphone Addiction Scale–Short Version (SAS-SV)**,** a validated 10-item instrument and Pittsburgh Sleep Quality Index (PSQI)**,** a standardized questionnaire consisting of 19 items assessing sleep quality over the preceding one month across seven components. Data was entered and analysed using IBM SPSS Statistics for Windows, version 26.0. *Results:* A total of 205 students were included in the present study. The mean global PSQI score was 5.51 ± 2.93, and the mean SAS-SV score was 31.15 ± 9.71. Based on SAS-SV cut-offs, 48.3% were classified as smartphone addicted and 51.7% as non-addicted. In multivariable linear analyses, smartphone addiction status showed a significant association with moderate to large effect sizes with global PSQI score ($F = 20.22$, $p < 0.001$, partial $\eta^2 = 0.094$). *Conclusion:* Nearly half of the participants were classified as smartphone-addicted and disturbed sleep is common in this age group, reflecting academic demands, irregular schedules, and lifestyle factors. Females showed higher sleep latency scores and higher daytime dysfunction scores than males.

Keywords: Smart phone addiction, Sleep Quality, Medical Undergraduate, Pittsburgh Sleep Quality Index (PSQI).

Introduction

Since their introduction in the late 2000s, smartphones have become an integral part of daily life, particularly among medical students. Following the COVID-19 pandemic, smartphone use has increased further in this group, with several studies reporting higher levels of smartphone addiction among medical undergraduates compared with non-medical students [1-2]. While smartphones are crucial for today's competitive academic environment and irregular schedules of medical training may increase vulnerability to the adverse effects of excessive smartphone use, including its impact on sleep [3]. Smartphone addiction worsens sleep mainly by delaying bedtime and increasing sleep latency through excessive night-time use, which shortens total sleep duration and disrupts normal sleep routines [4-5].

Screen exposure and emotionally engaging content near bedtime increase mental and physiological arousal, making it harder to fall asleep and reducing sleep efficiency [5-6]. Repeated use while in bed, notifications, and night-time checking disturb sleep and further impair habitual sleep efficiency and subjective sleep quality [6-7]. Psychological factors such as anxiety, craving, stress, depression, and loneliness act as key mediators, keeping the mind active at bedtime and increasing sleep disturbances [8-10]. Poor sleep then leads to daytime dysfunction and fatigue, reinforcing dependence on smartphones and creating a self-perpetuating cycle of poor sleep and addictive use [11-12].

Several studies report a significant relationship between smartphone addiction and poor sleep quality. A study in Uttarakhand found a mean Pittsburgh Sleep Quality Index (PSQI) score of 6.3, with over 65% of medical students classified as poor sleepers [13]. In South India, excessive smartphone usage among medical students was significantly associated with poor overall sleep quality [14]. Global studies have demonstrated that smartphone addiction is associated not only with poor sleep parameters such as increased sleep latency, reduced duration, and decreased quality but also with higher stress levels and lower satisfaction with life [15-16].

However, regional studies from Eastern India remain limited, particularly those simultaneously evaluating global and component-wise sleep quality domains using validated instruments such as the Smartphone Addiction Scale-Short Version (SAS-SV) and Pittsburgh Sleep Quality Index (PSQI). In addition, associations with residence status and academic year have not been adequately explored in this population.

This study, on undergraduate medical students in a medical college in Kolkata, determines the relationship between smartphone addiction and usage patterns and sleep quality; while incorporating academic year and residence (Hostelites vs. day scholar), areas not thoroughly explored in previous studies. We will also analyze all seven components of sleep evaluated by PSQI.

Objectives:

1. To estimate the mean sleep quality global and component scores among medical undergraduates using the Pittsburgh Sleep Quality Index (PSQI) questionnaire.
2. To determine the prevalence of smartphone usage immediately before sleep, after waking up and when unable to sleep, subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, daytime dysfunction and poor sleep quality and number of devices owned by medical undergraduates.
3. To determine the association between PSQI global and component scores and smartphone addiction, sex, residence status, professional year, and smartphone usage immediately before sleep, after waking up and when unable to sleep.
4. To determine the correlation between smartphone addiction and PSQI global and component scores.

