ORIGINAL RESEARCH ARTICLE

Restriction of Mobile Phone Usage at Bed Time: Effect on Sleep Quality, Mood and Cognitive Function

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ABSTRACT

Introduction: Mobile phones are integral to modern life, but excessive use, particularly at night, can lead to disrupt well-being. Limiting mobile phone use before bedtime may improve individual well-being. This study aimed to evaluate whether restricting mobile phone use at bedtime enhances sleep quality, mood, and cognitive function.

Methodology: Undergraduate students from a selected engineering college were assessed for bedtime mobile phone use. Sixty-eight students were chosen via simple random sampling. A self-reported questionnaire including the Pittsburgh Sleep Quality Index, Positive and Negative Affect Scale, and Montreal Cognitive Assessment Scale evaluated sleep quality, mood, and cognitive function before implementing restrictions. The "Lock My Phone" app was used to enforce these restrictions. Post-intervention assessments were conducted on the 15th and 30th days.

Results: Before the intervention, all students reported poor sleep quality, 80.8% had reduced positive affect, 91.1% experienced high negative affect, and only 23.5% had normal cognitive function. Significant improvements were observed in sleep quality, mood, and cognitive function post-restriction ($p<0.001$).

Conclusion: Restricting mobile phone use before bedtime significantly improved sleep quality, mood, and cognitive function among undergraduate students.

Keywords: Bedtime mobile phone use, Cognitive function, Mood, Restriction of mobile phone, Lock my phone app, Sleep quality

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INTRODUCTION

India, the world's second most populous country, surpassed the United States in smartphone users in 2017.[1] Mobile phone usage and cellular subscribers have significantly increased during the COVID-19 pandemic due to global lockdowns, which impeded face-to-face communication, leading to increased daytime and nighttime mobile phone use for networking.[2]

By 2023, the number of smartphone users in India exceeded to one billion, with projections suggesting to reach 1.55 billion by 2040.[3] In the era of tech embedded digitalization, a person is deemed to be digitally disabled in the absence of mobile phone.

The primary users of smartphone are students who go for higher education in colleges. In India, 55% of smart phone users belong to the age of 18-24years[3] and reported undesirable or disruptive behaviours in children and young adults.[4] In recent years, mobile phones and electronic gadgets have consumed much of a person's sleep time. Sleep loss causes neurons to behave improperly, impacting behavior and performance in daily activities.[5] Mainly, the displacement of sleep, heightened physiological arousal and bright emission of light decreases the melatonin, a physiological marker for induction of sleep[6] affects the sleep quality resulting in altered grey matter volume and white matter integrity[7]. Thus, the digital device disrupts the internal self-regulation mechanism of the humans.[8]

The shift from 4G to 5G network connectivity, generated a significant excitement among college students. The technological capabilities of mobile phones offer an engaging and novel way to externalize information.[9] A recent study, reported that the mobile phone has become a necessity for living a life that is close to virtual reality of all ages.[10,11] A study among university students reported mobile addiction (21.49%), interpersonal sensitivity (18.80%)[12], sleep issue and depressive symptoms[13].

Evidences showed that longer duration of media usage led to sleep problem in students[14] and moderate to severe stress[15], impacted brain function and increased the cortical excitability which linked with sleep disruption and foster reaction time[16].

The literature exhibits numerous isolated studies focusing solely on one or two variables and identified the gap of studying more than two variables. Stakeholders encountered challenges in managing multiple entrenched behaviours associated with excessive mobile phone use at bedtime.

Therefore, the researcher aims to investigate the impact of restricted mobile phone usage at bedtime on sleep quality, mood, and cognitive function in undergraduate students and to identify the factors affecting sleep quality, mood and cognition.

METHODOLOGY

This study was conducted from November 2021 to December 2021. Ethical clearance for the study was obtained from the Institutional Ethical Clearance Committee of Vinayaka Mission's College of Nursing, Puducherry (VMCN PDY/IEC 2021/ 047) and registered under clinical trial registry of India http://www.ctri.nic.in/(Reg no: CTRI/2021/10/037649). The study adopted quasi experiment with one group pre and post-test design. An Engineering College in Puducherry was chosen for the study and formal permission was obtained from the institution. Study participants were explained about the procedure using participant information sheet including confidentiality, risks and benefits and written consent was obtained from them before enrolment in the study.

The undergraduate students who use mobile phone during bedtime (>30 mins), severe for Bedtime Mobile Phone Users and in the age group of 18-23 years were included to participate. The students with two mobiles and affected with medical condition and with sleeping pills were excluded.

