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Association of Childhood Obesity and Risk of Sleep-Disordered Breathing Among Children Using the Pediatric Sleep Questionnaire.

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Abstract

Background: Childhood obesity, now so widespread that the term "globesity" has been coined to describe its global reach, is strongly associated with sleep disorders, particularly obstructive sleep apnoea syndrome (OSA). Evidence suggests that inadequate sleep and physical inactivity are core drivers of the metabolic changes that culminate in obesity. Global surveillance data report an approximately 18% rise in the prevalence of overweight and obesity among children and adolescents aged 5–19 years over the last decade. Study objective: To evaluate the prevalence of obesity among participants with high-risk Pediatric Sleep Questionnaire (PSQ) scores, to assess the association between obesity status and the risk of sleep-disordered breathing using the PSQ, and to compare overall PSQ scores and risk categories between obese and normal-weight groups. ***Methodology***: A community-based comparative cross-sectional study was conducted among 128 children aged 6–16 years in Sushilpura, Jaipur. Participants were divided into normal-weight (n=64) and overweight/obese (n=64) groups based on BMI-for-age criteria. Sleep-related breathing disorder risk was assessed using the validated Pediatric Sleep Questionnaire (PSQ), with a score ≥0.33 indicating high risk. Comparisons between groups were performed using the chi-square test, independent t-test, and odds ratio analysis. ***Results***: Among 128 children, overweight/obese children showed a significantly higher prevalence of sleep-disordered breathing symptoms, daytime sleepiness, and behavioural disturbances compared with normal-weight children ($p<0.05$). High-risk PSQ status was significantly more common among overweight/obese children (75.0% vs 34.4%; OR=5.73, 95% CI: 2.66–12.32). Mean PSQ scores were significantly higher in overweight/obese children, and BMI showed a significant positive correlation with PSQ score ($r=0.36$, $p<0.001$). ***Conclusion***: Overweight and obese children had significantly higher sleep-disordered breathing symptoms, daytime sleepiness, and behavioural disturbances compared with normal-weight children. Increasing BMI was associated with greater severity of sleep-related symptoms, highlighting the importance of early screening and intervention for sleep-related problems among overweight and obese children.

Keywords: Childhood obesity; Sleep-disordered breathing; Daytime sleepiness; Behavioural disturbances; Pediatric Sleep Questionnaire (PSQ).

INTRODUCTION

Childhood obesity has emerged as one of the most pressing public health concerns worldwide, with a consistent rise in prevalence over the last few decades. The scale of the problem has been so striking that the term "globesity" is increasingly used to capture the pandemic character of excess weight across high-, middle-, and low-income countries alike. Current estimates indicate that overweight and obesity among children and adolescents have increased substantially, contributing to an expanding burden of metabolic and cardiovascular disorders later in life (1,2). The pooled analysis by the NCD Risk Factor Collaboration, which drew on measurements from more than 128 million individuals, documented a more than tenfold rise in the global prevalence of childhood and adolescent obesity between 1975 and 2016, with the steepest increases now occurring in parts of Asia (2). India, undergoing a rapid nutrition and lifestyle transition, is experiencing a parallel escalation in paediatric overweight and obesity, adding urgency to research in this population.

While unhealthy dietary practices and sedentary lifestyles remain established contributors, increasing attention is being given to the role of sleep in the development of childhood obesity. Adequate sleep is essential for healthy growth, metabolic regulation, appetite control, and behavioural functioning in children. Sleep disturbances—including short sleep duration, poor sleep quality, and sleep-disordered breathing—are increasingly being linked to childhood obesity. Children with

inadequate sleep often experience daytime tiredness, lower participation in physical activity, unhealthy dietary patterns, prolonged screen exposure, and sedentary behaviour, which may collectively increase the risk of overweight and obesity (3–6).

At a mechanistic level, curtailed or fragmented sleep is thought to promote weight gain through dysregulation of the appetite-controlling hormones leptin and ghrelin, increased insulin resistance, altered circadian timing, and greater opportunity for energy intake during extended wakefulness (4,6,8). Conversely, excess adiposity narrows and destabilises the upper airway, predisposing to snoring and obstructive events during sleep. Recent evidence therefore suggests a close and potentially bidirectional relationship between obesity and sleep disturbances in children and adolescents: poor sleep may contribute to weight gain, while excess adiposity may further increase the risk of sleep-related breathing disorders, creating a self-perpetuating cycle (7–9).