Material and Methods

Study Design and Setting: This was a cross-sectional observational study conducted at Nil Ratan Sircar Medical College and Hospital, Kolkata, a government tertiary-care teaching institution.

Study Population: The study population comprised first and second year MBBS undergraduate students enrolled at a government medical college in Kolkata during the study period.

Eligibility Criteria: Students who were willing to participate and provided informed consent were included in the study. Students with a previously diagnosed sleep disorder or those currently using sedative or sleep-altering medications were excluded.

Sampling: The sample size was calculated based on a previously reported mean Global Pittsburgh Sleep Quality Index (PSQI) score of 6.3 with a standard deviation of 3.2 [13]. Assuming a precision of 0.5, a 95% confidence level (Z = 1.96), and using the formula -

$$\mathbf{n} = \frac{z^2\sigma^2}{d^2}$$

the minimum required sample size was calculated as 157.4. Accordingly, a minimum sample size of 158 participants was considered adequate for the study.

We used a convenience sampling technique. After advertising via institutional WhatsApp groups and using the selection criteria, a total of 205 students participated in the study.

Study Instruments: Data were collected using a structured, self-administered questionnaire comprising 33 items, which included the following components:

a) Participant Information Sheet and Informed Consent Form, detailing the purpose and procedures of the study.
b) General Information Section, used to collect demographic and academic details such as age, sex, academic year, and residence status (hostelite or day scholar).
c) Smartphone Addiction Scale–Short Version (SAS-SV), a validated 10-item instrument with responses recorded on a six-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). Smartphone addiction was defined using established cut-off scores of ≥31 for males and ≥33 for females [17].
d) Pittsburgh Sleep Quality Index (PSQI), a standardized questionnaire consisting of 19 items assessing sleep quality over the preceding one month across seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. A global PSQI score greater than 5 was used to indicate poor sleep quality [18].

Study Variables:

a) Outcome variables included sleep quality as assessed by the Pittsburgh Sleep Quality Index (PSQI), measured as:
   i) Global PSQI score, analysed both as a continuous composite score and categorised as good or poor sleeper using a cut-off score >5 [18].
   ii) Component-wise PSQI scores (C1–C7), analysed as raw scores variables and categorised using cut-offs ≥2 for classifying to be affected.
b) Exposure variable was
   i) Smartphone addiction, assessed using the Smartphone Addiction Scale–Short Version (SAS-SV), analysed as a continuous score and categorised based on established cut-off values. [17]
   ii) Sex (male/female),
   iii) Residence status (day scholar/hostelite),
   iv) Professional year (First Year / Second Year),
   v) Smartphone use behaviours (use before bedtime, on waking up, and when unable to sleep),
   vi) Number of electronic devices used (1/2/≥3).

Operational Definitions:

a) Poor sleep quality: Defined as a global PSQI > 5
b) PSQI component scores: subjective sleep quality (C1), sleep latency (C2), sleep duration (C3), habitual sleep efficiency (C4), sleep disturbances (C5), use of sleep medication (C6), and daytime dysfunction (C7) each scored from 0 to 3, with higher scores indicating poorer sleep in that domain.
c) Smartphone addiction: Smartphone Addiction Score – Short Version (SAS-SV) score >31 in males and >33 in females [17].
d) Smartphone use before bedtime: Self-reported use of a smartphone immediately prior to sleep.
e) Smartphone use on waking up: Self-reported smartphone use immediately after waking from sleep.
f) Smartphone use when unable to sleep: Self-reported smartphone use during periods of nocturnal wakefulness.
g) Residence status: Classified as day scholar if the participant resided at home and commuted daily, and hostelite if residing in college hostel.
h) Professional year: Categorised according to year of undergraduate medical training at the time of data collection.

Data Collection Procedure: Eligible students were invited to participate voluntarily. After obtaining informed consent, data were collected using the self-administered questionnaire, which was distributed electronically through Google Forms. Participants completed the questionnaire independently.

Statistical Analysis: Data were entered and analysed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables, including global and component PSQI scores, were summarised as mean with standard deviation

(SD). Categorical variables, including PSQI cut-off categories, smartphone addiction status, sex, residence status, and professional year, were expressed as frequencies and percentages. For categorical analyses, global PSQI scores and individual component scores were dichotomised using established cut-off values.

