*Original Research Article*

**Effect of sleep on recurrent respiratory illnesses and school performances in children**

ABSTRACT

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| **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, in which parents were interviewed about their children’s sleeping behaviours, as well as about the details of respiratory illness and school functioning. The children's growth parameters were also recorded. **Results:** A total number of 300 children enrolled in the study. 97% of children with early bedtimes were more attentive/ non-sleepy in class and 83.7% of them had a lower risk of respiratory illness than children with late bedtimes (P<0.004). 93.9% of children who slept for >8 hours in the night were more attentive and 69.5% of them had a lesser frequency of respiratory illnesses than those who slept for less than 8 hours in the night (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 sleep duration, higher sleep latency, and waking up difficulties had a higher risk of respiratory illnesses and poor school performance. 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. |

*Keywords: [Sleep behaviour in children, school performance, respiratory illnesses, screen time, sleep latency, waking up difficulties, sleep hours, bedtime]*

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 very important to detect and identify these symptoms among children during the early 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. 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. material and methods

Our study adopted an observational cross-sectional design and was conducted among children who visited in 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 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 paediatric OPD or IPD. Among these, Children with chronic medical conditions, 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. Duration of the study was from August 2019 to January 2022 with a sample size total of 300 study participants. With prior informed consent, eligible participants were interviewed, questionnaires were filled and pamphlets explaining the best sleep hygiene practices were given to the parents. The data was exported to SPSS version 28.0 and P-value less than 0.05 was considered statistically significant.

3. results and discussion

Sleep is an important predictor of immunity [7]. Children and adolescents require an average sleep time of approximately 9 hours/night, but studies revealed that 45% of children sleep only for less than 8 hours/night [8]. 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 [9]. It also reduces necessary overnight brain activity for neurocognitive functioning [9].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 [10].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 [11]. 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 [11]. 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 [12,13].

Our study enrolled subjects between 3 to 15 years of age. Mean age of the study population was 7.3 years with standard deviation of ±3.2 (7.3±3.2 years). The age group of the study population has been classified into three groups where the half (50%) of the children belonged to 6-10 years of age followed by 33% (n=99) children belonged to the age group of 3-5 years (Table 1). There was near equal distribution of boys (52.3%) and girls (47.7%) in the study. There was no gender influence on any of sleep parameter in the study. Nearly two third of the study population (64%) belonged to primary standard of class. Based on BMI, 42.7% (n=128) children were among either overweight or obese category.

**Table 1: Demographic data of the subjects enrolled in the study.**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Category | Frequency(n) | Percentage %(N=300) |
| Age (in years)Mean -7.3SD- 3.2 | 3-5 years | 99 | 33 |
| 6-10 years | 150 | 50 |
| 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**: **Sleep Parameters in comparison with respiratory illness and school performance**