Sleep-disordered breathing (SDB) in children spans a continuum from primary snoring to obstructive sleep apnoea syndrome (OSA), and obesity is among its strongest risk factors (10,12). Untreated paediatric SDB is associated with impaired attention and behaviour, daytime sleepiness, poor school performance, and adverse cardiometabolic consequences (12,18). Because polysomnography—the diagnostic reference standard—is expensive, resource-intensive, and largely unavailable in community and primary-care settings, validated screening instruments are valuable for identifying children who warrant further evaluation. The Pediatric Sleep Questionnaire (PSQ) is a widely validated, parent-reported tool that has been shown to predict moderate-to-severe OSA in children with obesity (14).

Considering the growing importance of sleep as a modifiable risk factor and the limited Indian community-based data on this association, the present study was conducted to assess the association between obesity status and the risk of sleep-disordered breathing using the Pediatric Sleep Questionnaire, and to compare overall PSQ scores and risk categories between study groups.

MATERIALS AND METHODS

Study design and setting. A community-based comparative cross-sectional study was conducted among children aged 6–16 years residing in Sushilpura, Jaipur, Rajasthan. The study was carried out over a period of six months with the objectives of evaluating the prevalence of obesity among participants with high-risk PSQ scores, assessing the association between obesity status and the risk of sleep-disordered breathing using the Pediatric Sleep Questionnaire (PSQ), and comparing overall PSQ scores and risk categories between obese and normal-weight groups.

Consent and eligibility. Written informed consent was obtained from parents or guardians, and assent was obtained from participating children prior to data collection. Children with previously diagnosed obstructive sleep apnoea, chronic respiratory illness, neurological disorders, craniofacial abnormalities, congenital syndromes affecting sleep or growth, or those receiving treatment that could influence sleep patterns were excluded.

Sample size and sampling. A total of 400 children were initially screened. Sample size was calculated based on previous literature demonstrating an increased prevalence of sleep-disordered breathing among obese children (10), with a 95% confidence level, 80% power, and 1:1 group allocation. A minimum of approximately 60 participants per group was required. To compensate for incomplete responses and maintain equal group allocation, 64 participants were recruited in each group, resulting in a final sample size of 128. Following anthropometric assessment and BMI calculation using WHO growth references, participants were stratified into normal-weight (n=248) and overweight/obese (n=86) groups; others (n=66) with underweight BMI status or incomplete responses were excluded. Separate sampling frames were prepared for each BMI category. Using stratified random sampling, 64 children were randomly selected from each stratum through the lottery method / computer-generated random numbers, resulting in a final sample of 128 participants (64 normal-weight and 64 overweight/obese). Equal allocation was performed to ensure balanced group comparison and improve statistical efficiency for assessing sleep-disordered breathing risk using the Pediatric Sleep Questionnaire.

Data collection and anthropometry. Information regarding sociodemographic characteristics and sleep-related history was collected from parents or caregivers using a predesigned semi-structured questionnaire. Anthropometric assessment was performed using standard procedures. Weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale with children wearing light clothing and no footwear. Height was measured to the nearest 0.1 cm using a portable stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared. Nutritional status was classified according to age- and sex-specific World Health Organization BMI-for-age reference standards (11). Children with BMI-for-age >+1 SD were categorised as overweight/obese, while those between −2 SD and +1 SD were considered normal weight.

Assessment of sleep-disordered breathing. Risk of sleep-disordered breathing was assessed using the Pediatric Sleep Questionnaire, a validated parent-reported screening tool consisting of items related to snoring, breathing difficulty during

sleep, daytime sleepiness, and behavioural concerns (14). PSQ scores were calculated according to standard scoring guidelines, and participants were categorised into high-risk and low-risk groups based on recommended cut-off values. Responses are scored as "yes," "no," or "don't know," and a score ≥0.33 indicates high risk for sleep-disordered breathing.

