Study of Sleep Parameters on Respiratory Health and School Performance in Urban Children

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SG, MM, NR, AS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SG, MM and SJP managed the analyses of the study. Author SJP managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Background: Sleep plays a crucial role in maintaining the health and well-being of children, affecting their physical, psychological, and cognitive development. However, research has shown that sleep problems in children are increasingly prevalent, impacting their health and quality of life.
Objective: To study the impact of sleep parameters on respiratory illnesses and school performance among children of age group 3 to 15 years.
Methods: An observational, cross-sectional study was conducted using a validated questionnaire, in which 300 parents were asked about their children's sleeping behaviours, as well as about the

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details of respiratory illness and school functioning. The children's growth parameters were also recorded.

Results: 97% of children with early bedtimes (before 10 PM) were found to be more attentive in the class and 83.7% of them had a lower risk of respiratory illness than 82.2% and 52% children with of late bedtimes consecutively (P<0.004). 93.9% of children with night sleep duration of >8 hours, were more attentive and 69.5% of them had a lesser frequency of respiratory illnesses than 78.7% and 53.7% of those with night sleep of <8 hours (P<0.001). The most frequent cause of abnormal sleep behaviour was late-night screen use (25.7%), leading to overweight/obesity in the study population.

Conclusion: Children with late bedtime, <8 hours of night sleep, sleep latency >30 minutes, and waking up difficulties had a higher risk of respiratory illnesses and poor school performance. Educating parents and teachers in early identification and correction of children with sleep disorders is very vital.

1. INTRODUCTION

Sleep plays a crucial role in maintaining the health and well-being of children, affecting their physical, psychological, and cognitive development. Research has shown that sleep problems in children are increasingly prevalent, impacting their quality of life and posing long-term consequences for their health and well-being. [1]. Understanding the correlation between sleep and health-related quality of life in children is essential for developing effective strategies to address sleep disorders and promote overall well-being. "Sleep is a reversible neurobehavioral state of perceptual disengagement from and unresponsiveness to the environment. It is a complex amalgam of physiologic behavioural processes "defined by Carskadon and Dement [2]. Sleep issues among children are ranked as the fifth leading concern of parents [3]. Globally around one-third of children suffer from sleep disorders [3]. Studies conducted in India estimated the prevalence of sleep problems as 3.2-25.5% [4,5]. The magnitude of this problem is associated with certain complaints of children including bed wetting, sleep talking, sleepwalking, teeth grinding, and night terrors [6] Therefore, it is particularly important to detect and identify these symptoms among children during the initial stages to prevent physical and behavioural deterioration. Extensive research has been conducted in the field of sleep medicine all over the world, and measures to assess various disorders of sleep disturbance have been developed [2,4]. However, in the Indian context, there is paucity of studies regarding the associations between sleep problems, respiratory illness, and academic performance among small children under the age of 15 years as majority of these studies were conducted among teenagers and adolescents [7].

The current study is the unique of its kind, conducted in urban part of Maharashtra, and it aims to describe the sleep characteristics of children aged 3 to 15 years in urban setting, as well as to find the associations between sleep parameters, respiratory illness in children, and their school performance.

2. MATERIALS AND METHODS

The study adopted an observational, cross-sectional design and was conducted among children who visited the outpatient department (OPD) or were admitted to the inpatient department (IPD) in the department of pediatrics at the Bhaktivedanta Hospital and Research Institute, Mira Road (East), Thane, Maharashtra. The duration of the study was from August 2019 to January 2022, with a total sample size of 300 study participants. The study participants were recruited based on the inclusion criteria, which enrolled patients belonging to the age groups 3–15 years (boys and girls) who visited the pediatric OPD or IPD. Among these, children with chronic medical conditions and children who required multiple hospital visits for the treatment of chronic heart disease, chronic kidney disease, seizure disorders, chronic asthma, etc. were excluded from this study. Eligible participants were interviewed after being informed and obtaining consent. A questionnaire form was formulated with questions on the sleep practices of their children, the frequency of inattentiveness of the child in the classroom as complained by their teachers, the grades received in the last exam, the frequency of sick days due to respiratory illnesses in a year, along with the

demographic details. The questionnaire form was made according to the standards of sleep parameters given in the CDC* (Centers for Disease Control and Prevention) guidelines and practical knowledge in paediatric OPD and was validated by subject experts [8]. The study was approved by the institutional ethics committee. The questionnaires were filled out by the doctor interviewing parents, and in the end, they were educated about the best sleep practices.

