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Original Research Article

Sleep-related breathing disorder among adolescents and its association with obesity, sleep pattern and mood

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ABSTRACT

Background: Sleep-related breathing disorders (SRBD) are widely prevalent among adolescents; however, are often undiagnosed, impacting their physical and psychological well-being. This study examined SRBD prevalence and its association with obesity, sleep patterns and mental health of adolescents.
Methods: Adolescents aged 10-19 years were enrolled after requisite permission of school authorities and necessary assent and consent for participation. Participants were explored for their sleep quality, daytime sleepiness, SRBD and mood changes using standardized questionnaires like Pittsburgh sleep quality index (PSQI), pediatric daytime sleepiness scale (PDSS), sleep related breathing disorder-pediatric sleep questionnaire (SRBD- PSQ) and depression anxiety stress scale-21 (DASS-21) respectively.
Results: SRBD was present in 18.05% (389) adolescents and 15.83% (341) were obese. Males, as well as older adolescents, had higher SRBD susceptibility with 56%; p=0.008 and 52.7%; p<0.001, respectively. Older adolescents had higher body mass index (p=0.017), shorter sleep durations (p<0.001), poorer sleep quality (p=0.006), increased daytime sleepiness (p<0.001), and elevated levels of depression, anxiety, and stress (p<0.001). Among SRBD-positive adolescents, 40.1% were obese, 32.1% were overweight, 82.5% experienced poor sleep quality (p<0.001) and 66.3% (258) were sleep deprived.
Conclusions: An increasing trend in sleep disturbances, reduction in sleep quality and duration, increase in obesity as well as SRBD was observed with age among adolescents, with Older adolescents exhibiting the highest scores for all the parameters, including compromised emotional health.

Keywords: Sleep-related breathing disorder, Obesity, Seep quality, Obstructive sleep apnea, Daytime sleepiness, Adolescent

INTRODUCTION

Sleep-related breathing disorder (SRBD) refers to irregularities in breathing patterns during sleep, encompassing conditions such as obstructive sleep apnoea (OSA), central sleep apnoea (CSA), sleep-related hypoventilation, and sleep-related hypoxemia.[1] Among these, OSA, is the most prevalent, affecting 1.2 to 5.7% of children and adolescents.[1-3] It results mainly from partial (hypopnea) or complete (apnea) upper airway obstruction during sleep due to pharyngeal muscle relaxation, leading to reduced oxygen levels and increased carbon dioxide in the bloodstream.[4] Contributing factors for these pathophysiological changes also include reduced lung volume at exhalation, impaired respiratory drive, lowered arousal threshold, diminished muscle responsiveness, and unstable ventilation control.[5]

Obesity and overweight conditions are closely linked to various health issues of which OSA is of notable concern.[6,7] A recent meta-analysis by Zhang et al reported pooled global prevalence rates of overweight and obesity among children and adolescents as 8.5% and 14.8%, respectively.[8] In India, a 2024 systemic review highlighted regional variations in obesity prevalence, ranging from 12% to 29%.[9]

Spectrum of SRBD in children ranges from mild snoring in 1.5–27.6% to severe OSA reported in 5.7% of children.[10] SRBD if untreated, can not only manifest as poor sleep quality, increased fatigue and daytime sleepiness in young individuals, but can lead to growth impediments, cognitive deficits resulting in learning delays, and behavioral disorders characterized by attention deficit and hyperactivity.[6,11,12] Early detection and treatment of OSA can substantially decrease morbidity and improve quality of life.[4] Although nocturnal polysomnography (PSG) is the gold standard for diagnosing and evaluating SDB, its substantial resource demands, both in terms of cost and time, make it impractical for large-scale population screening.[13] The SRBD-pediatric sleep questionnaire (SRBD-PSQ) exhibits satisfactory sensitivity (85%) and specificity (87%) for screening OSA among children in both clinical and epidemiological studies.[14]

Numerous studies have explored the link between SRDB and obesity but most are either clinic or hospital-based and/or are focused either on young children or adults, rarely targeting adolescents in community settings.[15-17] Adolescents, a vulnerable group experiencing significant physiological and lifestyle changes, are understudied regarding the association between SRBD and overweight/obesity. In the present study, we endeavoured to explore the prevalence of SRDB among school-going adolescents, examining its association with obesity and exploring its impact on their sleep quality, daytime sleepiness, and mood.