Statistical analysis. Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 25. Continuous variables were summarised as mean ±standard deviation, while categorical variables were expressed as frequencies and percentages. Comparison of mean PSQ scores between study groups was done using the independent-samples t-test. Association between obesity status and PSQ risk categories was assessed using the chi-square test, and the Pearson correlation coefficient was used to examine the relationship between BMI and PSQ score. Normality of continuous variables was assessed using the Shapiro–Wilk test. Multicollinearity among predictor variables was evaluated prior to regression analysis, and model fitness for logistic regression was assessed using the Hosmer–Lemeshow goodness-of-fit test. Binary logistic regression analysis was performed to determine the association between obesity status and the risk of sleep-disordered breathing, estimating odds ratios with 95% confidence intervals. Variables found clinically relevant or statistically significant in bivariate analysis were included in the regression model. A p-value of <0.05 was considered statistically significant.

Ethics. Ethical approval was obtained from the Institutional Ethics Committee of SMS Medical College, Jaipur (Approval No. 124/MC/EC/2023). Written informed consent/assent was obtained from parents or guardians prior to data collection, and confidentiality of participant information was maintained throughout the study.

RESULTS

The study observed 12.5% overweight and 3.5% obese children among the 400 screened children. The final analytic sample included 64 children each in the normal-weight and overweight/obese groups. The mean age and sex distribution were comparable between the groups (Table 1). However, overweight/obese children had significantly higher BMI compared with normal-weight children (27.2 ±3.8 vs 17.4 ±1.9 kg/m²; p<0.001).

As shown in Table 2, symptoms suggestive of sleep-disordered breathing were significantly more common among overweight/obese children, including snoring more than half the night (48.4% vs 28.1%, p=0.018), frequent snoring (45.3% vs 21.9%, p=0.005), noisy snoring (37.5% vs 20.3%, p=0.032), heavy/loud breathing during sleep (51.6% vs 26.6%, p=0.004), mouth breathing during the daytime (53.1% vs 25.0%, p=0.001), dry mouth on waking (37.5% vs 17.2%, p=0.010), trouble breathing during sleep (31.3% vs 14.1%, p=0.020), and witnessed apnoea episodes (20.3% vs 7.8%, p=0.042). Daytime symptoms such as waking unrefreshed (59.4% vs 32.8%, p=0.003), daytime sleepiness (50.0% vs 26.6%, p=0.006), difficulty waking in the morning (46.9% vs 29.7%, p=0.045), teacher-reported daytime sleepiness (32.8% vs 15.6%, p=0.023), and morning headaches (28.1% vs 12.5%, p=0.028) were also significantly higher among overweight/obese children. Behavioural symptoms including not listening when spoken to (40.6% vs 23.4%, p=0.037), easy distractibility (60.9% vs 28.1%, p<0.001), and hyperactive behaviour (48.4% vs 31.3%, p=0.047) were significantly more prevalent in the overweight/obese group.

As shown in Table 3, overweight/obese children were significantly more likely to have high-risk PSQ status compared with normal-weight children (75.0% vs 34.4%; OR=5.73, 95% CI: 2.66–12.32; p<0.001). The mean PSQ score was also significantly higher among overweight/obese children than normal-weight children (0.43 ±0.17 vs 0.31 ±0.12; p<0.001), with a large effect size (Cohen's d=0.82) (Table 4).

Multivariate binary logistic regression analysis demonstrated that increasing age (adjusted OR=1.52, 95% CI: 1.25–1.84; p<0.001) and overweight/obesity (adjusted OR=8.61, 95% CI: 3.45–21.48; p<0.001) were independent predictors of high-risk PSQ status, whereas sex was not significantly associated (Table 5). A moderate-to-large positive correlation was observed between BMI and PSQ score (r=0.38, 95% CI: 0.22–0.52; p<0.001), indicating increasing sleep-related symptoms with higher BMI (Table 6).

Table 1. Demographic and anthropometric characteristics of children according to obesity status

Characteristic	Normal-weight (n=64)	Overweight/Obese (n=64)	p-value
Age (years), mean ±SD	10.8 ± 2.4	11.2 ± 2.6	>0.05
Sex, male : female	31:33	35:29	>0.05
BMI (kg/m²), mean ±SD	17.4 ±1.9	27.2 ±3.8	<0.001

Independent t-test and chi-square tests were used for continuous and categorical variables, respectively. Mean age and sex distribution were comparable between groups (p>0.05); exact values to be inserted from the study dataset.