Multivariable linear analyses were performed to assess adjusted associations between global PSQI score and study variables including smartphone addiction status, sex, residence status, professional year, smartphone use behaviours, and number of devices used. Since the global PSQI represents a composite summed score, it was analysed as an approximately continuous variable. Adjusted linear analyses with reporting of F statistics and partial η^2 values were used to allow simultaneous assessment of statistical significance and practical relevance of associations across multiple predictors. Because PSQI component scores are ordinal and demonstrated skewed distributions, non-parametric methods were preferred for group-wise comparisons, and Mann–Whitney U tests were used to compare median scores.

Spearman's correlation coefficient was used to assess correlations between SAS-SV scores and global as well as each component PSQI scores. All statistical tests were two-tailed, and a *p*-value <0.05 was considered statistically significant. Effect sizes were interpreted using partial η^2 values, with larger values indicating greater practical relevance of observed associations.

Ethical Considerations: Approval for the study was obtained from the Institutional Ethics Committee of Nil Ratan Sircar Medical College, Kolkata, prior to commencement of data collection [NRSMC/IEC/]. Participation was voluntary, and informed consent was obtained from all participants. Data confidentiality was maintained throughout the study, and the collected information was used solely for academic and research purposes.

Results

A total of 205 students were included. The mean global PSQI score was 5.51 ± 2.93, and the mean SAS-SV score was 31.15 ± 9.71. Component-wise PSQI means ranged from 0.11 ± 0.42 (use of sleep medication) to 1.46 ± 0.83 (sleep duration) (Table 1).

Table-1: Descriptive statistics of continuous study variables (N = 205)

Variable	Mean ± SD
PSQI C1 – Subjective Sleep Quality	1.12 ± 0.67
PSQI C2 – Sleep Latency	0.66 ± 0.79
PSQI C3 – Sleep Duration	1.46 ± 0.83
PSQI C4 – Sleep Efficiency	0.65 ± 1.05
PSQI C5 – Sleep Disturbances	0.45 ± 0.57
PSQI C6 – Use of Sleep Medication	0.11 ± 0.42
PSQI C7 – Daytime Dysfunction	1.07 ± 0.84
Global PSQI Score	5.51 ± 2.93
SAS-SV Score	31.15 ± 9.71

Footnote: Values expressed as mean ± standard deviation.

Based on SAS-SV cut-offs, 99 participants (48.3%) were classified as smartphone-addicted and 106 (51.7%) as non-addicted. The sample included 123 males (60.0%) and 82 females (40.0%). Day scholars comprised 111 (54.1%) participants and hostel residents 94 (45.9%). Using a global PSQI cut-off >5, 119 participants (58.0%) were classified as poor sleepers. Component-wise categorical distributions are shown in Table 2.

In multivariable linear analyses, smartphone addiction status showed a significant association with moderate to large effect sizes with global PSQI score ($F = 20.22$, $p < 0.001$, partial $\eta^2 = 0.094$). At the component level, smartphone addiction status showed significant associations with habitual sleep efficiency (C4: $F = 12.73$, $p < 0.001$, partial $\eta^2 = 0.062$) and daytime dysfunction (C7: $F = 22.58$, $p < 0.001$, partial $\eta^2 = 0.104$). No significant associations were observed with subjective sleep quality (C1), sleep latency (C2), sleep disturbances (C5), or use of sleep medication (C6) (Table 3). A statistically significant but small effect size association was observed for sleep duration (C3: $F = 4.28$, $p = 0.040$, partial $\eta^2 = 0.022$).