METHODS

Study design

A cross-sectional study was conducted among school-going adolescents, both male and females, aged 10 to 19 years in Bhopal, central India from August 2022 till December 2023. Five schools having 6th to 12th grade were randomly selected from a pool of eligible institutions using computer-generated random numbers. The sample size was calculated using "CRT size" package in the R software, resulting in a total of 92 clusters- with 30 adolescents per cluster, yielding an overall sample of 2,760 adolescents. The study was conducted in accordance with the declaration of Helsinki. and ethical clearance was obtained from the institutional ethics committee before the commencement of the study. Following the necessary approvals from school authorities, students of grades 6th to 12th from each selected school with a minimum of two sections for each class, were invited to participate in the study.

Procedure

Eligible students were introduced to the study and those who assented to participate and submitted the signed parental consent were enrolled. Standardized questionnaires were used to inquire about sleep quality, daytime sleepiness, sleep-related breathing disorders, and mood. Students undergoing long-term medication for conditions such as epilepsy, ADHD, pulmonary disease, and similar illnesses were excluded from the study.

Vital information, including age, height, weight, and bedtime routines, was recorded for all the participants. Further, all the participants were explored for their sleep quality, daytime sleepiness, SRBD, and mood using standard questionnaires.

Pittsburgh sleep quality index

Pittsburgh sleep quality index (PSQI), a 19-item self-reported questionnaire, was used to estimate the sleep quality and severity of sleep-related disruption over the past month. It has seven components- sleep duration, sleep onset latency, sleep disturbance, daytime dysfunction, sleep quality, sleep efficiency and use of sleep medications, evaluated on a 4-point likert scale ranging from 0 to 3. An aggregated scores of all the seven components give a total PSQI score ranging from 0 to 21. Total scores >5 are indicative of poor sleep quality.[18]

Pediatric daytime sleepiness scale

Pediatric daytime sleepiness scale (PDSS) has eight self-reported questions that measure daytime sleepiness in school-aged children and adolescents. Each item is scored on a Likert scale of 0 to 4, contributing to a total score that spans from 0 to 32. Higher scores indicate increased daytime sleepiness.[19]

Sleep related breathing disordered-pediatric sleep questionnaire

A 22-item scale with a sensitivity of 85% and specificity of 87% for detecting sleep related breathing disorders among 2-18 years of children investigates scoring frequency, loud snoring, observed apneas, difficulty in breathing during sleep, daytime sleepiness, inattentive or hyperactive behavior and other pediatric OSA features. Each item is scored as being present, absent, or unknown. The score is obtained as the following ratio for answered questions: present/ (present + absent); any questions that are not answered (unknown) are not included in the calculation. Scores >0.33 are considered positive and are suggestive of high risk for an SRBD pediatric sleep questionnaire (SRBD-PSQ) and are taken as an indicator of OSA.[14]

Depression anxiety stress scales-21

Depression anxiety stress scales-21 (DASS-21) is a 21-item scale to evaluate depression, anxiety, and stress. Comprised of seven items in each domain, each item being scored on a Likert scale of 0-3. "0" indicates "did not apply to me at all", 1 represents "applied to me to some degree or some of the time", 2 implies "applied to me to a considerable degree or a good part of the time", 3 as "applied to me very much or most of the time". Scores for each emotional domain is calculated by summing the responses to the respective seven items. Scores are further categorized as normal, mild, moderate, severe or extremely severe, providing an assessment of the individual's emotional state in each domain.[20]

Statistical method

Data entry was done in Microsoft excel and was screened for missing values. Statistical analysis employed statistical package for the social sciences (SPSS) version 22, Inc., Chicago, IL, USA. Descriptive statistics were utilized to represent continuous variables as mean±SD and categorical variables as percentage (N). Group differences were assessed using independent sample t-tests, the Chi-square test, and one-way analysis of variance. Spearman correlation was employed for assessing correlation between continuous variables. A significance level of 0.05 and a confidence interval of 95% were applied for determining statistical significance in all tests, which were conducted with a two-tailed approach.

RESULTS

The prevalence of SRBD was 18.05% (389), and 15.83% (341) of adolescents had obesity in our study. Among the 2,289 questionnaires retrieved from the participants, 135 forms were incomplete; thus, data of 2,154 students was included for final assessment. Mean age of adolescents was 13.87±1.92 years, including 49.9% (1,075) males and 50.1% (1,079) females who underwent comprehensive screening of their sleep patterns, including sleep quality, daytime sleepiness, and sleep-related breathing disorders along with assessments of body mass index (BMI) and mood.

