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Original article

A comparative study of screen time, sleep duration and behavioural disturbances in urban and rural high school children

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Abstract

Background: Sleep disturbance is a common but unrecognized problem in adolescents. Light emitting electronic devices negatively influence sleep quality, leading to reduced alertness, increased fatigue, compromised daytime functioning and impaired mood.

Aims: The current study aimed to assess the impact of screen viewing on sleep duration, sleep quality and behavioural disturbances in high school students.

Methods: This was a cross sectional community-based study involving sixty urban and sixty rural high school students in Karnataka, India. The Pittsburgh sleep quality index (PSQI), Epworth Sleepiness scale (ESS), Aberrant Behaviour Checklist (ABC) were used to assess sleep quality in the past one-month, daytime drowsiness and behavioural disturbances respectively. A self-designed, semi-structured proforma was used to assess demographics, medical information, screen viewing duration, patterns and content of device use.

Results: Television use was prevalent in 95% urban and 76% rural students, and cell-phone use in 70% urban and 51.6% rural students almost every night. The total screen duration in the urban group was nearly double that of the rural group. We observed a significant positive correlation of total screen duration with weekday sleep duration, weekend catch-up sleep, PSQI, ESS and ABC scores in urban school adolescents. All behaviour subscale scores of ABC were significantly higher in the urban compared to rural group.

Conclusions: Adolescents in in both groups had sleep durations considered insufficient for age. The recommendations for healthy media use needs updating, with development of age-specific guidelines regarding the quantity and timing of electronic media.

Keywords: Screen exposure, sleep quality, behavioural disturbances, adolescents, screen time, high school students

Introduction

An adolescent is defined as a person aged between 10 to 19 years. As per April 2016 UNICEF data of adolescent demographics, there are around 1.2 billion adolescents, who make up 16% of the world's total population. South Asia is home to 340 million of them, which is greater than any other region in the world, and of these, 243 million live in India alone [1, 2]. It has been well established that adequate sleep is necessary for adolescent growth, including learning, memory processing and school performance [3]. According to the National Sleep Foundation, the recommended sleep duration for adolescents is around 9 hours per day for optimal health and development [4]. However, current studies indicate that adolescents sleep far less than this amount, although most studies have been conducted in developed countries, with similar information lacking for the Indian demographic [5, 6].

Adolescents today live in an era of continued advancement in technology, resulting in an increase in the ownership and use of screen viewing devices such as television (TV), mobile phones and other portable devices [7]. The total daily screen time across devices had increased from 5 hours/day in 1996 to 8 hours/day in 2016 [8]. Individual associations have been established between increasing screen time and concurrent reduction in sleep duration and quality [9,10]. Mechanisms by which screen times cause sleep disturbance have been attributed to time displacement, such as device use leading to delay in bedtime, factors such as content of the media causing arousal and interfering with the ability to fall asleep, and even biological factors, such as light emission of devices in the blue spectrum cause melatonin suppression, leading to difficulty in sleep initiation and non-restorative sleep [11,12]. An association noted between excessive screen time and behavioural disturbances, being possibly mediated through sleep disturbances, has been postulated by Parent et al. They found that higher levels of screen time were associated with higher rates of internalising, externalising behaviours and peer problems [8]. The other mechanism is the content of the media itself influencing behaviour, such as violent video games leading to increase in aggressive behaviour as found by a meta-analysis [13]. Data from India is not well studied, and the acquired data in the present study would help to identify correlations in the Indian population and would be of use in formulating recommendations for healthy screen use in the Indian population. Given this background, this study aims to explore the effects of screen viewing on sleep duration, sleep quality and behavioural disturbances in a cross-sectional sample of adolescents and to compare the various parameters between rural and urban populations.