Table-2: Distribution of study characteristics, sleep quality categories, and smartphone use behaviours among participants (N = 205)		
Variable	**Category**	**n (%)**
Smartphone addiction status (SAS-SV)	Non-addicted	106 (51.7)
	Addicted	99 (48.3)
Sex	Male	123 (60.0)
	Female	82 (40.0)
Residence status	Day scholar	111 (54.1)
	Hostelite	94 (45.9)
Professional year	Year 1	147 (71.7)
	Year 2	58 (28.3)
Global PSQI category (cut-off >5)	Good sleeper (≤5)	86 (42.0)
	Poor sleeper (>5)	119 (58.0)
PSQI components (cut-off ≥2)	C1 – Subjective sleep quality (affected)	47 (22.9)
	C2 – Sleep latency (affected)	33 (16.1)
	C3 – Sleep duration (affected)	81 (39.5)
	C4 – Sleep efficiency (affected)	40 (19.5)
	C5 – Sleep disturbances (affected)	8 (3.9)
	C6 – Use of sleep medication (affected)	6 (2.9)
	C7 – Daytime dysfunction (affected)	51 (24.9)
Smartphone use behaviours	Smartphone use before bedtime	153 (74.6)
	Smartphone use on waking up	100 (48.8)
	Smartphone use when unable to sleep	99 (48.3)
Number of devices used	1 device	62 (30.2)
	2 devices	102 (49.8)
	≥3 devices	41 (20.0)

Table-3: Multivariable linear analyses for global and component-wise PSQI scores												
	Global PSQI			**C1**			**C2**			**C3**		
Source	**F**	**p**	**Partial η^2**	**F**	**p**	**Partial η^2**	**F**	**p**	**Partial η^2**	**F**	**p**	**Partial η^2**
Smartphone Addiction Status	**20.22**	**<.001**	**.094**	1.25	.265	.006	2.36	.126	.012	**4.28**	**.040**	.022
Professional year	2.11	.148	.011	2.55	.112	.013	0.31	.578	.002	3.43	.066	.017
Residence	0.03	.860	.000	0.44	.507	.002	0.13	.715	.001	1.13	.290	.006
Sex	**11.60**	**.001**	**.056**	**5.47**	**.020**	.027	**15.14**	**<.001**	**.072**	3.29	.071	.017
Devices	0.49	.691	.007	0.83	.479	.013	1.02	.384	.016	**3.38**	**.019**	.050
Smartphone use before bed	0.00	.964	.000	1.89	.171	.010	1.21	.273	.006	1.08	.299	.006
Smartphone use on waking	0.29	.591	.001	0.33	.567	.002	0.05	.829	.000	0.00	.952	.000
Smartphone use when unable to sleep	1.06	.306	.005	1.16	.282	.006	**8.81**	**.003**	.043	2.80	.096	.014

Table-3: Multivariable linear analyses for global and component-wise PSQI scores												
	C4			C5			C6			C7		
Source	F	p	Partial η^2	F	p	Partial η^2	F	p	Partial η^2	F	p	Partial η^2
Smartphone Addiction Status	**12.73**	**<.001**	**.062**	1.63	.203	.008	2.47	.118	.013	**22.58**	**<.001**	**.104**
Professional year	0.01	.929	.000	1.10	.296	.006	0.88	.350	.005	**5.13**	**.025**	.026
Residence	1.33	.250	.007	1.31	.254	.007	0.58	.447	.003	1.22	.271	.006
Sex	0.17	.682	.001	0.16	.686	.001	0.07	.790	.000	**14.02**	**<.001**	**.067**
Devices	1.42	.239	.021	1.54	.205	.023	1.03	.380	.016	0.81	.491	.012
Smartphone use before bed	2.09	.150	.011	1.98	.161	.010	0.05	.819	.000	0.16	.688	.001
Smartphone use on waking	0.02	.888	.000	0.47	.494	.002	1.00	.318	.005	3.79	.053	.019
Smartphone use when unable to sleep	0.16	.687	.001	**8.01**	**.005**	.040	1.10	.296	.006	0.20	.659	.001

Sex was significantly associated with a small effect size with global PSQI score ($F = 11.60$, $p = 0.001$, partial $\eta^2 = 0.056$) and a moderate to large effect size with sleep latency (C2: $F = 15.14$, $p < 0.001$, partial $\eta^2 = 0.072$) and daytime dysfunction (C7: $F = 14.02$, $p < 0.001$, partial $\eta^2 = 0.067$). Professional year showed an association, though small effect size with daytime dysfunction (C7: $F = 5.13$, $p = 0.025$, partial $\eta^2 = 0.026$). Residence status was not associated with global or component PSQI scores.