The estimated sample size for the present study was 62 based on the findings of Wen He J[17], considering the attrition rate of 10%, the final sample size was computed as 68. It was calculated using following formula: $n = \frac{(\sigma_1{}^1+\sigma_2{}^2)^2(Z_{1-\beta}+Z_{1-\alpha/2})^2}{d^2}$

Initially 314 students from the selected college were screened for severity of Bedtime Mobile Phone Usage using Bedtime Mobile Phone Use scale (BMPU) which was originally developed by **Liese Exelmans**[18]. The scale was used with author's permission. It was a 5-point likert scale with 6 items. The options in the scale were Never= 1, One to three times a month=2, Once a week= 3, Several times a week= 4, Everyday= 5 and the score ranges from 1-30. The score 1- 6 was interpreted as normal mobile use, 7 -18 as moderate for Bed time mobile phone use and 19 – 30 as severe for bedtime mobile phone use. Out of 314 students, 33 were normal mobile user, 148 as moderate mobile user and 133 were severe mobile user.

A total of 68 students were recruited from 133 students, using simple random sampling technique (lottery method). This study used self-report questionnaire with four sections. Section – A contains the demographic variables, Section – B included Pittsburgh Sleep Quality Index Scale to determine the Sleep quality. This scale was originally developed by University of Pittsburgh.[19] The scale consists of 19 items and divided into seven component: subjective sleep quality (3items), sleep latency (3 items), sleep duration (3 items), habitual sleep efficiency (3 items), sleep disturbances, use of sleep medication (3 items), and daytime dysfunction (3 items) with total score of 21 and the score above 5 indicates bad sleep. Section – C on Positive Affect and Negative Affect

Scale which was originally developed by Watson,et al.,[20] . This scale assesses the mood of an individual. It was a 5 Point Likert Scale with 20 items, where question no. 1,3,5,9,10,12,14,16,17 & 19 were meant for positive affect with mean Score 33.3 (SD±7.2). Similarly question no. 2,4,6,7,8,11,13,15,18 & 20 measure the negative affect with mean Score 17.4 (SD ± 6.2). The categories in the scale were Very slightly or not at all =1, A little = 2, Moderately = 3, Quite a bit = 4, Extremely = 5. Section D comprises of Montreal Cognitive Assessment Scale which was developed by Ziad Nasred dine MD[21]**.** This scale has with 7 components: Visuo-spatial, Naming, Memory, Attention, Language, Abstraction and Orientation. The total score was 30 and the score 26 and above was considered as normal cognitive function. The validity of the questionnaire was obtained from the domain experts. The reliability of the questionnaire was checked using Cronbach's alpha. The r value for Bedtime Mobile Phone Use scale was 0.893, Pittsburgh Sleep Quality Index was 0.874, Positive and Negative Affect scale was 0.917 and Montreal Cognitive Assessment scale was 0.757.

Before the implementation of intervention, baseline data was collected from the study participants using the self-report questionnaire. Awareness session about hidden dangers of mobile phone usage at bedtime was conducted. Followed with study participants were instructed not to use their phones for 30 minutes before their typical bedtime. Also demonstrated the LOCK MY PHONE app facilities. The participants were instructed to download the app from the Google Play store and set the phone lock period time for every night as 9 pm - 5 am. The adherence for lock was verified by the investigator every day. As a result, during the designated lock period, the participants' mobile screens were off and couldn't be used for any apps, and automatically the screen gets "ON" in the next day morning. As remainder to act, the participants were sent with "Switch off" SMS, 10 minutes prior to the lock time. Further, they were called to ensure that their mobiles were turned off. At the 15th and 30th day from the pre-test, post-test was conducted. The collected data was compiled in data sheet and analysed using SPSS 28.

Categorical variables were analysed using the frequency and percentages. Continuous variables are analysed using mean and Standard Deviation. Repeated Measures ANOVA was used to compare effectiveness of sleep quality, mood and cognitive function at different point of time. Kruskal Wallis test was used to associate the findings with the selected demographic variables as the data is non-randomly distributed. Karl Pearson's correlation test was performed to correlate the variables.

RESULTS

Out of 68 participants, the majority of them were in the age of 20 years (n=34, 50%), most of them (n= 44, 64.7%) were males, with regard to year of study, (n=33, 48.5%) most of them were in third year of undergraduate collegiate program, Majority, 67 (98.5%) of them were day scholars, none of them reported to have history of co-morbid illness.