Methodology

This study used a cross sectional community-based, self-report study design. The study population included 120 high school students between the ages of 12 to 16, with sixty each from a rural and an urban school located in a South Indian district being recruited. Invitations were sent to schools listed in the website of the Department of Public Instruction, Karnataka [14], under the taluks- Mysore South and Mysore Rural, which form part of the Mysore District. Two of these responded and were included for the study. Based on the average classroom strengths in both schools, the investigators felt that 60 was an appropriate sample size to be sufficiently representative of urban and rural high school students. The inclusion criterion was adolescents studying between 8th and 10th standard. Students who had a history of substance use, a diagnosed sleep disorder, and any other psychiatric disorder diagnosable as per International Classification of Diseases-10th edition (ICD-10) criteria were excluded from the study [15]. Simple random sampling was used. The school assigns a unique student identity (ID) number for each student in the school admission records. Computer generated random sampling was utilized by feeding ID numbers of students enrolled in 8th to 10th standard classes.

Assessment tools and variables measured

1. A semi-structured proforma was designed for obtaining socio-demographic details such as age, gender, class of enrolment, religion, family-size, socio-economic status, along with information about total sleep duration, onset latency, wake lag, catch-up sleep, presence and duration of use of electronic devices, and purpose of using the device. Information about exercise was collected in the same proforma for ease of administration.
    a. *Information about sleep*: The participants were asked to indicate what time they usually go to bed and wake up on an average weekday (Monday to Friday) and on an average day of the weekend (Saturday to Sunday). Sample items include: (1) When have you usually gone to bed on a weekday (Monday-Friday) night (clock time)? (2) When have you usually gotten out of bed on a weekday (Monday-Friday) morning (clock time)? (3) How many hours of actual sleep do you get at night (starting from when you fell asleep) (hours and minutes)? The average daily sleep duration was calculated by the sum of the sleep duration on weekdays and weekends divided by seven. Sleep onset latency was checked by the following questions: How long does it take you to fall asleep? (Select from 0–5 mins, 5–15 mins, 15–30 mins, or More than 30 mins). Wake-lag was calculated as the difference between wake times on school days vs. weekends.

Catch up sleep was calculated as the difference between sleep duration on weekdays and weekends.

b. *Information about Presence and Use of Electronic Devices (EDs)*: Participants indicated the presence (yes/no) of the following devices in their bedroom: TV, computer, laptop, mobile phone, tablet computer. Participants were asked ‘‘During the hours you would normally be sleeping how often would you do the following activities in bed?’’, for which they rated how often they performed each of the following on a 5-point Likert scale (Never, Rarely, A Few Nights a Month, A Few Nights a Week, Every or Almost Every Night): a) Watch TV; b) Use the computer or laptop; and c) Use mobile phone or tablet computer. For screen viewing duration, the participants were asked to report the exact amount of time that they spent viewing TV, computers, mobile phones, and tablet computers on weekdays (Monday to Friday) and over the weekends (Saturday and Sunday). They were also asked a follow-up question on their self-reported total screen viewing duration on weekdays and weekends. Purpose of use of the device was evaluated by asking students to choose the purpose as well as indicate the duration of time spent on the devices for each purpose (academic, social media use, recreational, gaming and others). Details of exercise were collected, and regular exercise was defined as moderate- or vigorous intensity aerobic physical activity, such as running, hopping, skipping, jumping rope, swimming, dancing, and bicycling [16].

2. *Epworth Sleepiness Scale (ESS)* was used to assess excessive daytime sleepiness in adolescents. It consists of a four-point scale to rate the likelihood of dozing in eight daily life situations. The situations include sitting and reading, watching TV, sitting and talking to someone, sitting quietly after a lunch without alcohol, and so on. The total

score ranges from 0 to 24, with a total score of more than 10 indicating excessive daytime sleepiness. It has good internal consistency, with Cronbach's alpha between 0.73 and 0.90, and test-retest reliability, with intra-class correlation coefficient between 0.81 and 0.93 [17].

