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Use of Screen-Based Electronic Gadgets and Sleep: A Cross-Sectional Study in Pre-School and School-Age Children

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ABSTRACT

Background and Objective: The use of educational and entertainment screens has increased enormously since the coronavirus disease 2019 (COVID-19) pandemic. The artificial blue light emitted from these devices affects the circadian rhythm, and the use of these devices one hour before bedtime may delay the onset and total amount of rapid eye movement (REM) sleep. Therefore, this study was conducted to investigate the role of digital media in children's lives and its effects on various health domains, especially sleep.

Methods: This cross-sectional observational study was conducted in the Pediatric Department of a Tertiary Medical College Hospital, Mysuru, India, over a period of 18 months from January 1, 2020 to June 30, 2021 on a total of 200 eligible subjects aged 3 to 12 years. Parents/caregivers were interviewed using a two-part questionnaire to obtain details of screen time and sleep quality. The responses were recorded and analyzed.

Findings: A majority (61%) of subjects spent 2 hours or less gaming without the use of a screen device. A significant association was found between screen use 30 minutes before bedtime and delay in falling asleep (P=0.001). Second, longer total screen time per day was associated with higher body mass index (BMI) (P=0.036) for age and gender.

Conclusion: Sleep onset is delayed when screen use is stopped shortly before bedtime. With increasing age, total screen time per day increases significantly. Higher screen time is associated with higher BMI for age and gender. Screen use during mealtimes is very high among preschool and school-age children.

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Introduction

It is well known that poor sleep quantity and quality is often associated with poor academic performance, obesity & its adverse metabolic effects, impaired cellular immune responses, depression and anxiety [1]. Electronic media such as smart phones, tablets, video games and laptops continue to attract a large number of children, adolescents and young adults contributing to disturbances in their sleep, [1] compromised exercise, dietary habits and increased adiposity [2], in turn laying the foundation for chronic illnesses like diabetes, dyslipidemia etc [3].

It has been proven that short-wavelength, artificial blue light emitted by these devices is responsible for suppression of the hormone melatonin, impairing the circadian rhythm. Using these devices the hour before bedtime delays the onset and the total amount of rapid eye movement (REM) sleep compromising one's alertness the next morning [4]. In the light of the recent Covid 19 pandemic resulting in multiple phases of lockdown, scientists point towards the problem of increasing digital technology use by children and adolescents for both educational and entertainment purposes. In contrast to adults, a child's sleep wake schedule is largely determined by the parents/care takers, their school hours and extracurricular activities [5]. So, understanding the role of increased screen time and its impact on sleep is crucial for promoting the healthy development of children and adolescents, by those concerned with it such as parents, Pediatricians, policymakers, educators, and public health groups [6].

The primary objective was to determine the relation between use of screen based media devices and sleep in children aged 3-12 years. Secondary objectives were to determine the association between age of the subject and total screen time per day; the relation between daily total screen-time and body mass index (BMI) for age & gender and finally to find the frequency of mealtime screen usage.

Methods

Study design and sample

A cross-sectional observational study was conducted in the Pediatric Department of a Tertiary Medical College Hospital, in Mysuru, Karnataka, India, after obtaining approval from the Institutional Ethical Committee. Informed consent was obtained from the primary caregiver or parent of the child prior to the commencement of the study. A total of 200 children in the age group of 3–12 years were selected over a period of 18 months from January 2020 to June 2021 based on eligibility criteria through convenience sampling. Children with a known history of sleep disorders, children taking medications known to affect sleep such as hypnotics, sedatives, antiepileptics, antidepressants, psychostimulants, alcohol, antihistamines, thyroid hormones, medications with caffeine, angiotensin-converting enzyme inhibitors, ARBs and beta blockers were excluded. In addition, children diagnosed with psychiatric disorders that can affect sleep, such as attention deficit hyperactivity disorder (ADHD), mood disorders, anxiety disorders and schizophrenia, as well as children with developmental disorders were excluded from the study.

Data collection

The parents/caregivers of the subjects were interviewed using a two-part questionnaire. The first part involved the administration of a self-developed, internally validated questionnaire to collect information on the subjects' demographics, medical and medication history, and anthropometric data, followed by a semi-structured questionnaire adapted from the "C.S. Mott Children's Hospital National Poll on Children's Health" [7] for the use of screen-based electronic gadgets in children. In the second part of the study, a validated questionnaire developed by Bonuck et al. (2017) on children's sleep habits (Modified Children's Sleep Habits Questionnaire 8) was used to assess sleep behavior.