Table 1: Distribution of demographic variables

Demographic variables (N = 68)	Participants (%)
Age in years	
18	04(5.9)
19	22(32.4)
20	34(50.0)
21	08(11.8)
Sex	
Male	44(64.7)
Female	24(35.3)
Year of study	
Second year	20(29.4)
Third year	33(48.5)
Fourth year	15(22.1)
Residence	
Hostel	1(1.5)
Day scholar	67(98.5)
Routine time to bed	
9-10pm	3(4.4)
10-11pm	14(20.6)
above 11pm	51(75.0)
Average hours spent on mobile phone at bedtime	
<30mins	3(4.4)
30 mins	4(5.9)
>30mins	61(89.7)
Consumption of tea/coffee	
Once in a day	40(58.8)
Twice a day	25(36.8)
Three times a day	1(1.5)
More than three times a day	2(2.9)
Comfortable measures	
Blanket	19(27.9)
Extra pillows	25(36.8)
Evening bath	8(11.8)
None	16(23.5)
Habit of day time sleeping	
Yes	28(41.2)
No	40(58.8)

Table 2: Distribution of sleep quality, mood and cognitive function

Variable	Subdivision	Pre intervention (%)	Post intervention – I (%)	Post intervention – II (%)
Sleep quality	Good	0 (0)	0 (0)	6 (8.8)
	Bad	68 (100)	68 (100)	62 (91.2)
Positive affect	Higher	13 (19.14)	18 (26.4)	20 (29.4)
	Lower	55 (80.8)	50 (73.5)	48 (70.5)
Negative affect	Higher	6 (8.8)	3 (4.4)	1 (1.4)
	Lower	62 (91.1)	65 (95.5)	67 (98.5)
Cognitive function	Impaired	52 (76.5)	43 (63.2)	35 (51.5)
	Normal	16 (23.5)	25 (36.8)	33 (48.5)

Table 3. Restriction of mobile phone usage at bedtime on Sleep quality, Positive affect, Negative affect, Cognitive function

Variables	Score (Mean ± SD)	P-value	Post – hoc analysis		
			Pairwise Comparison	Mean Difference ± SE	P-value
Sleep					
Pre test	10.4 ± 2.18	<0.001	Pre Vs Post – I	0.721 ± 0.113	<0.001
Post-test– I	9.68 ± 2.01		Pre Vs Post - II	3.441 ± 0.262	<0.001
Post-test – II	6.96 ± 1.27		Post – I Vs Post - II	2.721 ± 0.232	<0.001
Positive Affect					
Pre test	28.43 ± 5.72	<0.001	Pre Vs Post – I	-1.118 ± 0.228	<0.001
Post-test – I	29.54 ± 5.23		Pre Vs Post - II	-1.794 ± 0.285	<0.001
Post-test – II	30.22 ± 5.00		Post – I Vs Post - II	-0.676 ± 0.172	<0.001
Negative Affect					
Pre test	24.13 ± 6.11	<0.001	Pre Vs Post – I	0.676 ± 0.155	<0.001
Post-test – I	23.46 ± 5.63		Pre Vs Post - II	2.044 ± 0.324	<0.001
Post-test – II	22.09 ± 4.98		Post – I Vs Post - II	1.368 ± 0.243	<0.001
Cognitive function					
Pre test	22.63 ± 3.12	<0.001	Pre Vs Post – I	-1.471 ± 0.195	<0.001
Post-test – I	24.10 ± 2.47		Pre Vs Post - II	-2.779 ± 0.276	<0.001
Post-test – II	25.41 ± 2.05		Post – I Vs Post - II	-1.309 ± 0.213	<0.001