3. *The Pittsburgh sleep quality index (PSQI)* is a 19-item self-report measure of sleep quality over the previous month. It consists of seven component scores, each rated on a 0 to 3 scale, with higher scores implying greater difficulties. S*ubjective sleep quality* is measured with one item and assesses how one rates one's overall sleep quality. S*leep latency* consists of two items and is the average length of time it takes one to fall asleep. *Sleep duration* is measured with one item and is the average hours of sleep one engages in each night. *Habitual sleep efficiency* is calculated from three items and represents the number of hours slept, given the number of hours spent in bed. *Sleep disturbance* measures the frequency with which various situations have troubled one's sleep and consists of nine items representing different situations (e.g., bad dreams, pain, inability to breathe well). *Use of sleep medications* consists of one item inquiring about how frequently one has taken medicine to aid sleep. The seventh component is *daytime dysfunction,* which consists of two items and measures daily problems related to sleep, such as having trouble staying awake or having enough enthusiasm to get things done. These seven component scores can be summed to form a single global score, which ranges from 0 to 21, with higher scores reflecting greater overall sleep disturbance. It has high internal consistency, with Cronbach's alpha of 0.83 [18].

4. *The Aberrant Behaviour Checklist (ABC)* was used to assess behaviour problems. This is a rating scale with 58 items for assessing behaviour problems in children and adults with intellectual disability. Each item is rated on a 4-point scale: (0) the behaviour is not at all a problem, (1) the behaviour is a problem but slight in degree, (2) the problem

is moderately serious, and (3) the problem is severe in degree. The items include a wide range of behaviours that are summed up in five subscales: (I) Irritability, (II) Lethargy, (III) Stereotypy, (IV) Hyperactivity, and (V) Inappropriate Speech. The scale has high internal consistency, fair to good interrater reliability and high test-retest reliability [19].

Procedure: The purpose of the study was explained to the principals of the target schools. All questionnaires were in English, print form and were self-reported. All participants were well versed in English, as they had studied English at the second-language level till 7th std. Participants were given clear instruction about meanings of each term before they filled responses. A member of the research team was available, in case participants had doubts regarding the same. Participants were given forty-five minutes to complete the questionnaires, and were instructed to take breaks whenever they desired. Teachers were present during the entire procedure to organise data collection and ensure confidentiality.

Ethical considerations: Institutional ethics committee approval was obtained prior to approaching the schools. Assent was taken from participating students, and in-loco-parentis consent was taken from the school principal. Written informed consent was not taken from parents. However, a passive consent method was used, the class teachers were provided with the subject information sheet which described the objectives of the study which had to be given to the students' parents along with a reply slip. The reply slip could be returned by the parent to the teacher if they did not want their child to participate in the study. Confidentiality was ensured by collecting anonymous data and identification of participant questionnaires through serial numbers. Participants did not receive any reimbursement, and after completion of the survey, they were provided feedback about sleep habits and were also directed to seek further evaluation and help where responses were indicative of sleep problems.

Statistical analysis: SPSS version 21 was used for statistical analysis [20]. We examined descriptive data for all variables of interest. Continuous variables with a normal distribution are presented as means ± standard deviations. Correlations were computed between sleep variables and screen use variables. Between-group comparisons were made by Kruskall-Wallis test and Fisher's exact test to assess for statistical significance. The level of statistical significance was set at p=0.05. Spearman's correlation coefficient was used to assess strength of association between variables such as sleep duration, latency, catch-up sleep, PSQI and ESS scores, and screen duration.

Results

Socio-demographic data: The majority of the participants, i.e., 96.67% of rural and 98.33% of urban students were aged 14-16 years. The study also had a higher number of male participants, with 71.67% and 68.33% in the rural and urban schools respectively. Lower socio-economic status (SES) was noted in 80% students of the rural school, with rest being of upper-lower SES. However, the urban school had a more even distribution, with 48.3%, 40.3%, 8.3% and 3.3% for upper-lower, lower-middle, upper-middle and lower SES respectively. 96.63% of rural students engaged in regular physical activity as compared to 88.3% of the urban ones. [Table 1]

Table-1: Demographic profile of participants, including details about exercise habits

Demographic variable		**Rural**	**Urban**
		N (%)	
Age (in Years)	12-13 14-16	2 (3.33) 58 (96.67)	01 (1.67%) 59(98.33)
Gender	Male Female	43 (71.67 %) 17 (28.33%)	41 (68.33%) 19 (31.67 %)
Class studying in	10th 9th 8th	28 (46.67%) 2 (3.33%) 30 (50.0%)	2 (3.33%) 1 (1.67%) 57 (95.0%)