Number of devices owned was associated with sleep duration but effect size obtained was small (C3: $F = 3.38$, $p = 0.019$, partial $\eta^2 = 0.050$). Smartphone use when unable to sleep was associated but with small effect sizes with sleep latency (C2: $F = 8.81$, $p = 0.003$, partial $\eta^2 = 0.043$) and sleep disturbances (C5: $F = 8.01$, $p = 0.005$, partial $\eta^2 = 0.040$). No significant associations were observed for number of devices used or other smartphone use behaviours (Table 3).

By Mann–Whitney U tests as in Table 4, smartphone-addicted students had higher global PSQI scores compared with non-addicted students (median [IQR]: 6 [4] vs 4 [3]; $U = 3331.5$, $p < 0.001$). Habitual sleep efficiency scores (C4) differed between addicted and non-addicted students (median [IQR]: 0 [2] vs 0 [0]; $U = 3911.0$, $p < 0.001$). Daytime dysfunction scores (C7) showed same medians but statistically significant differences due to ordinal nature of data (median [IQR]: 1 [1] vs 1 [1]; $U = 3244.5$, $p < 0.001$) (Table 4). Sex-wise comparisons showed differences in sleep latency (C2) (median [IQR]: females 1 [2] vs males 0 [1]; $U=3708.0$, $p< 0.001$) and daytime dysfunction (C7) (median [IQR]: females 1 [1] vs males 1 [1]; $U = 4078.5$, $p = 0.012$).

SAS-SV scores showed a significant correlation with global PSQI scores ($\rho = 0.381$, $p < 0.001$). At the component level, significant correlations were observed with daytime dysfunction (C7: $\rho = 0.421$, $p < 0.001$) and habitual sleep efficiency (C4: $\rho = 0.265$, $p < 0.001$). Statistically significant but weak correlations were also observed with subjective sleep quality (C1), sleep latency (C2), and sleep disturbances (C5). No significant correlations were observed with sleep duration (C3) or use of sleep medication (C6) (Table 5).

Table-4: Mann–Whitney U comparison of PSQI scores for selected exposure - outcome pairs					
Exposure	**Outcome**	**Group**	**Median (IQR)**	**U statistic**	**p-value**
Smartphone addiction status	Global PSQI	Non-addicted	4 (3)	3331.5	<0.001
		Addicted	6 (4)		
	C4 – Habitual sleep efficiency	Non-addicted	0 (0)	3911.0	<0.001
		Addicted	0 (2)		
	C7 – Daytime dysfunction	Non-addicted	1 (1)	3244.5	<0.001
		Addicted	1 (1)		
Sex	C2 – Sleep latency	Male	0 (1)	3708.0	<0.001
		Female	1 (2)		
	C7 – Daytime dysfunction	Male	1 (1)	4078.5	0.012
		Female	1 (1)		

Table-5: Spearman's correlation of Pittsburgh Sleep Quality Index (PSQI) global and component scores with Smartphone Addiction Scale–Short Version (SAS-SV) scores (N = 205)		
PSQI Variable	**Spearman's ρ**	**p value**
Global PSQI score	0.381	<0.001
Subjective sleep quality (C1)	0.220	0.001
Sleep latency (C2)	0.240	0.001
Sleep duration (C3)	0.112	0.110
Habitual sleep efficiency (C4)	0.265	<0.001
Sleep disturbances (C5)	0.163	0.019
Use of sleep medication (C6)	0.135	0.054
Daytime dysfunction (C7)	0.421	<0.001

Discussion

Overall, the analyses showed that sleep quality among medical undergraduates varied widely, with a high burden of poor sleep reflected in both global and component PSQI scores (Tables 1 and 2). Smartphone addiction status was associated with differences in global PSQI score, habitual sleep efficiency, and daytime dysfunction, while sex was associated with differences in sleep latency and daytime dysfunction (Tables 3 and 4). Correlation analysis further demonstrated that higher smartphone addiction scores were accompanied by higher global PSQI scores and changes in specific sleep domains (Table 5).