SD – Standard deviation; SE – Standard error

Table4. Association of sleep quality, mood and cognitive function

Demographic variables	Sleep quality		Positive affect		Negative affect		Cognitive function	
	Mean ± SD	p-value*	Mean ± SD	p-value*	Mean ± SD	p-value*	Mean ± SD	p-value*
Year of study								
Second year	10.30 ± 2.34	0.640	31.35 ± 6.37	**0.02***	24.05 ± 6.64	0.936	23.75 ± 2.92	0.1547
Third year	10.27 ± 2.34		26.42 ± 4.62		24.39 ± 5.93		22.00 ± 3.26	
Fourth year	10.80 ± 1.61		28.93 ± 5.55		23.67 ± 6.18		22.53 ± 2.85	
Routine time to bed								
9-10pm	10.67 ± 1.15	0.861	33.67 ± 6.51	0.312	20.67 ± 4.62	0.483	21.67 ± 4.62	0.5763
10-11pm	10.57 ± 2.53		28.36 ± 4.78		25.36 ± 7.33		23.14 ± 3.23	
Above 11pm	10.33 ± 2.15		28.14 ± 5.87		24.00 ± 5.84		22.55 ± 3.06	
Average hours spent on mobile phone at bedtime								
<30mins	11.67 ± 2.52	0.384	30.00 ± 1.73	0.457	24.00 ± 8.00	0.569	21.67 ± 3.79	0.6482
30 mins	09.25 ± 2.87		30.25 ± 2.22		21.00 ± 8.76		24.00 ± 4.40	
>30mins	10.41 ± 2.12		28.23 ± 5.98		24.34 ± 5.92		22.59 ± 3.05	
Consumption of tea/coffee								
Once in a day	10.23 ± 2.09	0.570	28.90 ± 4.95	0.298	23.22 ± 6.02	0.402	23.00 ± 2.91	**0.0442***
Twice a day	10.72 ± 2.37		28.36 ± 6.66		25.6 ± 6.28		22.60 ± 3.24	
Three times a day	12.00 ± -		20.00 ± -		20.00 ± -		19.00 ± -	
>three times a day	09.00 ± 1.41		24.00 ± 7.07		26.00 ± 5.66		17.50 ± 0.71	
Comfortable measures								
Blanket	10.05 ± 2.17	0.891	27.89 ± 5.89	0.744	25.63 ± 5.97	0.215	23.21 ± 2.82	0.1456
Extra pillows	10.60 ± 2.45		29.04 ± 5.24		22.08 ± 6.64		22.12 ± 3.33	
Evening bath	10.25 ± 2.12		28.63 ± 6.67		24.88 ± 6.40		24.38 ± 2.92	
None	10.56 ± 1.90		28.00 ± 6.21		25.19 ± 4.81		21.88 ± 3.03	
Habit of day time sleeping								
Yes	10.07 ± 2.24	0.245	28.29 ± 5.50	0.911	24.79 ± 6.11	0.508	22.57 ± 3.04	0.9999
No	10.62 ± 2.13		28.52 ± 5.93		23.67 ± 6.15		22.68 ± 3.22	

*KW test applied for statistical significance; KW – Kruskal Wallis Test; *p<0.05 level of significance

Nearly, 40(58.8%) of the undergraduate students drink tea/ coffee once in a day, notably none of them had the history of taking sleeping pill. The findings showed that 25 (36.8%) of them use extra pillows as comfort measure for their sleep and 08(11.8%) of them prefer to take bath in the evening as it promotes sleep. None of them reported to have habit of substance use (Table 1).

In this study, we assessed the level of sleep quality, mood and cognitive function. Out of 68 participants, 6 (8.8%) participants showed improved sleep quality from bad to good sleep-in post-test – II. Similarly, higher positive affect got increased and higher negative affect got decreased from post-test I to II. Also, there was a drop in the number of cognitive impaired participants and 33(48.5%) of them attained normal cognitive function in the post-test- II (Table 2).

The comparison of pre and post-test – I & II data was analysed by using ANOVA Repeated Measures test. The effect of restriction of mobile phone usage at bedtime on sleep quality shows a statistically significant changes in their sleep quality from Pre-test to

Post test – II (F = 146.131, p < 0.001). The effect of restriction of mobile phone usage at bedtime on mood found to be highly significant on their positive affect (F = 39.73, p<0.001) and negative affect (F = 39.921, p <0.001). Similarly, the effect of restriction of mobile phone usage at bedtime on cognitive function from Pre-test to Post test - II (F = 72.686, p< 0.001). The post – hoc analysis using pairwise comparison to determine the effect of restriction in different point of assessment showed statistically significant improvement in sleep quality, positive affect, negative affect and cognitive function from Pre-test to Post test – I (p <0.001) and from Post-test to Post test – II (p <0.001). This finding inferred that the restriction of mobile phone use at bed time was effective in promoting the Sleep quality, Mood and Cognitive function (Table 3).

Moreover, the study identified that the year of the study has significantly contributed to positive affect at p<0.05 level. The Consumption of tea/coffee once or twice in a day has been identified as a significant predictor for the cognitive function at p<0.05 level. (Table 4)

Table 5: Correlation of restriction of mobile phone usage at bedtime on sleep quality, mood and cognitive function

Variables	r value	p value
Negative affect Vs Positive affect	-0.252	**0.038***
Cognitive function Vs Positive affect	0.245	**0.044***
Cognitive function Vs Negative affect	0.067	0.585
Sleep quality Vs Positive affect	-0.023	0.850
Sleep quality Vs Negative affect	0.285	**0.018***
Sleep quality Vs Cognitive function	-0.051	0.682

*p<0.05 level of significance

In table 5, the correlation between the variables before the restriction of mobile phone at bedtime were analysed using Karl Pearson's coefficient test. It depicts a mild negative correlation between negative affect and positive affect (r = 0.245, p< 0.05) which means that the negative mood impacts the positive perception. Similarly, mild positive correlation was observed between cognitive function and positive affect (r = 0.245, p<0.05), infers that positive affect helps in better cognitive function. However, the poor sleep quality in the pre-test and negative affect showed mild positive correlation (r = 0.285, p<0.05) shows that the sleep quality impacts one's mood. Thus, the triad sleep quality, mood and the cognitive function are highly interlinked to each other.