Religion	Hindu Muslim Christian Others	60 (100%) 0 (0%) 0 (0%) 0 (0%)	54 (76.7%) 3 (5.0%) 3 (5.0%) 0 (0%)
Family Size	1-2 3-4 5-6 > 6	2 (3.3%) 26 (43.3%) 24 (40.0%) 8 (13.3%)	1 (1.67%) 34 (56.6%) 23 (38.3%) 2 (3.33%)
Socioeconomic Status	Lower Lower Middle Upper Lower Upper Middle	48 (80.0%) 0 (0%) 12 (20.0%) 0 (.0%)	2 (3.3%) 24 (40.3%) 29 (48.3%) 05 (8.3%)
Exercise	Yes No	58 (96.6.3%) 02 (3.3%)	53 (88.3%) 07 (11.6%)

Frequency and duration of use of each device: TV and cell-phone use was most widely predominant, with 95% urban and 76% rural students watching TV, and 70% urban and 51.6% rural students using cell-phones almost every night of the week. Computer use was found to be low, with none of rural students using them, and only 1.2% urban students using for only few nights a week. Use of tablet-computers was 20% in rural and 10% in urban students. The difference in frequency of TV use amongst the two groups was statistically significant. The mean duration of TV use was 129 minutes (SD=44 minutes) in urban, and 60 minutes (SD=77 minutes) in rural students, and the same for cell-phone use was 45 minutes (SD=39 minutes) and 25 minutes (SD=25 minutes), in urban and rural students respectively. The differences in both TV and cell phone screen time duration were statistically significant. Although duration of computer use was higher in urban, and that of tablet use higher in rural, neither were statistically significant. Finally, the difference in mean total screen duration was statistically significant, with 177 minutes (SD=100 minutes) amongst the urban group, compared to 93 minutes (SD=53 minutes) in the rural group. [Table 2]

Table-2: Frequency and duration of use of each device

Device	Frequency of use	Rural	Urban	P	Mean duration of use		P
					Rural	Urban	
TV	A few nights a week Almost every night Rarely Never	9 46 2 3	0 57 1 2	0.002	60.5 ± 44.01	129.5 ± 77.62	0.0001
Computer	A few nights a week Almost every night Rarely Never	0 0 0 60	1 2 0 57	0.244	0 0	2.5 ± 11.44	0.080695
Cell-phone	A few nights a week Almost every night Rarely Never	6 31 4 19	2 42 1 15	0.130	25.92 ± 25.5	45.33 ± 39.58	0.006235
Tablet	A few nights a week Almost every night Rarely Never	5 6 1 48	1 5 0 54	0.188	7 ± 16.68	2.75 ± 8.51	0.117421
Total screen duration					93.58 ± 53.22	177.58 ± 100.75	0.000001

Purpose of use of devices: Using devices for academics was reported by 35% urban students, as opposed to 13.3% of the rural group. Distribution of time, social media wise, was similar in both groups, with a majority of students of both groups using it for 30-60 minutes. Use for gaming was higher in the rural group, with 50% of them using devices for up to an hour, and only 25% urban students using devices for gaming, which was a significant difference. Recreational use though, had higher numbers and time durations in the urban group, with more than 50% of them using devices daily for greater than two hours, as opposed to only 10% of the rural students, with this difference being statistically significant. [Table 3]

Table-3: Purpose of using each device and duration

Purpose for using the device	Duration	Rural	Urban	p-value
Academic purposes	Less than 30 mins 30 mins-1 hour 1-2 hours More than 2 hours No use	6 2 0 0 52 (60)	20 1 0 0 39 (60)	0.004298
Social media use	Less than 30 mins 30 mins-1 hour 1-2 hours More than 2 hours No use	6 9 2 0 43 (60)	5 15 0 2 38 (60)	0.229684
Others	Less than 30 mins 30 mins-1 hour 1-2 hours More than 2 hours No use	19 2 0 0 39 (60)	8 0 0 0 52 (60)	0.011646
Gaming	Less than 30 mins 30 mins-1 hour 1-2 hours More than 2 hours No use	13 14 3 0 30 (60)	5 7 3 0 45 (60)	0.0242
Recreational	Less than 30 mins 30 mins-1 hour 1-2 hours More than 2 hours No use	10 22 17 6 5 (60)	3 10 13 32 2 (60)	0.000002