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| --- |
| Table 2a: Association between Sleep and Respiratory illness |
| Variables | **Respiratory Illness (Frequency)** |  **Respiratory Illness (Duration)** |
| <2 Times n(n%) | 2-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****Bedtime****(Before 10.00 PM)** | 8283.7 | 1313.3 | 33.1 | 98100 | 9495.9 | 44.1 | 00 | 98100 |
| **Late****Bedtime****(After 10.00 PM)** | 10552.0 | 8039.6 | 178.4 | 202100 | 13566.8 | 4321.3 | 2411.9 | 202100 |
| **P value** |  P<0.001 | P<0.05 |
| Sleep latency | **< 30 min** | 11071.08 | 3523.2 | 64.0 | 151100 | 12784.1 | 1912.6 | 53.3 | 151100 |
| **>30 min** | 7751.7 | 5838.9 | 149.4 | 149100 | 10268.5 | 2818.8 | 1912.8 | 149100 |
| **P value** | P<0.05 | P<0.05 |
| Sleephours | **≤ 8 hours** | 7353.7 | 5339.0 | 107.4 | 36100 | 8764 | 2820.6 | 2115.4 | 136100 |
| **>8 hours** | 11469.5 | 4024.4 | 106.1 | 164100 | 14286.6 | 1911.6 | 31.8 | 164100 |
| **P value** | P<0.05 | P<0.001 |
| Waking up difficulty | **No** | 14974.9 | 4321.6 | 73.5 | 199100 | 4948.5 | 3130.7 | 2120.8 | 101100 |
| **Yes** | 3837.6 | 5049.5 | 1312.9 | 101100 | 18090.5 | 168 | 31.5 | 199100 |
| **P value** | P<0.001 | P<0.001 |
| Table 2b Association of sleep-in relation to the academic performance |
|  |  | **School Performance (Grade)** | **School Attentiveness** |
|  | **Variables** | **Excellent n(n%)** | **Good n(n%)** | **Average n(n%)** | **Total n(n%)** | **Attentive n(n%)** | **Total class n(n%)** |
| Bedtime | **Early****Bedtime** | 9091.8 | 88.2 | 00 | 98100 | 9597.0 | 98100 |
| **Late****Bedtime** | 13868.3 | 5828.7 | 63.0 | 202100 | 16682.2 | 202100 |
| **P value** | P<0.001 | P<0.004 |
| Sleep latency | **< 30 min** | 13186.75 | 2013.24 | 00 | 151100 | 7473.3 | 101100 |
| **>30 min** | 9765.10 | 4630.87 | 64.02 | 149100 | 126.0 | 199100 |
| **P value** | P= 0.98 | P<0.001 |
| Sleephours | **≤ 8 hours** | 8461.8 | 4433.8 | 64.4 | 136100 | 10778.7 | 136100 |
| **>8 hours** | 14487.8 | 2012.2 | 00.9 | 164100 | 15493.9 | 164100 |
| **P value** | P<0.001 | P<0.001 |
| Waking up difficulty | **No** | 17386.9 | 2512.6 | 10.5 | 199100 | 18784.0 | 199100 |
| **Yes** | 5455.5 | 4140.6 | 55.0 | 101100 | 7473.3 | 104100 |
| **P value** | P<0.001 | P<0.001 |

**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.) [14]. 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). Based on a study conducted by Jodi Mindell et al [15] 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 our 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 [16] in 2018 and Hua Diao et al [17] in 2020 found that as the children reaches early puberty, they tend to sleep late. While in terms of growth parameters i: e BMI, obese (56%) and overweight children (50%) slept later (between 10.00pm to 12.00 am) as compared to underweight children (slept before 10.00 pm). However, no significant association was found *(P<0.08).* Significant association was found between respiratory illness in children and sleep time *(P <0.05).*

**1.1 Bedtime and respiratory illnesses:** (Table 2a) In our study, 83.7% of early sleepers (Sleeping prior to 10 PM) had a lower risk of respiratory illness (<2 episodes/year) than the 52% of late sleepers (sleeping after 10 PM). This association was found statistically significant with *P<0.001. However*, late sleepers had three-fold higher frequency (39.6%)of respiratory illness in compared to early sleepers. Furthermore, in our study, 95.9% of children who went to bed early had lesser days with respiratory illness (< 15 days in a year) than 66.8% of the late sleepers, this was also statistically significant *(P<0.05).* A study conducted in 2022 by Katarzyna et al [18] 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 bedtime (>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.