The data was exported to SPSS version 23.0, and a P-value less than 0.05 was considered statistically significant. A statistical significance test was conducted using the chi-square or Fisher exact test and the ANOVA test.

3. RESULTS

The study enrolled 300 study participants between 3 and 15 years of age. The mean age of the study population was 7.3 years, with a standard deviation of ±3.2 (7.3±3.2 years). The age group of the study population has been classified into three groups, where 50% of the children belonged to 6–10 years of age, followed by 33% (n = 99) of the children belonged to the age group of 3-5 years (Table 1). There was a near-equal distribution of boys (52.3%) and girls (47.7%) in the study. There was no gender influence on any of the sleep parameters in the study. Nearly two-thirds of the study population (64%) belonged to the primary standard of class.

Based on BMI, 42.7% (n = 128) of the children were in either the overweight or obese category.

Four sleep parameters: 1) bedtime, 2) sleep latency, 3) sleeping hours, and 4) wake-up difficulties were recorded along with causes of abnormal sleep behavior, and they were compared with the frequency and duration of respiratory illnesses and school performance of the child over the last year, as mentioned in Tables 2 and 3. The results were as follows:

3.1 Comparison of Sleep Parameters with Respiratory Health and School Performance

In the study, 67.4% of our population (children aged 3 to 15 years) were late sleepers (they went to bed after 10 p.m.) (Table 2). Among them, 48.7% of the children went to bed between 10.00 PM and 12.00 am, and 18.7% went to bed late after 12.00 am. Only 32.6% (n = 68) were early sleepers (going to bed before 10 PM). 97% of children with early bedtimes (before 10 PM) were found to be more attentive in the class, and 83.7% of them had a lower risk of respiratory illness than 82.2% and 52% of children with late bedtimes consecutively *(P<0.004).* It was also seen that early sleepers had a higher frequency of excellent performance in the exam in the previous year (91.8%) as compared to those with late sleepers (68.3%) *(P<0.001)* (Tables 2 and 3).

Table 1. Demographic data of the enrolled in the study participants

Variable	Category	Frequency (n)	Percentage % (N=300)
Age (in years)	3-5 years	99	33
Mean -7.3	6-10 years	150	50
SD- 3.2	11-15 years	51	17
Gender	Males	157	52.3
	Females	143	47.7
Class	Pre-primary (LKG & UKG)	86	28.7
	Lower primary (1-4)	147	49
	Upper primary (5-7)	45	15
	High school (8-10)	22	7.3
Height (in cm)	<100	43	14.3
	100-139	63	21
	140-170	194	64.7
Weight (in kg)	≤20	141	47
	21-40	129	43
	41-60	28	9.3
	>60	2	0.67
Body Mass Index	Underweight	42	14.0
	Healthy weight	130	43.3
	Overweight	78	26.0
	Obese	50	16.7