Comparison of sleep parameters including PSQI components: Total sleep duration on weekdays in rural students was 7.1 hours (SD=83 minutes), as opposed to 6.6 hours (SD=73 minutes) in urban, and onset latency of 15.5 minutes (SD=13) in rural and 25 minutes (SD=17) in urban students, with the latter being statistically significant. During weekends, total sleep duration was similar in both groups, with 7.8 hours (SD=95 minutes) and 7.7 hours (SD=90 minutes) in urban and rural groups respectively. Onset latency during weekends was also statistically significant, with urban students having 25 minutes (SD=16), as compared to 12 minutes (SD=12) in rural. The wake lag and catch up sleep, when compared between weekdays and weekends were similar in both groups, with no statistical significance. PSQI subjective sleep quality had considerable difference, with 85% of rural students reporting very good subjective sleep quality, as opposed to only 51% of urban students. Although a greater number of rural students had lower sleep latency, greater sleep duration, better habitual sleep efficiency and lesser daytime dysfunction, none of them had statistically significantly differences between urban and rural groups. Sleep disturbance, however, was reported by 60% of urban students, as compared to only 18.3% of the rural group, which had statistical significance. [Table 4, Table 5]

Table-4: Comparison of sleep parameters in rural and urban population

Sleep parameters		**Rural**	**Urban**	**P-value**
		Mean ± SD		
Sleep on weekdays in mins	Total sleep duration Onset latency	426.25 ± 82.96 15.5 ± 13.58	400 ± 73.21 25 ± 16.62	0.069809 0.001875
Sleep on weekends	Total sleep duration Onset latency	468.5 ± 95.62 12.42 ± 12.13	462.2 ± 89.89 25.42 ± 16.42	0.416127 0.000012
Weekdays VS Weekends	Wake lag Catch up sleep	48.75 ± 52.66 49.08 ± 48.24	61.25 ± 77.54 59.75 ± 77.65	0.895946 0.850794

Table-5: Comparison of PSQI components in rural and urban population

PSQI components	**Component indicators**	**Rural**	**Urban**	**P-value**
Subjective Sleep quality	Very good Fairly good Fairly bad Very bad	57 3 0 0	32 23 5 0	0.000002
Sleep latency	< 15 minutes 16-30 minutes 31-60 minutes >60 minutes	37 17 3 3	24 17 9 10	0.022393
Sleep duration	>7 hours 6-7 hours 5-6 hours <5 hours	32 24 2 2	24 25 11 0	0.017312
Habitual sleep efficiency	>85 % 75-84% 65-74% <65%	60 0 0 0	58 2 0 0	0.495798

Sleep disturbances	0 1-9 10-18 19-27	49 11 0 0	24 31 5 0	0.000007
Use of sleep medications	Present/absent	0	0	
Daytime dysfunction	0 1-2 3-4 5-6	60 0 0 0	57 2 0 0	0.243859

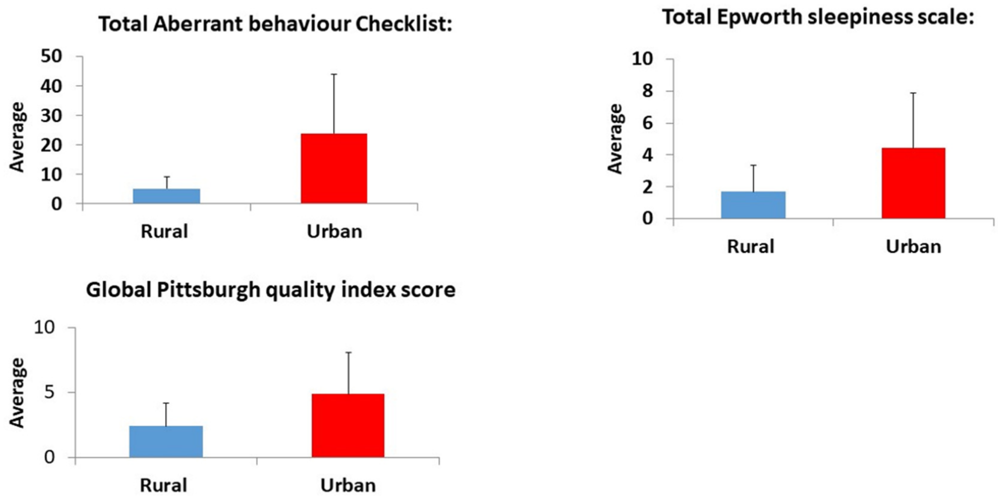
Differences in behavioural parameters: Measured through the ABC checklist, all the behavioural subscales, i.e., irritability and lethargy, stereotypic behaviour, hyperactivity and non-compliance and inappropriate speech had significantly higher scores in the urban students as compared to the rural group. ($p<0.05$) [Table 6]