DISCUSSION

The mobile phone usage behaviour on bedtime impacts both physiological and psychological wellbeing. The present study assessed the impact of restricted mobile phone usage at bed time on sleep quality, mood and cognitive function using a one group pre and post-test design.

In the current study, we observed that all the students who used mobile phone at night time perceived bad sleep quality. Longer average screen time during bedtime and the sleeping period were associated with poor sleep quality, sleep efficiency and longer sleep onset latency reported by Christensen[22] and findings of few more studies were consistent with the present study, collectively highlighting the negative impact of screen exposure before bedtime. The blue light emitted by mobile phones interferes with melatonin production, disrupting the circadian rhythm and leading to poorer sleep outcomes.[23-26]

In addition, it was found that mobile usage at bedtime resulted in low level of their positive mood as like with other research studies.[27-30] The constant engagement with stimulating content on mobile phones can cause emotional arousal, making it harder for users to unwind and fall asleep, thus negatively affecting their mood. This is corroborated by the broader literature, which has documented the association between electronic media use before sleep and increased risks of mood disturbances and depressive symptoms.

The behaviour of bed time mobile phone use had not spared their cognition status as the present study identified cognitive impairment in these individuals. This finding is consistent with previous research showing that bedtime mobile phone usage negatively impacts cognitive performance.[31-34] Lack of sleep lead to brain fog and have trouble in concentration.[35] A study by Barr N identified a link between relying on smartphone and mental laziness leading to interference with one's analytical, logical thinking resulting in decreased intelligence.[9] Moreover, Ward AF reported significant reduction in cognitive capacity when smart phones are within their reach even if it was switched off.[36] The above findings implied that mobile phone usage during night affect sleep that in turn leads to decreased mood and impaired cognitive function.

Further participants were instructed about the ways to restrict the usage by lock my phone app. Adherence of the intervention for about 4 weeks resulted in improved sleep quality, increase in positive affect and decrease in negative affect and improved cognitive function. This was consistent with the result of a previous study which revealed that adolescence who restrict usage of mobile phone during bedtime had a significant increase in sleep. Further the study reported a significant difference in the between group post-test (p<0.01) and significant difference over time (p<0.01) for somatic and cognitive arousal.[17] The intervention like building awareness and setting limit that alter the pre bedtime mobile phone use by using screen on/off logger lite app appeared to be effective for total sleep time and mobile phone stop time.[37] In an intervention smartphones are secured in a locked cabinet over the weekend which reveals a contradictory finding that participants were negatively affected by the interaction and there was no significant difference between the intervention and

the outcome variables.[38] These mixed results suggest that the effectiveness of interventions may vary based on individual differences in mobile phone dependency and the context of the intervention.

The findings of this study highlight the critical need to address bedtime mobile phone usage habits to improve sleep quality, mood, and cognitive function. Future research should explore the long-term effects of restricted mobile phone usage and identify the most effective strategies for reducing bedtime mobile phone use across different populations. Investigating the underlying mechanisms through which mobile phone usage impacts psychological and physiological health could also lead to more targeted interventions.

Limitations

The present study acknowledges various limitations. Firstly, it's reliant on a relatively small sample size and specific setting restricted the extent to which the findings could be generalized. Furthermore, the study focused solely on mobile phone usage, other electronic devices such as televisions, laptop & desktop could also play a significant role, given their potential for internet connectivity and entertainment value. Moreover, subjective phenomena were measured rather objectively. Lastly, the study fails to account for daytime mobile phone usage which may hold implication for individual's overall quality of life.

It is recommended that further research need to be initiated by addressing the aforementioned limitations and explore new avenues of inquiry to deepen our understanding of the complex interplay between mobile phone and well-being. By adopting a multidisciplinary approach and leveraging advanced methodologies, researchers can generate robust empirical evidence that informs public health policies and interventions aimed at promoting healthy sleep habits in the digital age.

Conclusion

The restricted use of mobile phone before bed time brought improvement in sleep quality, which in turn led to an improvement in positive mood and cognitive function in undergraduate students. Thus, the study suggests for frequent sensitization program focussing towards mindfulness limit setting and smart usage to culminate the negative effects of bed time mobile phone usage.

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