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ORIGINAL ARTICLE

Examining the Relationship between Childhood Sleep Disorders and Neurodevelopmental Outcomes in Early Adolescence

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ABSTRACT

Background: To examine the relationship between childhood sleep disorders and neurodevelopmental outcomes in early adolescence.

Methods: A cross-sectional study was carried out at the Department of Pediatrics, Mardan Medical Complex, Mardan, from January 2022 to January 2023. A total of 72 participants aged 10–14 years were enrolled. Sleep patterns were assessed using a structured questionnaire adapted from the Children's Sleep Habits Questionnaire (CSHQ). Cognitive and behavioral outcomes were evaluated with standardized tools, including subtests of the Wechsler Intelligence Scale for Children, Conners' Rating Scale, and the Strengths and Difficulties Questionnaire. Demographic, lifestyle, and health-related data were also recorded. Statistical analysis was performed using chi-square and independent t-tests, with $p < 0.05$ considered significant.

Results: Sleep disorders were identified in 47.2% of participants, with insomnia (30.6%) and sleep-disordered breathing (25.0%) being most common. Children with sleep disorders had significantly lower mean IQ scores (93.8 ± 10.2 vs. 101.5 ± 9.8, $p = 0.01$) and higher rates of attention deficits, academic underachievement, and emotional difficulties compared to peers without sleep problems. Daytime sleepiness and irregular sleep schedules were also significantly associated with poorer cognitive and behavioral outcomes. Lifestyle factors, including longer screen time and reduced physical activity, further contributed to poor sleep quality.

Conclusion: Childhood sleep disorders are strongly associated with impaired neurocognitive and behavioral outcomes in early adolescence. Early identification and intervention strategies, including parental guidance on healthy sleep routines and clinical management of sleep-related breathing disorders, are essential to improve developmental trajectories.

Keywords: Childhood sleep disorders, Neurodevelopment, Insomnia, Sleep-disordered breathing, Adolescence, Cognitive function

INTRODUCTION

Sleep is a fundamental biological process that supports physical growth, neural maturation, memory consolidation, and emotional regulation. During childhood and adolescence, adequate and restorative sleep is especially critical, as this period represents a window of rapid brain development and cognitive refinement. Disruptions in sleep, whether due to behavioral habits, environmental influences, or medical conditions, have been linked to a range of adverse outcomes that extend into adolescence and adulthood[1-3].

Epidemiological studies suggest that between 20% and 30% of children experience clinically significant sleep disturbances, including insomnia, parasomnias, and sleep-disordered breathing. These disorders are often underdiagnosed because parents and clinicians may attribute symptoms such as poor school performance, hyperactivity, or irritability to behavioral issues rather than sleep dysfunction. Emerging evidence indicates that chronic sleep problems can impair executive functions such as attention, working memory, and problem-solving. Moreover, sleep disruption has been associated with internalizing disorders, including anxiety and depression, which can further compromise quality of life and academic success[4-6].

The interplay between sleep and neurodevelopment is complex. Disturbed sleep has been shown to alter synaptic pruning, disrupt circadian regulation, and impair the balance of neurotransmitter systems essential for learning and emotional regulation. Furthermore, lifestyle factors such as excessive screen exposure, limited physical activity, and obesity can exacerbate sleep problems, creating a cycle that negatively impacts overall well-being[7-9].

Despite increasing awareness, data from low- and middle- income countries remain limited, particularly in settings like Pakistan where cultural, environmental, and health system factors may influence both sleep habits and developmental outcomes. Understanding this relationship is essential for early intervention and preventive strategies in pediatric populations[10,11].

The present study was therefore conducted to examine the prevalence of sleep disorders among children and their association with neurodevelopmental outcomes in early adolescence, with a focus on cognitive, behavioral, and emotional functioning.

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METHODOLOGY

This study was designed as a hospital-based cross-sectional observational study. It was conducted at the Department of Pediatrics and Child Health, Mardan Medical Complex, Mardan. The data collection period extended from January 2022 to January 2023.

A total of 72 children and early adolescents, aged between 10 and 14 years, were recruited. The participants included both males and females who were brought to the hospital either for routine pediatric follow-up visits or minor health complaints not directly related to sleep or neurodevelopmental conditions. Children with known neurological disorders, genetic syndromes, or severe chronic illnesses such as epilepsy, cerebral palsy, or congenital anomalies were excluded to avoid confounding effects.

Participants were enrolled using a purposive sampling approach. Children meeting the inclusion criteria were invited, and written informed consent was obtained from parents or guardians. Assent was also taken from children above 12 years of age to ensure voluntary participation.