Table-6: Differences in mean scores of individual components of the ABC checklist

ABC Behavioral Components	**Rural**	**Urban**	**P-value**
	Mean score ± SD		
Irritability, Agitation	2.2 ± 1.70	7.05 ± 5.72	0.0001
Lethargy and Social Withdrawal	2.11 1.73	6.36 6.15	0.0011
Stereotypic Behaviour	0.2 0.44	3.01 4.38	0.0002
Hyperactivity and Non-compliance	0.18 0.62	3.18 4.85	0.0001
Inappropriate Speech	0.48 1.09	1.46 ± 2.00	0.0053

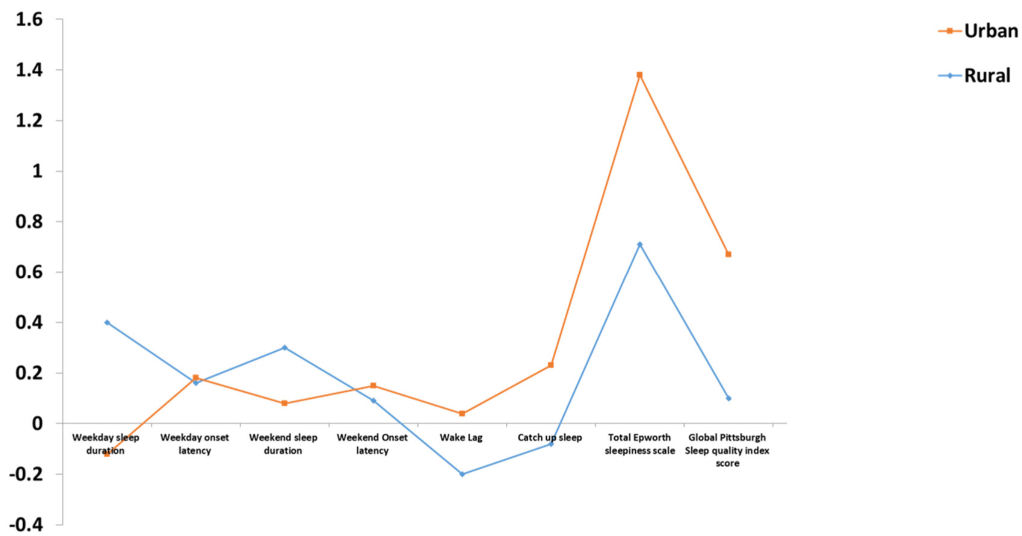
Comparison of scale scores between rural and urban groups: The ABC checklist indicated significant behavioural disturbances in urban compared to the rural group ($p<0.05$). The former had a mean score of 23.9 (SD=20.06) and the latter 5.16 (SD=3.97). Daytime sleepiness was also higher in urban students, indicated by an ESS score of 4.41 (SD=3.48) in urban and 1.7 (SD=1.63) in rural students. Urban students had global PSQI (GPSQI) score of 4.48 (SD=3.16), with rural group having score of 2.41 (SD=1.76), indicating overall poorer sleep quality in the urban students. [Figure 1]

Figure-1: Scale comparisons significantly differ between rural and urban populations with Wilcoxon rank-sum (Mann-Whitney) test, P<0.05.