Table 2. Comparison of Pediatric Sleep Questionnaire symptoms between normal-weight and overweight/obese children

Symptom	Normal-weight (n=64)	Overweight/Obese (n=64)	p-value
Snoring and sleep-disordered breathing symptoms, n (%)			
Snoring more than half the night	18 (28.1)	31 (48.4)	0.018
Frequent snoring	14 (21.9)	29 (45.3)	0.005
Noisy snoring	13 (20.3)	24 (37.5)	0.032
Heavy/loud breathing during sleep	17 (26.6)	33 (51.6)	0.004
Mouth breathing during daytime	16 (25.0)	34 (53.1)	0.001
Dry mouth on waking	11 (17.2)	24 (37.5)	0.010
Trouble breathing during sleep	9 (14.1)	20 (31.3)	0.020
Witnessed apnoea episodes	5 (7.8)	13 (20.3)	0.042
Daytime sleepiness symptoms, n (%)			
Wakes unrefreshed	21 (32.8)	38 (59.4)	0.003
Daytime sleepiness	17 (26.6)	32 (50.0)	0.006
Difficulty waking in the morning	19 (29.7)	30 (46.9)	0.045
Teacher-reported daytime sleepiness	10 (15.6)	21 (32.8)	0.023
Morning headaches	8 (12.5)	18 (28.1)	0.028
Behavioural symptoms, n (%)			
Does not listen when spoken to	15 (23.4)	26 (40.6)	0.037
Easily distracted	18 (28.1)	39 (60.9)	<0.001
Hyperactive behaviour	20 (31.3)	31 (48.4)	0.047

Chi-square test / Fisher exact test applied as appropriate. Counts shown are derived from the reported percentages for a group size of n=64.

Table 3. Comparison of overall PSQ risk status for sleep-disordered breathing between normal-weight and overweight/obese children

PSQ risk status	Normal-weight (n=64)	Overweight/Obese (n=64)	OR (95% CI); p-value
High-risk (score ≥0.33), n (%)	22 (34.4)	48 (75.0)	5.73 (2.66–12.32); <0.001
Low-risk (score <0.33), n (%)	42 (65.6)	16 (25.0)	

OR represents the odds of high-risk PSQ status in overweight/obese children relative to normal-weight children.

Table 4. Comparison of mean Pediatric Sleep Questionnaire scores between normal-weight and overweight/obese children

Measure	Normal-weight (n=64)	Overweight/Obese (n=64)	p-value
Mean PSQ score, mean ±SD	0.31 ±0.12	0.43 ±0.17	<0.001

Independent-samples t-test. Cohen's d = 0.82 (large effect size).

Table 5. Binary logistic regression analysis for predictors of high-risk PSQ status among children

Predictor	Adjusted OR (95% CI)	p-value
Age (per 1-year increase)	1.52 (1.25–1.84)	<0.001
Overweight/obesity (vs normal weight)	8.61 (3.45–21.48)	<0.001
Sex (male vs female)	Not significant	>0.05

Multivariate binary logistic regression model adjusted for age, sex, and obesity status.

Table 6. Correlation between BMI and Pediatric Sleep Questionnaire score among children

Variables	Pearson r (95% CI)	Direction	p-value
BMI vs PSQ score	0.38 (0.22–0.52)	Positive	<0.001

Pearson correlation coefficient. A positive correlation indicates that sleep-related symptoms increased with higher BMI.

DISCUSSION

The present study found that overweight and obese children had a significantly higher prevalence of sleep-related disturbances compared with normal-weight children. Symptoms suggestive of sleep-disordered breathing—including frequent snoring, noisy breathing, mouth breathing, dry mouth on waking, and witnessed apnoea episodes—were considerably more common among overweight/obese children. In addition, these children reported greater daytime sleepiness and behavioural disturbances, along with significantly higher PSQ scores and high-risk PSQ status.

These findings are consistent with the growing evidence linking childhood obesity with poor sleep health. The increasing burden of childhood obesity reported globally by the World Health Organization (1) and the NCD Risk Factor Collaboration (2) has drawn greater attention to obesity-related complications, particularly sleep-disordered breathing and OSA. Marcus et al. (12) described obesity as one of the strongest risk factors for paediatric OSA, while Dong et al. (13) demonstrated a significant association between overweight/obesity and OSA in their meta-analysis. Similarly, Wing et al. (10) observed higher rates of sleep-related breathing disorders among obese children compared with non-obese children, reporting that both BMI and pharyngeal lymphoid tissue independently increased the risk of obstructive events—an observation that helps explain the higher symptom burden seen in the present cohort.