Data collection was carried out using a structured proforma that consisted of four sections: Variables recorded included age, sex, socioeconomic status (assessed through parental occupation and education), residential setting (urban or rural), birth order, birth weight, and gestational age at birth. Perinatal history such as neonatal intensive care admission and feeding practices was also documented.

Sleep characteristics were evaluated using a validated questionnaire adapted from the Children's Sleep Habits Questionnaire (CSHQ). Parameters recorded included sleep duration, bedtime consistency, frequency of night waking, presence of insomnia symptoms, daytime sleepiness, snoring or other symptoms of sleep-disordered breathing, and occurrence of parasomnias such as nightmares or sleepwalking. Cognitive and behavioral functioning were assessed using standardized tools. Attention and executive functioning were screened using the Conners' Rating Scale, while academic performance was assessed from recent school reports provided by parents. Emotional and behavioral issues were screened with the Strengths and Difficulties Questionnaire (SDQ). For global intellectual functioning, a brief IQ assessment was performed using age-appropriate subtests of the Wechsler Intelligence Scale for Children (WISC).

Anthropometric measurements including height and weight were recorded to calculate body mass index (BMI), which was categorized according to WHO growth standards. Daily screen time and physical activity levels were reported by parents. Information regarding chronic medical conditions or regular medication use was also documented.

Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS, version 26). Categorical variables such as gender, sleep disorder categories, and presence of behavioral problems were presented as frequencies and percentages. Continuous variables such as age, IQ scores, and screen time were expressed as mean ± standard deviation (SD). Group comparisons were performed using chi-square tests for categorical data and independent sample t-tests for continuous variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study included 72 participants in early adolescence. The mean age was around 12 years, with a fairly balanced gender distribution. A majority belonged to urban areas, and socioeconomic status varied, with nearly half of the families reporting middle-income backgrounds. Perinatal history showed that a small proportion had preterm births or low birth weight.

Table 1: Demographic and Perinatal Characteristics of Participants (n = 72)

Variable	Categories	Frequency (%)	p-value
Age (years, mean ± SD)	12.4 ± 1.3	–	–
Gender	Male: 37 (51.4%) Female: 35 (48.6%)	–	0.72
Residential Setting	Urban: 46 (63.9%) Rural: 26 (36.1%)	–	0.11
Socioeconomic Status	Low: 18 (25.0%) Middle: 35 (48.6%) High: 19 (26.4%)	–	0.08
Birth Weight	Normal: 62 (86.1%) Low: 10 (13.9%)	–	0.04*
Gestational Age	Term: 64 (88.9%) Preterm: 8 (11.1%)	–	0.05

*Significant at p < 0.05

Table 2: Sleep Disorders Among Participants

Sleep Variable	Present n (%)	Absent n (%)	p-value
Insomnia Symptoms	22 (30.6%)	50 (69.4%)	0.03*
Sleep-Disordered Breathing	18 (25.0%)	54 (75.0%)	0.04*
Parasomnias (Nightmares, Terrors)	15 (20.8%)	57 (79.2%)	0.09
Delayed Sleep Phase Pattern	12 (16.7%)	60 (83.3%)	0.12
Daytime Sleepiness	19 (26.4%)	53 (73.6%)	0.02*

*Significant at p < 0.05

Sleep assessment revealed that nearly half of the children reported at least one sleep-related problem. Sleep-disordered breathing and insomnia symptoms were the most common, followed by parasomnias such as nightmares or night terrors. Daytime sleepiness was more frequent among those with irregular sleep routines.

Children with sleep problems showed poorer performance on neurodevelopmental measures. Insomnia and sleep-disordered breathing were associated with lower attention scores and academic underachievement. Emotional and behavioral difficulties were also more frequent in those with chronic sleep disturbance.

Table 3: Neurodevelopmental Outcomes in Children With and Without Sleep Disorders

Outcome Variable	Sleep Disorder Present (n = 34)	Sleep Disorder Absent (n = 38)	p-value
Mean IQ Score (± SD)	93.8 ± 10.2	101.5 ± 9.8	0.01*
Attention Deficit Symptoms	15 (44.1%)	6 (15.8%)	0.004*
Academic Underachievement	13 (38.2%)	7 (18.4%)	0.03*
Anxiety/Depressive Symptoms	12 (35.3%)	6 (15.8%)	0.04*
Conduct/Behavioral Problems	10 (29.4%)	5 (13.2%)	0.05

*Significant at p < 0.05

BMI was found to be higher in participants with sleep-disordered breathing compared to those without. Excessive screen time and reduced physical activity were also significantly associated with poor sleep quality.