To assess the sleep behavior of the study participants, parents/caregivers were asked about the duration of sleep and the sleep behavior of their children in the last month. The answers were recorded in a digital database. A scoring system was

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then used to determine the presence of behavioral sleep problems in these candidates. This system was adapted from the validation study conducted by Bonuck et al. [8] in 2017 for the "Modified Children's Sleep Habits Questionnaire for Behavioral Sleep Problems". The questionnaire consisted of 29 questions divided into 8 sub-areas, of which 23 questions were subject to a scoring system. Each of these questions had four response options - "Never", "Rarely (once a week)", "Sometimes (2-4 days a week)", "Usually (5-6 days a week)" and "Always (7 days a week)", each scored between 0 and 4. In line with Bonuck's original study, a cut-off point of 30 was chosen to distinguish between children with and without sleep problems reported by their parents [8]

Statistical analysis

Statistical analysis was conducted using IBM ® SPSS ® version 21 to determine the relationship between excessive use of screen-based electronic gadgets and sleep. The answers given by the parents/caregivers were recorded and presented in the form of frequency tables, graphs and cross tabulations. The data were summarized using frequencies and percentages. The associations of the various elements were examined for statistical significance using chi-square tests and linear association. A value of P< 0.05 was considered statistically significant

Results

Among the 200 children, the mean age (in years) was 7.455 ±0.425 (±5.70%) and the data were fairly well distributed among all age groups. The male to female ratio was 1.3:1. It was found that the majority (n= 123, 61.5%) of the children were within the normal range of BMI for their age (i.e. between the 15th and 85th percentiles). About three-quarters (n=156) of the subjects were from an urban environment and 22% (n=44) came from a rural environment. There was a statistically significant association between screen cessation before bedtime and sleep onset latency (p=0.001) by linear-by-linear association analysis (**Table 1**). When the time interval between ending screen use and going to bed was more than one hour, the sleep onset latency of the study children tended to be normal, i.e., 70.8% of children slept within 20 minutes of bedtime on all 7 days and 20.8% slept within 20 minutes on at least 5-6 days of the week when they turned off the screen more than 1 hour before bedtime. However, if the interval between the last screen use and bedtime was less than 30 minutes, the child was less likely to fall asleep within 20 minutes of bedtime**.**

Analysis of sleep quality revealed that 17.5% (35) children had a score of ≥30 (a total sleep score of 30 was taken as the cut-off point for detecting behavioral sleep problems in the candidates (according to the Modified Children's Sleep Habits Questionnaire), [8] indicating the presence of a possible behavioral sleep problem. There was no significant association between screen use <1 hour before bedtime and behavioral sleep problems (P>0.05). Moreover, no significant association was found between the subjects' total screen time per day and total sleep score (P=0.707). The relationship between children's age and sleep score is illustrated in **Figure 1**. There was a statistically significant association between age and total sleep score (P<0.05). The trend line in the graph shows that the risk of behavioral sleep problems decreases with increasing age.

About 54% (n=108) of children spent less than 2 hours on indoor activities and 67% (n=134) on outdoor activities, without a gadget. Most (86.5%, n=173) children owned five or fewer screen-based gadgets such as televisions, mobile phones, video games, computers and tablets in their household and only one household had more than 10 gadgets.

Total screen-time per day for educational and entertainment purposes (hours) is shown in **Table 2**. The linear by linear association test was used to analyze the relationship between the number of screen-based gadgets owned by the subjects and total screen time per day, and no significant relationship was found (p=0.157). However, the graph represents that with increasing availability of gadgets, there is a tendency towards longer screen time. There was a statistically significant relationship (p=0.036) between total screen time and BMI for age and gender (according to the World Health Organization (WHO) growth charts) and it was found that as the duration of total daily screen time increased, the

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proportion of children with obesity (BMI> 97th percentile) also progressively increased; i.e. among the subjects who used the screen for 0-2 hours, the BMI of only 5.5% of the children was >97th percentile, while among those who watched screen for 4-6 hours, 22% had a BMI abovethe 97th percentile. There was a significant correlation between the age of the subjects and their total screen time per day (p=0.001). The duration of daily screen time increased proportionally with increasing age. **Figure 2** indicates the positive relationship between the age of the children and screen use for educational (Fig. 2a) and entertainment purposes (Fig. 2b).