Correlation of screen time with different sleep parameters and individual scale scores: This was assessed by comparing the Spearman correlation coefficients for total screen duration and the sleep parameters and scale scores. Higher screen time correlated with poorer score values in all scales used, as well as impairment in all sleep parameters. Higher screen times and poorer scores were observed across all parameters and scales in the urban students as compared to the rural ones. [Figure 2]

Figure-2: Spearman correlation coefficients for total screen duration and its correlation with different sleep parameters individual scale scores in rural and urban students



Discussion

With regards to sleep measures in general, adolescents in the present study sample of both groups had a sleep duration considered insufficient for this age group, not only on weekdays, but on weekends as well, as per the American Academy of Paediatrics Childhood Sleep Guidelines [21]. There were significant differences in sleep quality, with poorer subjective sleep quality, longer sleep onset latency, higher sleep disturbances in the urban group compared to rural. Although daytime sleepiness, as measured by the ESS was higher in urban, neither groups had scores greater than the cut-off of 10, indicating that, though present, it was not problematic or dysfunctional. Similar results of less than ideal sleep parameters were obtained by Murugesan et al, who studied sleep patterns in Indian adolescent school goers, and found that a large proportion of them had abnormal sleep patterns and poorer sleep hygiene behaviours [22]. Gupta et al studied sleep patterns in adolescents in Delhi, and noted that sleep deprivation worsened with increasing grades, with lesser sleep times and more frequent awakenings [23]. This may have been true in our study too, although we did not make this comparison.

The overall use of electronic devices (EDs) and duration of screen time was significantly high in the urban students compared to the rural population. While a greater number of urban students used devices for academic purposes, a larger number of rural students used them for gaming. Overall, the most common purpose was recreational use and then gaming, with the least common being academics. We did not find significant differences in social media use, use of computers and cell-phones, and in fact, the use of tablet devices was actually flipped, with a greater number of rural students using them than urban. Overall, the use of devices was higher than expected in the rural population, which could be an indication of successful digital penetration into rural regions of India.

We observed a significant dose response relationship between adolescents' total screen viewing duration, sleep disturbance and behavioural disturbances, with both individual and overall scores being high across most scale components. Effects of device use on sleep latency, wake lag, catch up sleep, habitual sleep efficiency and daytime dysfunction were less consistent. Forester et al found that higher screen time was associated with difficulties in falling asleep and more nocturnal awakenings, with which our findings were partly consistent [24]. Another large population-based study found that dose response relationships between increased use of EDs and poorer sleep measures, such as longer onset latency and increased sleep deficiency in adolescents [25]. A review by Le Bourgeois et al notes that amongst the studies conducted on associations between screen time and sleep parameters, 90% of them reported increased duration of screen time being associated with poorer sleep, such as delayed bedtimes and shorter total sleep time, and amongst the studies which examined TV use and sleep quality, 75% of them found significant associations between the two [26]. A systematic review and meta-analysis conducted by Mei et al also found that excessive technology use had significant effects on sleep in adolescents of over 14 years of age, with which our findings were consistent [27].

Parent et al [8] noted that higher levels of screen time, by virtue of causing sleep disturbances, were associated with higher levels of internalising, externalising and behavioural problems. Whether this is additive or greater than the sum of both, warrants further exploration. We could not find other studies which investigated irritability and agitation, lethargy and social withdrawal and stereotypic behaviour in association with screen time, although our study did find a positive association between the same, in that, urban students who had longer duration of screen use had higher scores in irritability and agitation component of the ABC checklist. Suchert et al reported a positive association between screen time and hyperactivity and inattention, a finding noted in the present study as well [28]. A systematic review found weak evidence for association of screen time with behavioural problems, anxiety, hyperactivity and inattention, poorer self-esteem and poorer psychosocial health in children, moderate evidence for lower quality of life and moderately strong evidence for depressive symptoms [29]. Page et al also reported that greater screen use was associated with greater psychological difficulties [30]. Regarding sleep disturbance itself leading to behavioural problems, one study compared adolescents with insomnia and without insomnia, and found that the insomnia group reported more attention, social problems, aggressive behaviour, somatic complaints, anxiety and depression [31]. Our study had similar results- students having higher scores on aberrant behaviours had poorer sleep quality, which in turn, was secondary to increased screen use. Hale et al also showed similar results, with worsening of mood and reduced ability to regulate negative emotions associated with screen use [32]. The policy statement by the Council on Communications and Media, American Academy of Paediatrics, 2016 recommend personalised media use plans, taking into consideration age, health, temperament, developmental stage, adequate sleep, physical activity [33].