Average BMI of participants was 23.61±4.57, which was within normal weight range (WHO BMI classification).[21] 66.4% (1,430) of adolescents slept after 10 pm and 83.8% (1,806) rose at 6 am or before in the morning (Table 1). This behavior resulted in an average sleep duration of 6:40±1:07 hours, causing a considerable number of adolescents to experience sleep deprivation. Additionally, 43.5% (936) reported having poor sleep quality with a mean daytime sleepiness score of 14.25±5.43. Levels of depression, anxiety and stress among this group of adolescents was higher than normal (Table 1).

Participants were divided into two groups: group A, which consisted of 81.94% (1,765) students demonstrating a negative or low SRBD score (≤33%), and group B, comprising 18.05% (389) students showing a positive or high SRBD score (>33%) (Table 2). SRBD was significantly more prevalent among older adolescents (52.7%, 205) compared to younger adolescents (47.3%, 184), with a statistically significant difference (p<0.001). Furthermore, males (56%, 218) exhibited significantly higher SRBD scores than females (p=0.008). Among participants in group B, 79.2% (308) went to bed after 10 pm, and 87.7% (341) woke up early, till 6 am, contributing to sleep deprivation (sleep duration <7 hours) experienced by 66.3% (258) of adolescents (Table 2). Additionally, 82.5% (321) of adolescents in group B reported a decline in sleep quality (p<0.001). Notably, 72.2% of adolescents in group B were either obese or overweight, with BMI>25, in contrast to only 29% of adolescents in group A.

Table 1: Demographic characteristics and sleep pattern of adolescents.

Variables	Subjects (n=2154)
Age in years	13.87±1.92
Gender (male)	49.9% (1075)
BMI	23.61±4.57
Sleep duration	6:40±1:07
Bedtime (after 10 pm)	66.4% (1430)
Wakeup time (before/at 6 am)	83.8% (1806)
Sleep quality (PSQI>5)	936 (43.5%)
Daytime sleepiness	14.25±5.43
Depression	10.54±7.67
Anxiety	9.75±7.22
Stress	11.15±7.53

According to WHO classification, adolescents were divided into young adolescents (10-14 years) and older adolescents (15-19 years) (Table 3).[22] The findings revealed that older adolescents (38.77%, 835) had significantly higher BMI (p=0.017), short sleep durations (p<0.001), poorer sleep quality (p=0.006) and increased levels of daytime sleepiness (p<0.001) compared to young adolescents (61.23%, 1319). Consequently, older adolescents demonstrated significantly higher scores on SRBD-PSQ (p<0.001) and reported elevated levels of depression (p<0.001), anxiety (p<0.001), and stress (p=0.005) relative to young adolescents.

Adolescents were classified based on their BMI according to WHO standards, revealing significant differences in various sleep and mood-related aspects among the different BMI groups.[21] Overweight adolescents and those with obesity had reduced total sleep duration (p<0.001), poorer sleep quality (p<0.001) and higher daytime sleepiness (p<0.001) compared to their peers with normal and underweight BMI (Table 4). Moreover, the scores on the SRBD-PSQ were significantly higher for participants with obesity (0.31±0.28) when compared to other BMI categories (p<0.001). Additionally, overweight and obese adolescents reported heightened levels of depression, anxiety, and stress (p<0.001). Furthermore, BMI, sleep quality, sleep duration, daytime sleepiness, and the three states of mood exhibited a significantly positive correlation (p≤0.001) with the SRBD score.

Table 2: Interplay between sleep-related breathing disorders, sleep patterns and BMI.

Variables	Group A, low SRBD score- ≤33% (n=1765), % (N)	Group B, high SRBD score- >33% (n=389), % (N)	P value
Age			
Young adolescents	64.3 (1135)	47.3 (184)	<0.001*
Older adolescents	35.7 (630)	52.7 (205)	
Gender			
Male	48.6 (857)	56.0 (218)	0.008*
Female	51.4 (908)	44.0 (171)	
Sleep duration (hours)			
<7	42.0 (741)	66.3 (258)	<0.001*
≥7	58.0 (1024)	33.7 (131)	
Bedtime			
Before/at 10 pm	36.4 (643)	20.8 (81)	<0.001*
After 10 pm	63.6 (1122)	79.2 (308)	
Wakeup time			
Before/at 6 am	83.0 (1465)	87.7 (341)	0.024*
After 6 am	17.0 (300)	12.3 (48)	
BMI			
Underweight (<18)	7.6 (134)	5.1 (20)	<0.001*
Optimal/normal (18.5-24.9)	63.4 (1119)	22.6 (88)	
Overweight (25-29.9)	18.5 (327)	32.1 (125)	
Adolescents with obesity (≥30)	10.5 (185)	40.1 (156)	
Sleep quality			
Poor	34.8 (615)	82.5 (321)	<0.001*
Better	65.2 (1150)	17.5 (68)	

*P<0.05 statistically significant

Table 3: Comparison of BMI, sleep patterns and mood between young and older adolescents.