The majority of caregivers felt that <1 hour (49%) or 1-2 hours (44%) of screen time was appropriate for their children. About one-third of children used the screen during mealtimes at least 2-4 times per week, while 37% look at the screen at least 5-6 times during mealtimes. It was also found that 69% of the subjects' family members had the habit of looking at the screen at least occasionally, if not always, during mealtimes.

It was found that 34% of the subjects used the screen before bedtime on at least 2 to 4 days per week and 14% on 5 to 6 days per week. A significant proportion of them (51.5%, n=103) ended their nighty screen use only 30 minutes before bedtime **(Table 3)**.

About three quarters of the caregivers regularly set screen time limits and "screen-free" days for their children. About 80 (40%) of the subjects had a normal sleep onset latency of 20 minutes or less on all 7 days of the week. In addition, 63 subjects managed to fall asleep within 20 minutes of going to bed on at least 5-6 days per week. However, a few subjects (n=7, 3.5%) never managed to fall asleep within 20 minutes. The significant correlation between the latency to fall asleep (<20 minutes) and screen time (**Table 1)**.

Table 1: Correlation between 'sleep latency <20 minutes' and 'screen time interval'

Screen-Bedtime Interval	Sleep Latency <20 minutes						Chi-Squared Test	
	Never	Once A Week (Rarely)	2-4 Days/ Week (Sometimes)	5-6 Days/Week (Usually)	7 Days A Week (Always)	Total	$\chi 2$	P Value
<30 minutes	7 (100.0%)	14 (82.4%)	20 (60.6%)	34 (54.0%)	28 (35.0%)	103 (51.5%)	25.293	0.001
30 minutes To 1 Hour	0 (0.0%)	2 (11.8%)	10 (30.3%)	20 (31.7%)	30 (37.5%)	62 (31.0%)		
> 1 Hour	0 (0.0%)	1 (5.9%)	3 (9.1%)	9 (14.3%)	22 (27.5%)	35 (17.5%)		
Total	7 (100.0%)	17 (100.0%)	33 (100.0%)	63 (100.0%)	80 (100.0%)	200 (100.0%)		

Table 2: Total screen time per day combined for educational and entertainment purposes (hours)

Screentime	Frequency (n)	Percent (%)
2 hours or less	91	45.5
2 – 4 hours	67	33.5
4 – 6 hours	41	20.5
More than 6 hours	1	0.5

Table 3: Distribution of participants in relation to the interval between screen and bedtime

Screen-Bedtime Interval	Frequency	Percentage	95% CI
<30 minutes	103	51.5%	44.4% - 58.6%
30 minutes To 1 Hour	62	31.0%	24.8% - 38.0%
> 1 Hour	35	17.5%	12.6% - 23.6%

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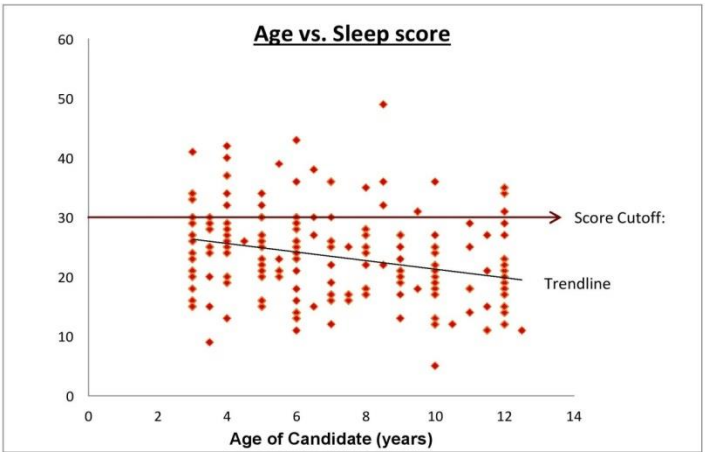