In the present study, as in Table 1, the mean global PSQI score was above the threshold for good sleep, with similar values being reported from studies across various regions of India in similar populations [13-14, 19-20]. These findings suggest that disturbed sleep is common in this age group, reflecting academic demands, irregular schedules, and lifestyle factors. Nearly half of the participants were classified as smartphone-addicted similar to results by Zeerak et. al [21]. A large proportion reported smartphone usage before bedtime, on waking up, or when unable to sleep (Table 2). The prevalence of poor sleep quality observed in this study is comparable to reports from similar prior studies, where smartphone use around sleep time is highly prevalent and poor sleep quality exceeds 50% [22-23].

Using multivariable linear analyses and non-parametric tests (Tables 3 and 4), statistically significant and practically meaningful associations were observed between smartphone addiction status and global PSQI, habitual sleep efficiency (C4), and daytime dysfunction (C7), as well as between sex and sleep latency (C2) and daytime dysfunction (C7). Smartphone-addicted students had higher global PSQI scores consistent with previous studies [24]. For component scores, higher scores of habitual sleep efficiency and daytime dysfunction were seen compared with non-addicted students. With respect to sex, females showed higher sleep latency scores and higher daytime dysfunction scores than males as also shown by Nair et. al [25], while medians for some components were similar across groups, indicating differences in score distributions rather than central tendency possible due to ordinal nature of data.

In Table 3, Number of devices owned showed a significant association with sleep duration (C3), while smartphone use when unable to sleep was associated with sleep latency (C2) and sleep disturbances (C5); however, the observed effect sizes were small. An earlier study in a similar population reported an association between hostel residence and poor sleep quality in unadjusted analyses alongside multiple lifestyle and stress-related factors, whereas residence status was not associated with PSQI scores after adjustment using multivariable linear analyses in the present study [26].

A statistically significant association between smartphone use when unable to sleep and poorer sleep latency (C2) and sleep disturbances (C5) was observed, consistent with findings from earlier studies [27]. Given the small effect sizes observed, these findings indicate that smartphone addiction may be more important in determining sleep quality than individual smartphone use patterns. Also, these findings indicate that sleep quality in medical students is influenced by multiple inter-related factors rather than a single exposure.

Smartphone addiction scores showed a significant positive correlation with global PSQI scores and with selected sleep components, particularly to sleep efficiency and daytime dysfunction (Table 5). The pattern of these correlations is consistent with earlier studies reporting positive correlations between smartphone addiction scales and global PSQI scores in student populations [28]. These findings support the view that increasing smartphone addiction severity is accompanied by worsening overall sleep quality and next-day functioning.

Strengths and Limitations: This study provides a detailed assessment of sleep quality and smartphone use among medical undergraduates using both global and component-wise sleep analysis via PSQI Questionnaire. Adjustment for key demographic, smartphone usage patterns, and academic variables was performed using multivariable linear analyses alongside non-parametric tests and correlation analyses to strengthen interpretation of the findings. However, although the global PSQI score was analysed as an approximately continuous composite measure, individual PSQI component scores are ordinal in nature and findings from component-wise adjusted analyses should therefore be interpreted cautiously.

Reporting effect sizes allowed assessment of the practical relevance of statistically significant associations, particularly for variables showing small but statistically significant effects. However, the cross-sectional design limits causal inference, and reliance on self-reported measures may introduce recall or reporting bias. The study was conducted in a single institution and focussed only on first- and second-year students, which may limit generalisability to other settings. In addition, objective measures of sleep and smartphone use were not included, and residual confounding cannot be excluded.

Conclusion

Smartphone addiction was associated with poorer overall sleep quality, reduced sleep efficiency, and greater daytime dysfunction among medical undergraduates. Compared with individual smartphone usage patterns, smartphone addiction showed more consistent associations with sleep outcomes. In addition, female students demonstrated higher sleep latency and greater daytime dysfunction, highlighting the relevance of sex differences in sleep quality within this population.

Recommendations: Medical colleges should consider incorporating sleep health education and awareness of responsible smartphone use into student support programmes. Interventions targeting reduced smartphone use around bedtime, especially among students reporting higher addiction scores, may help improve sleep quality and daytime functioning. Future research should use longitudinal designs, include students across all years and objective measures of sleep and smartphone use to better understand temporal relationships and inform targeted interventions.

AI Declaration: AI-assisted tools were used only for language refinement and formatting support. No AI tool was used for data analysis, interpretation, or generation of results.

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