Variables	Young adolescents (n=1319)	Older adolescents (n= 835)	P value
BMI	23.42±4.50	23.91±4.67	0.017*
Sleep duration	06:52±1:02	6:22±1:09	<0.001*
Sleep quality	4.98±2.44	5.29±2.64	0.006*
Daytime sleepiness	13.52±5.43	15.39±5.23	<0.001*
SRBD	0.16±0.22	0.21±0.26	<0.001*
Depression	9.94±7.12	11.48±8.38	<0.001*
Anxiety	9.16±6.60	10.68±8.02	<0.001*
Stress	10.78±7.15	11.74±8.07	0.005*

*P<0.05 statistically significant

Table 4: Differences across multiple domains of sleep and mood based on BMI categories.

Variables	BMI categories				P value
	Underweight (n=154)	Normal (n=1207)	Overweight (n=452)	Adolescents with obesity (n=341)	
Sleep duration	6:47±1:03	6:56±1:00	6:23±1:05	6:04±1:12	<0.001*
Sleep quality	4.62±1.81	3.93±1.92	6.43±1.70	7.72±2.76	<0.001*
Daytime sleepiness	13.47±5.35	13.68±5.43	15.00±4.95	15.61±5.70	<0.001*
SRBD	0.15±0.23	0.12±0.18	0.24±0.29	0.31±0.28	<0.001*
Depression	9.95±7.90	8.63±6.77	13.45±7.54	13.70±8.47	<0.001*
Anxiety	9.25±6.92	8.12±6.54	11.83±6.90	13.01±8.21	<0.001*
Stress	10.30±7.37	9.44±7.05	13.78±7.28	14.10±7.71	<0.001*

*P<0.05 statistically significant.

DISCUSSION

This study examined the prevalence of SRBD in adolescents aged 10 to 19 years, highlighting its association with age, sleep patterns, BMI, and emotional well-being. A notable increase in SRBD prevalence was identified among older adolescents, particularly those aged 15 to 19 years, with higher rates noted among those who were overweight or obese. These adolescents experienced reduced sleep duration, poor sleep quality, increased daytime sleepiness, and compromised emotional well-being.

Demographic characteristics

The global prevalence of SRBD varies depending on diagnostic tools, methodologies employed, geographical regions and populations studied.[23] In our study, 18.05% of adolescents had SRBD, which aligns closely with the findings of Thomas et al in Kerala, where 18.3% (42) of 229 adolescents were diagnosed with SRBD with 7.9% identified as snorers.[16] Prevalence of 10.5% was reported in a 2020 study from Jodhpur among 13-14 years adolescents; however, this study did not include 10-12 years and 15-19 years of adolescents lacking generalizability.[17] 15.83% of adolescents had obesity in our study which is aligns closely to 20.6% obesity among school-going adolescents (12-19 years) reported by Hales et al.[24]

Consistent with prior studies, majority of adolescents in our study exhibited delayed bedtimes, early awakenings, abbreviated sleep durations, presence of mild depressive and anxious tendencies (Table 1).[25,26] Both males and older adolescents depicted higher SRBD-PSQ scores. While OSA affects both genders equally in prepubertal children, a male predominance is observed following the onset of puberty.[4,27] Higher BMI levels along with short sleep durations, poor sleep quality, increased daytime sleepiness, and poor mood were also observed among the older adolescents (Table 3). These factors collectively may have contributed to an increased prevalence of SRBD among the older age group (Table 2). Cohen et.al in their review highlighted a reciprocal relationship between sleep quality and sleep duration with weight gain and obesity.[28] Similarly, Lee et al suggested that poor sleep occurs more frequently among obese adolescents, who also exhibit higher incidence of SRBD.[29] Zandieh et al have reported that symptoms of SRBD were particularly prevalent among older adolescents.[30] Singh et al observed phase-delay behaviour, sleep deprivation leading to poor sleep quality and depression among teenagers aged 13-15 years in comparison to preteens aged 11-12 years.[26] These findings suggest that the prevalence of SRBD increases with age among adolescents. Spilsbury et al conducted a study among children in Cleveland that indicated obesity during middle childhood (ages 8 to 11) is a predictor of developing OSA in late adolescence (ages 16 to 19).[31]