Coming to the biological and physiological basis of it all, light emitted by EDs could cause hyper arousal and decreased sleep during bedtime, and a delay in the circadian phase of the melatonin rhythm [26]. This study also raises the question whether ED use displaces and adversely affects sleep, or if bad sleepers fill their wake time with media use. This needs well designed experimental methods to ascertain the right answer, and of course, both promises may equally hold good. The changing academic demands, social activities, decrease in parental involvement and strive towards autonomy on the adolescents' part also lead to significant delays in bedtimes, along with environmental factors such as ambient noise, vehicular traffic, commercial and industrial activity, leading to light and noise [34]. In line with all these findings, it becomes difficult to untangle the threads and identifying how much of the sleep disturbance occurs due to physiological changes and how much is actually attributed to ED use. The Big Sleep Study, a large online survey study conducted in Australia, observed associations between the use of EDs in bed and its effect on sleep and circadian rhythm, and found that these dose dependent associations were over and above the sleep-wake irregularities for adolescents, and were also strongest for computers, TV, cell phones. They also found that less frequent use, i.e., lower doses did not actually lead to deleterious sleep schedules [35]. Our study was consistent with these results, suggesting that ED use across different demographic profiles led to interestingly similar disturbances in sleep profiles. This study has some limitations, in that the sample size was small and included cross-sectional data only, which may not have captured typical use by the average adolescent. This sample also had a limited age-range. The retrospective nature of the self-reported data may have resulted in recall bias as well as underreporting. It is possible that the respondents tended to report shorter screening viewing times because they wanted to give a socially desirable answer. Even though we controlled for several possible confounding factors such as load of studies impacting sleep duration, pre-existing medical or psychiatric illnesses, use of medications, exercise and family's socio-economic status, we did not account for certain factors like caffeine consumption. Owing to the cross-sectional nature of the study and small sample size, the results cannot be generalized. However, the findings support the need for further longitudinal studies to substantiate these associations. We also did not include parental reports, which may have enriched our data further. However, this was not in the purview of the study, but further investigations taking parents' data need to be conducted.

To conclude, almost all adolescents reported using one or more electronic devices during the last hour before bedtime. Total screen duration in the urban group was nearly double that of the rural group, positively correlating higher degree of behavioral disturbance, with higher scores on all ABC subscales. The most common purposes of use were recreation and gaming, with least common being academics. A significant dose-response relationship between total screen-time and sleep disturbance was also noted. The mechanisms by which higher levels of screen time cause sleep disturbances could include effect of screen light on circadian rhythm and alertness, increased cognitive, physiologic, and emotional arousal as well as a direct displacement. The recommendations for healthy media use given to parents and adolescents need updating, and age-specific guidelines regarding the quantity and timing of electronic media use should be developed and made known to the public. Tailor-made health education programs should be developed to prevent adolescents from suffering from the negative effects of long screen times.

Considering the degree of adverse effects on sleep screen-time causes, it is imperative that interventions be made involving both adolescents as well as the family members. Interventions targeting adolescents could be done by targeting school populations, and conducting educational seminars as well as providing recommended electronic device (ED) use times. Children should be encouraged to follow schedules on their own, rather than being enforced upon them, which would not lead to ideal results. Parents should also be brought into the loop, and suggestions about what can be done from their side to ensure sleep hygiene could be explained. Further studies investigating into recommended ED use times need to be conducted in the Indian setting, as most data regarding this is from developed countries. Also, as the use of EDs is on an inevitable rise, investigating the ergonomics of the EDs themselves would help to design sleep friendlier devices, which requires collaboration between the engineering and the medical professions.

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Conflict of interest: None declared

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