Table 2. Association between sleep and respiratory illness*

Variables		Respiratory Illness (Frequency of cold/cough episodes/year)				Respiratory Illness (Sick days per year)			
		<2 Times n(n%)	2-5 Times n(n%)	>5 Times n(n%)	Total n(n%)	<15 days n(n%)	15-30 days n(n%)	>30 days n(n%)	Total n(n%)
Bedtime	Early	82	13	3	98	94	4	0	98
	Sleepers (<10PM)	83.7	13.3	3.1	100	95.9	4.1	0	100
	Late	105	80	17	202	135	43	24	202
	Sleepers (>10 PM)	52.0	39.6	8.4	100	66.8	21.3	11.9	100
	P value	*P<0.001*				*P<0.05*			
Sleep latency	< 30 min	110	35	6	151	127	19	5	151
		71.0	23.2	4.0	100	84.1	12.6	3.3	100
	>30 min	77	58	14	149	102	28	19	149
		51.7	38.9	9.4	100	68.5	18.8	12.8	100
	P value	*P<0.05*				*P<0.05*			
Sleeping Hours in night	≤8 hours	73	53	10	136	87	28	21	136
		53.7	39.0	7.4	100	64.0	20.6	15.4	100
	>8 hours	114	40	10	164	142	19	3	164
		69.5	24.4	6.1	100	86.6	11.6	1.8	100
	P value	*P<0.05*				*P<0.001*			
Waking up difficulty	No	149	43	7	199	180	16	3	199
		74.9	21.6	3.5	100	90.5	8	1.5	100
	Yes	38	50	13	101	49	31	21	101
		37.6	49.5	12.9	100	48.5	30.7	20.8	100
	P value	*P<0.001*				*P<0.001*			

*Based on CDC Guidelines 2017[8]

Table 3. Association of sleep-in relation to the academic performance

	Variables	School Performance (Grade)**				School Attentiveness	
		Excellent n(n%)	Good n(n%)	Average n(n%)	Total n(n%)	Attentive n(n%)	Total class n(n%)
Bedtime	Early	90	8	0	98	95	98
	Sleepers (< 10 PM)	91.8	8.2	0	100	97.0	100
	Late	138	58	6	202	166	202
	Sleepers (>10 PM)	68.3	28.7	3.0	100	82.2	100
	P value	*P<0.001*				*P<0.004*	
Sleep latency	< 30 min	131	20	0	151	144	151
		86.75	13.24	0	100	95.3	100
	>30 min	97	46	6	149	117	149
		65.10	30.87	4.02	100	78.5	100
	P value	P= 0.98				*P<0.001*	
Sleeping hours in night	≤8 hours	84	44	6	136	107	136
		61.8	33.8	4.4	100	78.7	100
	>8 hours	144	20	0	164	154	164
		87.8	12.2	0.9	100	93.9	100
	P value	*P<0.001*				*P<0.001*	
Waking up difficulty	No	173	25	1	199	187	199
		86.9	12.6	0.5	100	84.0	100
	Yes	54	41	5	101	74	101
		55.5	40.6	5.0	100	73.3	100
	P value	*P<0.001*				*P<0.001*	

**Excellent was defined as an A grade, good was defined as B and satisfactory was defined as C grade as per academic performance of children of their last academic year as per their schools.

Table 4. Association of Abnormal Sleep behaviour and difficulty in waking up

Abnormal sleep behaviors	Difficulty in waking up			P value
	No	Yes	Total	
Early morning to school	5 (21.7%)	18 (78.3%)	23 (100.0%)	*P<0.001*
Late night screen use	18 (23.4%)	59 (76.6%)	77 (100.0%)	*P<0.001*
Waiting for parents	3 (16.7%)	15 (83.3%)	18 (100.0%)	*P<0.001*
Day time/late evening sleep	5 (55.6%)	4 (44.4%)	9 (100.0%)	0.49
Total	31	96	127	

It is that only half of the children (50.3%) in the study had the recommended sleep latency (less than 30 minutes), while the other half had prolonged sleep latency (sleeping within 30 minutes to one hour) in 36% of children, and 13.7% took more than one hour. 71.8% (n = 110) of children with shorter sleep latency (<30 minutes) had a lesser frequency of respiratory illnesses in comparison to 51.7% (n = 77) of those with longer sleep latency (>30 minutes), with a statistically significant association *(P<0.05).* Also, 84.1% (n = 127) with shorter sleep latency had fewer sick days (<15 days/year) due to respiratory illness as compared to 68.5% of other children with prolonged sleep latency *(P<0.05).* 95.3% of children with lesser sleep latency (<30 minutes) were attentive (not sleepy) in the classroom, whereas 78.5% of children with prolonged sleep latency (>30 minutes) were attentive in the classroom *(P<0.001).* (Tables 2 and 3)