Fig 1. Age vs sleep score

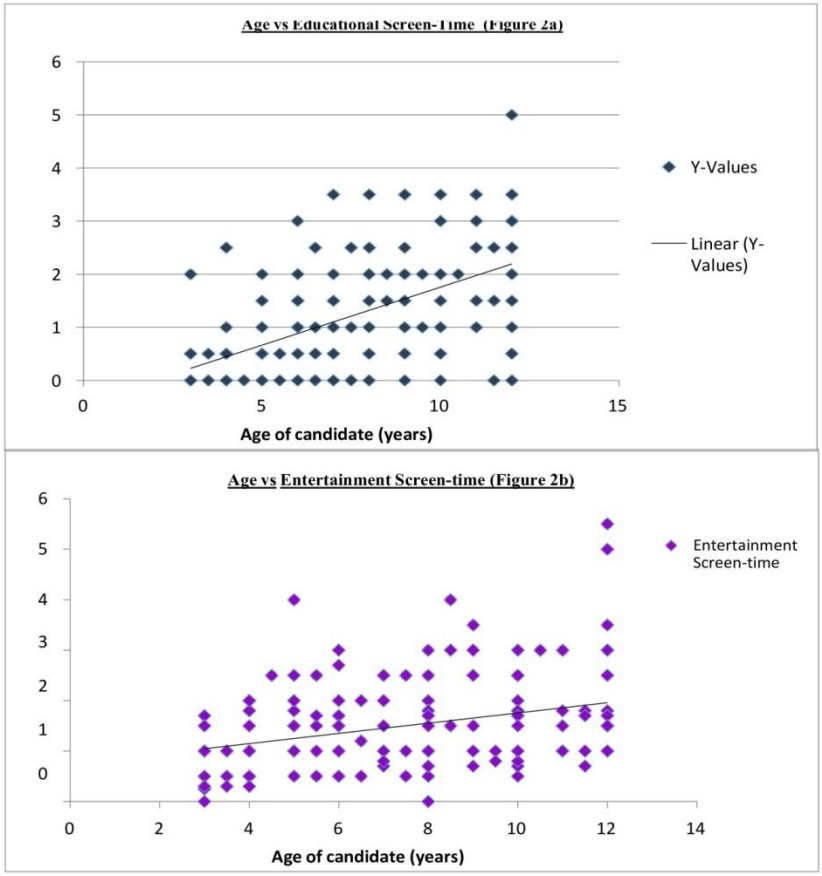

Fig 2. Age vs. screentime

Discussion

Our study showed that sleep onset is delayed when screen use is stopped shortly before bedtime. Nowadays, smartphones, tablets, televisions and computers have become an integral part of our daily lives. More so, in light of the coronavirus disease 2019 (COVID-19) pandemic, digital media has proven to be even more important to our daily lives as its usage has skyrocketed with the increasing number of professionals working from home and the

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introduction of online learning programs for students after the closure of educational institutions. While dwelling on the indispensability of these devices, we neglect their harmful effects on health. Excessive use of screen-based gadgets has a veraiety of negative effects, one of which is sleep disruption [1, 4-6]. In a 2021 study conducted on academic students by Pachiyappan et al., [9] it was found that the usual time participants spent on gadgets before lockdown increased from 4.75 hours per day to 11.36 hours per day during lockdown. Common health complaints associated with excessive screen time include headaches, insomnia, eye discomfort, fatigue and restlessness. By and large, the literature review indicates a significant association between the use of electronic gadgets and sleep behavior, even in young children as well. However, not many such studies have been conducted in our country, which was the reason for this study.

The age group of 3-12 years was selected for the study because the daily routine activities of these children after school are largely determined by their primary caregivers. This includes sleep patterns, mealtimes, extracurricular activities, and most importantly, screen time arrangements. Therefore, a survey of caregivers would provide relatively accurate answers. In addition, the widespread use of digital media for educational purposes in today's world has laid the foundation for regular screen use as early as preschool age. A project conducted from November 2016 to July 2018 in London, United Kingdom, called “Study of Cognition, Adolescents and Mobile Phone” (SCAMP) , [2] revealed that 71.5% of adolescents reported using at least one screen-based media device at night, and 32.2% reported using phones at night in the dark. Adolescents who used mobile devices in a lighted room were at higher risk for inadequate sleep on weekends than those who did not. The magnitude of this association was even stronger among candidates who used cellphones in the dark. However, in the present study, the duration of nighttime screen use did not significantly affect sleep scores althoygh sleep onset latency was significantly increased when screen use was discontinued less than 30 minutes before bedtime.