In the present study, overweight/obese children showed significantly higher frequencies of snoring and breathing difficulties during sleep. These findings are clinically important because habitual snoring is often considered an early symptom of paediatric OSA (12). Umano et al. (14) further demonstrated that the Pediatric Sleep Questionnaire is a useful screening tool for identifying moderate-to-severe OSA among children with obesity, supporting the use of the PSQ in routine paediatric screening, particularly in settings where polysomnography is not readily available.

Daytime consequences of poor sleep were also evident in the present study. Overweight/obese children more commonly reported waking unrefreshed, daytime sleepiness, morning headaches, and difficulty waking in the morning. Similar findings have been reported by Fatima et al. (5), who showed that poor sleep quality is significantly associated with obesity among children and adolescents. Gohil and Hannon (7) also described obesity and poor sleep as parallel epidemics that adversely affect adolescent health and functioning, linking short and poor-quality sleep to insulin resistance and a broader cardiometabolic risk profile.

Behavioural symptoms such as distractibility, hyperactivity, and difficulty paying attention were significantly more common among overweight/obese children in this study. Sleep disruption and fragmented sleep are known to affect cognitive and behavioural functioning in children. Marcus et al. (12) reported that children with sleep-disordered breathing often demonstrate behavioural and neurocognitive difficulties, including poor attention and hyperactive behaviour. Okoli et al. (8) similarly emphasised the effect of disturbed sleep on metabolic and behavioural health among adolescents, noting the compounding roles of increased screen time and early school start times.

Another important finding of the present study was the positive correlation between BMI and PSQ score, indicating that sleep-related symptoms increased with increasing BMI. Cappuccio et al. (3) previously demonstrated that short sleep duration significantly increases the risk of obesity, while Xi et al. (4) reported that inadequate sleep is associated with metabolic abnormalities and increased risk of the metabolic syndrome. Taken together, these observations situate the present findings within a coherent dose-response relationship between adiposity and the severity of sleep-related symptoms. The present study also identified overweight/obesity as an independent predictor of high-risk PSQ status after adjustment for age and sex. The relationship between obesity and sleep disturbance appears to be bidirectional. On one hand, poor sleep—especially with increasing age—may contribute to obesity through hormonal and metabolic changes; Chaput and Dutil (6) explained that inadequate sleep may increase appetite, promote unhealthy eating behaviours, and encourage a sedentary lifestyle among adolescents. Jehan et al. (15) further noted that sleep disorders may worsen obesity through metabolic dysregulation. On the other hand, obesity itself may worsen upper-airway obstruction during sleep and increase the severity of sleep-disordered breathing (16–18). Mathew and Narang (9) described this interaction as a vicious cycle in which obesity and sleep disorders aggravate each other, with each condition amplifying the cardiometabolic and neurobehavioural consequences of the other.

From a public-health perspective, these findings highlight the need for early identification of sleep-related problems among overweight and obese children. Considering the rising prevalence of childhood obesity, routine screening using simple, low-cost, and validated tools such as the PSQ may help identify children at risk for sleep-disordered breathing at an earlier stage, enabling timely referral, lifestyle intervention, and, where indicated, definitive management. Integrating brief sleep

screening into school health programmes and routine paediatric visits could be a pragmatic strategy in resource-limited settings.

Strengths and limitations. The strengths of this study include its community-based design, balanced group allocation, and the use of a validated, internationally recognised screening instrument. Nevertheless, certain limitations should be acknowledged. The cross-sectional design precludes inferences about causality or the temporal direction of the obesity–sleep relationship. As comparatively limited Indian literature is available on this topic, further research is needed to strengthen and expand the current findings. In addition, the study relied on parent-reported responses, which may be subject to recall and reporting bias, and PSQ-based risk was not confirmed by polysomnography. However, the Pediatric Sleep Questionnaire is a validated screening tool and provides meaningful and reliable evidence of the association between obesity and sleep-related symptoms among children.

CONCLUSION

Overweight and obese children had a significantly higher prevalence of sleep-disordered breathing symptoms, daytime sleepiness, behavioural disturbances, and high-risk PSQ status compared with normal-weight children. Increasing BMI was associated with greater severity of sleep-related symptoms, and overweight/obesity independently predicted high-risk PSQ status. These findings highlight the importance of early screening for sleep-related problems among overweight and obese children to facilitate timely intervention and reduce long-term metabolic, behavioural, and cardiovascular complications.

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