Sleep hours were broadly divided into two categories. 1) Adequate sleep duration= >8 hours/night and 2) Inadequate sleep duration= ≤ 8 hours/night (8 hours is minimum sleep duration criteria for age group 14 & above as per CDC). Only 54.6% (n=164) had adequate sleep (>8 hours in night). Among them, 154 (93.9%) were attentive in class, 144 (87.8%) scored an excellent grade, and 114 (69.5%) had a lower frequency of respiratory illness, which were much better compared to inadequate sleepers *(P<0.001).* (Tables 2 and 3)

Wake-up difficulty was found in 33.6% of the study participants. As the age increased, there was increase in difficulty to get up from bed *(P<0.05).* A significant association was found between difficulty in waking up and less sleeping hours (p<0.001). Children who had trouble in getting up from bed reported more respiratory illness (62.4%) as compared to children without such difficulty (37.6%) *(P<0.001).* Children without waking up difficulties scored better (86.9%) as compared to children with waking up difficulties, in which only 55.5% scored better in exam *(P<0.001).*

In the study, 127 (42.3%) had reported abnormal sleep behavior, and among them, 96 (75.59%) had wake-up difficulty in the morning. Late-night screen usage and early morning school being the common causes. A statistically significant association was seen *(P<0.001)* between above mentioned abnormal sleep behaviors and waking up difficulty (Table 3).

4. DISCUSSION

Sleep is an important predictor of immunity [9]. Children and adolescents require an average sleep time of approximately 8-9 hours/night, but studies revealed that 45% of children sleep for less than 8 hours/night [10]. Sleep deprivation results in poorer immune functions, such as reduced natural killer cell activity, suppressed interleukin-2 production, and increased levels of circulating proinflammatory cytokines. It causes attenuation of antibody response to both hepatitis and influenza immunizations [11]. It also reduces necessary overnight brain activity for neurocognitive functioning [10]. Poor sleep, characterized by short duration, poor efficiency and poor quality predicts the incidence and severity of number of chronic medical conditions, including cardiovascular disease, type 2 diabetes, and susceptibility to acute infectious illness [12]. Studies have shown that partial or total sleep restriction cause consistent changes in the immune system (e.g. diminished t-cell proliferation), a shift away from t-helper cell 1 cytokine production reduced natural killer cell cytotoxicity and activation of inflammatory pathways and increased the risk for upper respiratory infections [13]. Shorter sleep duration increased the risk of upper airway infection, whereas longer sleep duration did not. Simultaneously, studies have been shown that sleeping for less than 7-9 hours per night increases the risk of upper airway infection. Human studies on the relationship between sleep and catching a cold or other airway infection have mostly been small and yielded conflicting results [13]. Sleep is especially important for children as it affects learning, memory, and

school performance. Studies showed that poor sleep, increased sleep fragmentation, late bedtimes and early awakening adversely affect the learning capacity, academic performance, and neurobehavioral functioning of children [14,15].

4.1 Bedtime

Even though the recommended bedtime by Centers for Disease Control and Prevention (CDC) for adults is between 10:00 p.m. and 11:00 p.m., and for children is before 10:00 p.m., the majority, 67.4% of our study population (children aged 3 to 15 years) were late sleepers (they went to bed after 10 p.m.) [8]. Based on a study conducted by Jodi Mindell *et al.* [16] in 2009, bedtime routines are beneficial in improving multiple aspects of children's sleep, especially wakefulness, sleep continuity as well as children's emotional and psychological well-being. On Age-wise analysis in the study, children of younger ages went to bed earlier than children of older ages, so children's bedtimes get later as they get older. This reverse association between age and bedtime was found statistically significant *(P<0.001).* Previous research by Foley JE *et al.* [17] in 2018 and Hua Diao *et al.* [18] in 2020 found that as the children reach early puberty, they tend to sleep late.