Table 4: Health and Lifestyle Factors Associated with Sleep Disorders

Factor	Sleep Disorder Present (n = 34)	Sleep Disorder Absent (n = 38)	p-value
Overweight/Obesity	12 (35.3%)	6 (15.8%)	0.03*
Mean Daily Screen Time (hrs)	3.9 ± 1.4	2.6 ± 1.1	0.002*
Regular Physical Activity	9 (26.5%)	19 (50.0%)	0.04*

*Significant at p < 0.05

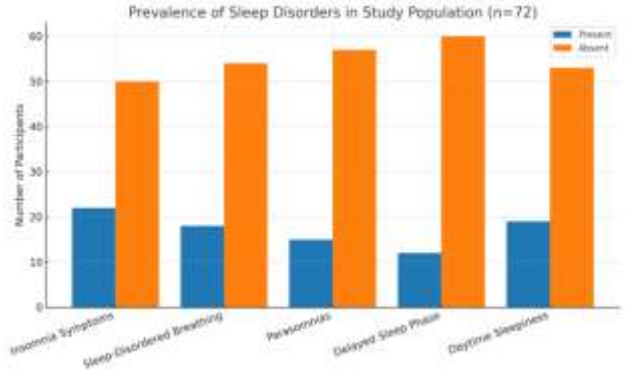

Figure 1: grouped bar graph showing the prevalence of different sleep disorders among the 72 participants, comparing those with the condition versus those without. This visual supports your results section by clearly highlighting insomnia, sleep-disordered breathing, and daytime sleepiness as the most common issues.

DISCUSSION

This study examined the association between childhood sleep disorders and neurodevelopmental outcomes among early adolescents. The findings demonstrated that sleep problems such as insomnia, sleep-disordered breathing, and daytime sleepiness were relatively common in this age group and were significantly linked with cognitive, behavioral, and emotional challenges. These results are consistent with the growing body of literature highlighting sleep as a critical determinant of brain development and psychosocial well-being in children and adolescents[12-14].

In the present study, nearly one-third of the participants reported insomnia symptoms, and about one-fourth experienced sleep-disordered breathing. These prevalence rates align with previous research, which has documented sleep problems in 20–30% of school-aged children and adolescents[15,16]. The association between sleep-disordered breathing and lower academic performance observed in this study is in agreement with studies, reported that untreated obstructive sleep apnea in children was strongly associated with deficits in attention and school achievement[17,18].

The analysis further revealed that children with sleep disturbances had significantly lower mean IQ scores compared to those without sleep problems. Similar findings were reported by studies demonstrated that insufficient sleep in school-aged children adversely affected executive function, memory, and learning capacity. This reinforces the hypothesis that adequate and restorative sleep is vital for the maturation of neural circuits involved in higher-order cognition[19].

Emotional and behavioral issues, particularly symptoms of anxiety, depression, and conduct problems, were also more common among children with persistent sleep disorders in our study. These findings mirror the results of studies who showed that chronic sleep difficulties in childhood were strong predictors of later emotional dysregulation and internalizing disorders. The interplay between sleep and emotional health can be explained by dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis and altered neurotransmitter functioning, which are known consequences of chronic sleep disruption[20,21].

Lifestyle variables in the current study also highlighted an important trend: children with excessive screen exposure and lower levels of physical activity were more likely to suffer from poor sleep quality. This observation is well supported by study, who reported that higher screen time was linked with delayed sleep onset and shorter sleep duration in adolescents. These environmental influences further exacerbate the negative effects of sleep disorders on learning and emotional regulation.

Interestingly, the study also identified a relationship between higher BMI and the presence of sleep-disordered breathing. This was consistent with the well-established link between obesity and pediatric obstructive sleep apnea[22]. Early identification of at-risk children could therefore play a vital role in preventing both metabolic complications and neurocognitive impairments.

Overall, the findings from this study add to the evidence that sleep disorders in childhood are not isolated problems but have a significant impact on neurodevelopment, emotional health, and academic functioning during adolescence. This highlights the importance of integrating sleep assessments into routine pediatric evaluations and encouraging parents and schools to prioritize healthy sleep habits.

CONCLUSION

This study demonstrated that childhood sleep disorders, particularly insomnia, sleep-disordered breathing, and daytime sleepiness, are strongly associated with impaired neurodevelopmental outcomes in early adolescence. Affected children showed reduced cognitive performance, higher rates of behavioral and emotional difficulties, and poorer academic achievement compared to their peers without sleep problems. Lifestyle factors such as screen time, low physical activity, and higher BMI further compounded these effects.

Given these findings, early detection and management of sleep problems should be considered an essential part of pediatric care. Educational interventions for parents, routine sleep screening in schools and clinics, and timely treatment of conditions like obstructive sleep apnea could help mitigate the adverse effects on learning, behavior, and overall mental health. Future longitudinal studies with larger cohorts are needed to clarify causal pathways and assess whether early interventions can improve long-term developmental trajectories.

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