**1.2 Bedtime and school performance:** (Table 2b) Our study also assessed the academic performance of children of their last academic year as per their schools, where excellent was defined as an A grade, good was defined as B and satisfactory was defined as C grade. It was seen that children who got into bed early (before 10 PM) 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%). This association was found significant *(P<0.001).* Okano, K.et al [19] in 2019, Zeek ML et al [20] in 2015 and Fakhari et al [21] in 2016 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 children with early bedtimes were more attentive/ non-sleepy in class than 82.2% children with late bedtimes (*P<0.004).*

**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 [22].Only half of the children (50.3%) in our 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% children and 13.7% took more than one hour 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*).*

**2.1 Sleep latency and respiratory illness:** (Table 2a**)** Our study found that 71.8% (n=110) of children with shorter sleep latency (<30 minutes) had 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 lesser sick days (<15 days/year) due to respiratory illness as compared to 68.5% of other children with prolonged sleep latency *(P<0.05)*. The same was proved in a study conducted by Choudhary et al [23] in and Cohen et al [24], 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.

**2.2 Sleep latency and school performance*:*** (Table 2b)73.3% of children with lesser sleep latency (<30 minutes), were attentive (not sleepy) in classroom whereas 6% of children with prolonged sleep latency (>30 minutes) were sleepy in classroom *(P<0.001).* Our findings are consistent with the findings of Joao Duarte et al, who demonstrated that sleep latency is associated with morning tiredness, daytime sleepiness during lectures [25].

**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.[26].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 [27] in 2019. Other reported factors by a study conducted by Jakobsson M et al [28] in 2018, include social and customs, cultural, and climatic factors that may affect children’s sleep duration. In our study, we found that more than 28.3% of children aged 3 to 5 years, 50% of children aged 6-10 years and 64.7% of children aged 11 to 15 slept for less than eight hours per night. There was no relation of sleeping hours with gender, class of study and BMI.

**3.1 Sleep hours and respiratory Illness:** (Table 2a)In our study, children who slept for more than eight hours (69.5%) were less likely to develop respiratory illness than children who slept for less than eight hours (53.7%) *(P<0.05).* In a study like ours, Cohen et al [29] 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 sleeping hours for their children.

**3.2 Sleep hours and performance in school:** (Table 2b)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 [20] in 2017 proved that adequate sleep in the night prior to an examination is positively associated with student’s exam grades. Similarly, in our study, children who slept for more than eight hours were more attentive (93.9%) and had an excellent academic performance (87.8%) as compared to those who slept for less than or equal to eight hours, 61.8% and 78.7% respectively *(P<0.001).* Children who slept for more than eight hours were more attentive (93.9%) than those who slept for less than eight hours, which is statistically significant *(P<0.001).*

**4.Wake up difficulty**

Consistent to a study conducted by Jakobsson et al [30], more than 30% of the study participants had wake-up difficulty.Many of the children who took part in our study had bedtime delays and sleep disturbances. This could be the reason for their delayed awakening. Like previous study conducted by Knutson et al [31] in 2017, lesser sleeping duration is associated with difficulty in getting up from bed. Our 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). However, not much significant gender difference was found between gender and waking up difficulty *(P value =0.83).* Wakeup difficulty was significantly associated with poor respiratory health and poor school performance with *P<0.001* as shown in Table 2a and Table 2b.

**Table 3: Association of Abnormal Sleep behaviour and difficulty in waking up**

|  |  |  |
| --- | --- | --- |
| Abnormal sleep behaviours | Difficulty in waking up | P value |
| No | Yes | Total |
| Early morning to schoolLate night screen useWaiting for parentsDay time/late evening sleep | 5 (21.7%)18 (23.4%)3 (16.7%)5 (55.6%) | 18 (78.3%)59 (76.6%)15 (83.3%)4 (44.4%) | 23 (100.0%)77 (100.0%)18 (100.0%)9 (100.0%) | P<0.001P<0.001P<0.0010.49 |

**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%). A study conducted by Punamaki et al [32] in 2016, late-night screen use was cited as the primary cause of sleep disturbance by the study population which supports our study finding. This 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 [14] 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 [15,33]. This might be a reason for sleep delay.

Our study provides a base for exploring the patterns of sleep behaviour among 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 study's generalizability was restricted due to its single-site design, conducted solely within a hospital setting consisting of only health seeking population.

4. 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 informed consent was obtained from the patient.

**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.

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