4.1.1 Bedtime and respiratory illnesses

In the study, early sleepers (Sleeping prior to 10 PM) had a lower risk of respiratory illness (<2 episodes/year) than the late sleepers (sleeping after 10 PM). The late sleepers had three-fold higher frequency (39.6%) of respiratory illness in compared to early sleepers. Furthermore, in the study, 95.9% of early sleepers had lesser sick days with respiratory illnesses (< 15 days in a year) than 66.8% of the late sleepers *(P<0.05).* A study conducted in 2022 by Katarzyna *et al.* [19] found that the relative risk of respiratory diseases was two-fold higher in those who went to bed after midnight versus those who went to bed between 10 PM and 12 AM. Hence, late sleepers (>10 PM) increases the risk of respiratory illnesses as proven in our study as well the other studies. Parents must be educated about importance of early bedtime to protect their children from respiratory illnesses.

4.1.2 Bedtime and school performance

The findings of the study were consistent with studies by Okano, K.*et al.* [20] in 2019, Zeek ML

et al. [21] in 2015 and Fakhari *et al.* [22] in 2016, which concluded that getting a full night sleep before taking an exam is associated with higher grade. As the performances of students were higher among early sleepers than with the late sleepers, parents must ensure early bedtime for better academic performance especially before exam. We discovered that 97% of early sleepers were more attentive/ non-sleepy in class than 82.2% children with late sleepers (*P<0.004).* Hence early bedtime can be concluded as an important parameter for better school performance.

4.2 Sleep Latency

According to sleep foundation, 2020, sleep latency refers to the amount of time it takes to fall asleep. Sleep latency ranges between 10 and 26 minutes on average. Sleep latency is important because it reflects person's sleepiness and provide insight into sleep quality [23]. Only half of the children (50.3%) in this study had the recommended sleep latency (less than 30 minutes). The causes of prolonged sleep latency included an unpleasant sleeping environment, too much light in the room (light sends "wake-up" signals to the child's brain, which can extend sleep latency and cause sleep deprivation), and the child's chronotype (chronotype is the body's proclivity for either late nights or early mornings).

4.2.1 Sleep latency and respiratory illness

The study also found that children with shorter sleep latency (<30 minutes) had lesser frequency and duration of respiratory illnesses in comparison to those with longer sleep latency *(P<0.05).* The same was proved in a study conducted by Choudhary *et al.* [24] in and Cohen *et al.* [25], that increased sleep latency (rapid and non-rapid eye movements) correlates with the elevated interleukin-4 and interleukin-b levels in patients with allergic rhinitis. As a result, sleep deprivation weakens the immune system, making children more vulnerable to respiratory issues.

4.2.2 Sleep latency and school performance

The findings of this study were consistent with the findings of Joao Duarte *et al.* [26] who demonstrated that sleep latency is associated with morning tiredness, daytime sleepiness during lectures.

4.3 Sleep Hours

As per CDC 2019, the recommended sleeping hours for various age groups are as follows: 10

to 13 hrs. for pre-schoolers (3-5 years), 9 to 11 hrs. for school-aged (5-13 years), 8 to 10 hrs. for children aged 14 to 17 years [27]. Reduced sleeping hours may be caused by emotional factors such as stress, anxiety, and mood disorder, as well as tension related to their academic activities and study load. Children's attention, behaviour, learning, memory, and overall mental and physical health may suffer because of fewer sleep hours. Homework, going out with friends, late-night television viewing, video games, and internet usage are the common causes of sleep deprivation, according to a study by Sari Stenholm *et al.* [28] in 2019. Other reported factors by a study conducted by Jakobsson M *et al.* [29] in 2018, include social and customs, cultural, and climatic factors that may affect children's sleep duration.

4.3.1 Sleep hours and respiratory Illness

In the study, children with night sleep of >8 hours were less likely to develop respiratory illness than children who slept less *(P<0.05).* In a similar study, Cohen *et al.* [30] in 2009 found that those who slept for seven hours were 2.94 times more likely to catch a cold than those who slept for eight hours. Hence parents should ensure adequate night sleeping hours for their wards.