Sleep related breathing disorder and its association with sleep parameters

According to recommendations from the American Academy of Sleep Medicine, adolescents aged 13 to 18 should aim for 8 to 10 hours of sleep each day to ensure optimal health.[32] Our study found that majority of teenagers exhibiting positive SRBD, tended to stay up late at night and also woke up early in the morning, resulting in reduced sleep duration and poorer sleep quality compared to their peers without SRBD (Table 2). Delasnerie-Laupretre et al also reported that snoring in adolescents (15-20 years) was associated with both short (<7 hours) and long (>10 hours) sleep durations, as well as increased nocturnal awakenings and daytime sleepiness.[33] Conversely, Goyal et al observed a different trend in younger population, indicating that sleep duration and delayed bedtimes did not significantly affect children aged 5 to 10, regardless of their SRBD status.[27] However, Miyahara et al noted that individuals ≥18 years of age with poor sleep quality had a higher risk for OSA (p=0.05).[34] Therefore, it is crucial to investigate the development of SRBD among adolescents, particularly as they navigate physiological sleep changes and puberty

BMI and its associations

Changes in weight are closely associated to SRDB.[35] In our study, 72.2% (281) of adolescents with high SRBD scores were either overweight or obese (Table 2). Deen et al suggested that overweight adolescents are at an increased risk of developing SRDB.[36] Wing et al reported that 32.6% of overweight children in their study experienced SRBD, a prevalence significantly higher than that observed among lean children aged 7-15 years.[37] Similarly, Park et al also noted that adolescents at high risk of OSA tend to have a higher BMI and low self-esteem as compared to them at low risk counterparts.[38]

Shorter sleep duration in adults is linked to obesity, which in turn can lead to OSA.[39] Our study also examined the relationship between BMI categories and various sleep parameters and mood among adolescents. As adolescents' BMI increased from normal towards overweight and obese, their sleep duration decreased, sleep quality deteriorated, daytime sleepiness intensified, SRBD scores increased, and their mood worsened, with increased levels of depression, anxiety, and stress (Table 4). This aligns with the findings of a previous study by Sivertsen et al which demonstrated a U-shaped relationship between sleep duration and BMI, as well as a linear correlation between BMI and the prevalence of OSA symptoms.[40] Calhoun et al explored an association of BMI with excessive daytime sleepiness (EDS) among school-age children and reported a prevalence of 15% EDS among them.[41] Verhulst et al have identified OSA as a common comorbid condition in adolescents with severe obesity, with rates reaching as high as 60%.[42] In obese adolescents with a BMI ≥40, the risk of developing OSA increases by 12% for every 10% rise in BMI.[43]

Rankin et al highlighted that obesity in youth is closely associated with reduced self-esteem.[44] Similarly, Park et al reported higher levels of anxiety and depression among adolescents at greater risk of OSA which aligns with the findings of our study.[38] Several, proposed explanations for these mood changes include neural injury resulting from inflammation induced by hypoxia, which may be a contributory factor for the development of depression and anxiety.[45] Secondly, the disrupted sleep patterns and heightened sympathetic activity triggered by hypoxia could worsen negative mood states.[46] Additionally, dysfunction of the hypothalamic pituitary-adrenal (HPA) axis, stemming from its hyperactivation due to sleep apnea, may also play a role in the manifestation of depression and anxiety.[47]

The present study highlights a very important finding of the increasing trend of obesity and SRBD among adolescents, however, it is not without limitations. The gold standard test for diagnosis of OSA is polysomnography, but in the present study we used a validated SRBD-PSQ questionnaire (parent reported) with 100% sensitivity and 96.8% specificity. The strength of our study was it enrolled a large sample of the adolescent population.

CONCLUSION

Our study observed an increasing trend in sleep disturbances, reduction in sleep quality and duration in addition to an increase in obesity as well as SRBD with age in 10-19 years of adolescents. Though this association of SRBD with obesity has been explored in several studies in adults as well as children, but limited studies have explored the same in adolescents. This increasing trend of sleep disturbances, sleep related breathing disorders as well as weight among adolescents as they navigate through physiological changes along with environmental stresses including academic pressure warrants intervention by policymakers and educators to emphasize maintenance of sleep hygiene in addition to food hygiene among this vulnerable group, who are the future of our society.

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