Li S. et al. [10] in 2007, while studying the effects of television and computer use on about 20,000 Chinese children with an average age of about 9 years, concluded that it is likely to have a negative impact on sleep and wakefulness and may also affect overall performance. Another study on school children in Puducherry, India in 2017 [11] revealed that 51.1% of students had sleep problems. Insufficient sleep or sleep deprivation was found in 15.4% children. Furthermore, screen time >2 hours contributed to late bedtime and insomnia. Lund, L. et al. (2021) reviewed 49 papers on the importance of sleep for children’s growing up and well-being. The analyses revealed that 6–12-year-old children go to bed late and have poor sleep quality due to the use of electronic gadgets [12]. In the current study, although 78% of the children were from urban households, almost all (98%) of the subjects were evenly distributed across four socioeconomic classes - i.e. upper lower, lower middle, upper middle and upper according to the modified Kuppuswamy scale [13]. In the Puducherry study [9], it was observed that a significantly higher proportion of children from the upper socioeconomic group went to bed later than children from the lower socioeconomic group. On analyzing the total screen time against the BMI of the candidates for age and gender (according to WHO), a significant correlation was found, i.e. as the duration of total daily screen time increased, the proportion of candidates with a BMI >97th percentile also increased. A majority of candidates (63.5%) in the ongoing study spent at least 1-2 hours of passive screen time per day and 3 candidates (1.5%) spent 4-6 hours, while 47.5% of participants spent less than one hour of active screen time on their devices, meaning that the majority of screen time for entertainment was passive screen time only. The researchers found that time spent watching commercial television was significantly associated with increased BMI, while time spent watching non-commercial educational television was not [14]. Furthermore, unlike passive screen time, there was no evidence of association between obesity and active screen use - such as gaming [15]. In fact, active screen use has been shown to be beneficial for improving cognitive skills in the growing brain of young children [16-19], and has also been trialed as part of the treatment of ADHD and to improve

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mental health in children with chronic debilitating disorders [20, 21]. Physically active screen time can be used as an aid to sporting and aerobic activities [22]. While 70% of the children in this study had developed the habit of using a screen at least 2-4 days per week during mealtimes, 69% of their own family members practiced the same. This shows the importance of family members' attitudes and practices in regulating screen use, especially during mealtimes. It is well known that children are exposed to advertisements for unhealthy foods through commercial television content [23]. They encourage snacking while reinforcing sedentary behavior. Overall, this contributes to increased food intake [23, 24]. A 2012 systematic review [25] of television consumption and the negative effects on the diet of 2-6-year-old children reported adverse effects from sitting passively in front of a screen for even 1 hour per day. A 2015 [26] Korean study found that short-wavelength light emitted from digital screens significantly disrupts sleep continuity and architecture, leading to increased daytime sleepiness.

The 2021 study done by Yeluri K. [27] on medical students in Mysuru, Karnataka, analyzing their screen time with perceived sleep quality and quantity and academic performance, concluded that total screen time had no direct correlation with sleep quantity, quality or academic performance. However, screen use before bedtime was significantly related to academic performance. In the present study, 48% of children used screens at least 2-4 days a week or more during bedtime. A large proportion of the study children (51.5%) did not stop using screens until 30 minutes before bedtime. When the time interval between ending screen use and bedtime was >1 hour, the subjects' sleep onset latency of the was normal, i.e. 70.8% of participants slept within 20 minutes of bedtime on all 7 days and 20.8% slept within 20 minutes on at least 5-6 days per week when they turned off the screen >1 hour before bedtime. On the contrary, when the interval between last screen use and bedtime was <30 minutes, there was a lower proportion of children who regularly had normal sleep onset latency. However, no significant association was observed between total screen time per day or screen use before bedtime and total sleep score. According to the current study, screen time exceeding the recommended time limit for children aged 3 to 12 years is not a risk factor for the development of behavioral sleep problems. The notable observation that screen use before bedtime undoubtedly has a significant impact on sleep onset seems to support our hypothesis and partially met the primary objective. However, there were also some limitations. The study was conducted in a hospital setting and therefore may not be representative of the general population. The sample size was relatively small, as excessive screen use among children is a growing problem. Parents' responses to the question about their children's sleep patterns in the last month may contain recall errors and response bias. As this was a random sample, there is also the possibility of selection bias.

Conclusions

Screen use of electronic devices has a detrimental effect on sleep in preschool and school-age children, i.e., there is a delay in falling asleep that exceeds the normal threshold of 20 minutes when screen use is stopped less than 30 minutes before bedtime. With increasing age, the total duration of screen use per day increases significantly. A longer time spent in front of the screen is associated with a higher body mass index in a child in relation to age and gender. Screen use during mealtimes is very common among preschool and school-age children.

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Ethical approval

Institutional Ethics Committee approval taken from the Institutional Ethical Committee (ID ethic No. after obtaining approval from the Institutional Ethical Committee (JSS/MC/PG/5189/2019-20).

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Conflict of interest

There is no conflict of interest.

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