4.3.2 Sleep hours and performance in school

Sleep provides an essential function for memory consolidation, which helps to remember what has been studied which in turn is critical for successful academic performance. Children who do not get enough sleep more likely to struggle with attention and behaviour issues, which can lead to poor school functioning. Megan *et al.* [21] in 2017 proved that adequate sleep in the night prior to an examination is positively associated with student's exam grades. Similarly, in the study, children with night sleep of >8 hours were more attentive and had an excellent academic performance as compared to inadequate sleepers *(P<0.001).*

4.4 Wake up Difficulty

The study found that those who went to school early were more likely to report waking up difficulty (78.3%) and found a significant association. The blue light emitted by through cell phone screen restrains the production of melatonin, the hormone that controls sleep-wake cycle, this makes falling asleep and waking up the next day even more difficult. This could

explain why children who used screens late at night had more difficulty waking up (76.6%) (Table 3). Consistent to a study conducted by Jakobsson *et al.* [31], more than 30% of the study participants had wake-up difficulty. Many of the children who took part in the study had bedtime delays and sleep disturbances. This could be the reason for their delayed awakening. Like previous study conducted by Knutson *et al.* [32] in 2017, lesser sleeping duration is associated with difficulty in getting up from bed. Wakeup difficulty was significantly associated with poor respiratory health and poor school performance with *P<0.001* as shown in Table 2 and Table 3.

4.5 Causes of Abnormal Sleep Behaviour

Most parents reported one or more of five causes for sleep disturbance. The most frequent cause reported was late night screen use (25.7%). Other causes reported include early morning school (7.7%), waiting for parents to return from job (either father or mother) prior to sleep (6%), daytime sleep/ late evening sleep of children (3%). In a study conducted by J.M. Nagata *et al.* [33] in 2023, late-night screen use was cited as the primary cause of sleep disturbance by the study population, which supports the study findings. However, the study was conducted during and post COVID-19 pandemic, where online classes and social isolation was common practice, thus affecting the screen time and the sleep. More than 80% of the children who had sleep disturbances for more than one per week had more duration of respiratory illness (more than 15 days). *(P<0.001)*

According to studies by Hirshkowitz *et al.* [34] in 2015 and CDC 2017, screen time in the hour before bed can stimulate children in such a way that blue light from televisions, computer screens, phones, and tablets may suppress melatonin levels and delay sleepiness [16]. This might be a reason for sleep delay.

This study provides a base for exploring the patterns of sleep behaviouramong children in urban Maharashtra and the association with respiratory illness and school performances. The study found and proved significant associations between bedtime of children, sleeping hours, sleeping disturbances in respiratory illness. A significant association was found between sleeping hours and exam scores, bedtime, and school performance. As a result, the study urgently calls for routine screening measures in

paediatric outpatient department to facilitate better and early detection of sleep disorders in children. Educating parents and teachers to identify children with sleep disorders is essential and must be implemented as part of long-term healthcare plans in the country.

5. LIMITATION

Further studies with a larger sample size are needed to make robust findings. Additionally, the studies generalizability was restricted due to its single-site design, conducted solely within a hospital setting consisting of only health seeking population.

6. CONCLUSION

The study endeavoured to examine the impact of various sleep parameters in children and has proven a significant correlation between disturbed sleep patterns with poor respiratory health and poor school performance. This presents a concern as it entails potential adverse health ramifications attributed to inadequate sleep duration, bedtime postponement, and excessive screen exposure. To safeguard children's well-being, comprehensive strategies are imperative at both educational institutions and within households to foster and reinforce healthy sleep patterns and behaviours among them for a brighter future and a healthier lifestyle.

CONSENT

Written consent was obtained from the parent or carer prior to inclusion for patients meeting the inclusion criteria.

ETHICAL APPROVAL

Ethical clearance has been obtained from the Institutional Ethics Committee. The participant's identity was kept strictly confidential, and the privacy of the data was maintained.

ACKNOWLEDGEMENTS

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/116588