RESEARCH PAPER

Role Of Polysomnography (Psg) In Early Identification Of Sleep Disordered Breathing Among Adolescents

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ABSTRACT

Introduction: Sleep Disordered Breathing (SDB), encompasses a broad range of abnormal respiratory events occurring during sleep; SDB severely impacts both the sleep quality of adolescents as well as their overall health. This study aimed to determine the pattern of polysomnography in adolescents with sleep disordered breathing, assess severity for timely intervention, evaluate sleep pattern and efficiency, and identify underlying treatable causes.

Methods: The data for this 24 month long longitudinal cross sectional observational study were collected in Dr. D.Y. Patil Medical College Hospital and Research Center in Pune, India from February 2023 through to February 2025. A total of 36 adolescents aged 14-18 years old who had symptoms of sleep disorders that cause breathing difficulties during sleep were selected as participants. The participants were clinically assessed using a comprehensive evaluation of their medical history; physical examinations; anthropometric measurement; and an ear, nose and throat (ENT) examination. To assess the effects on the participant's respiratory system due to sleep disordered breathing, level three polysomnography was utilized to evaluate a number of different sleep disorders including, but limited to, apnea-hypopnea index (AHI); oxygen desaturation index (ODI); respiratory index (RI); central apnea index (CAI); obstructive apnea index (OAI); etc.

Results: Amongst 36 participants, (the proportion of males to female was 58.4% : 41.6%), 75% of the participants were aged between 14 - 16 years old. The AHI Severity Distribution included; Mild 36.1%, Moderate 27.8%, Severe 36.1%. The symptoms presented as follows: Mouth Breathing was the most prevalent (66.7%) followed closely by Nocturnal Awakening (58.3%), Snoring (52.8%), Daytime Sleepiness (44.4%). The enlarged tonsils were identified in 36.1% of the participants and 69.2% of the severe AHI cases had Tonsillar Hypertrophy ($p = 0.0077$). Participants who were overweight and obese displayed a higher prevalence of severe AHI (66.7% and 100% respectively). Strong Positive Correlations were demonstrated amongst the AHI and RI ($\rho = 0.911$), ODI ($\rho = 0.901$), OAI ($\rho = 0.829$) and CAI ($\rho = 0.778$), all at the $p < 0.0001$ level. Interestingly, there was a paradoxical relationship, whereby severe AHI cases often did not display snoring ($p = 0.0017$), suggesting that snoring is likely to under estimate the severity of OSA. 44% of parents stated they perceived their adolescent as receiving inadequate sleep.

Conclusions: Sleep-disordered breathing in teenagers is a serious clinical problem that has been relatively unexplored due to the lack of objective PSG diagnostic testing. Obesity and tonsil enlargement are the most common risk factors for sleep apnea but these do not rule out moderate to severe OSA. The presence of subjective symptoms or parental reports may not accurately reflect the degree of the disease. Therefore early detection via PSG is very important as it may help avoid a variety of negative outcomes such as decreased school performance, behavioral problems and long term cardiovascular/metabolic complications.

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Keywords: Polysomnography, Sleep Disordered Breathing, Adolescents, Obstructive Sleep Apnea, Apnea-Hypopnea Index, Oxygen Desaturation Index, Tonsillar Hypertrophy, Sleep Quality

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INTRODUCTION

Sleep is one of the most essential biological functions for our body's development, managing our emotions and cognition, and total wellness. For kids and teenagers, the amount and quality of their sleep has a direct effect on their behavior, school performance, and their psychosocial functioning. The loss of regular sleep patterns can result in many serious health problems, especially if they are related to a sleep-related breathing disorder. Within this category of sleep-related breathing disorders, Sleep Disordered Breathing (SDB) is a range of conditions that represent a variety of different patterns of respiration while asleep, ranging from simple snoring to Obstructive Sleep Apnea (OSA). Each of these conditions can severely limit the quality of the individual's sleep and the severity of their health problems. [1]

Pediatric and adolescent populations often suffer from undiagnosed SDB because it is usually presented clinically in an unobvious manner. While adult patients typically have excessive daytime sleepiness as the main indicator of sleep apnea, children will exhibit hyperactivity, poor school performance, growth failure, or behavioral problems.[1] These symptoms can change over time and overlap with other psychosocial factors or mood disorders as children enter adolescence. Additionally, physiological changes during pubertal stages of development (such as increased weight, changes in the structure of the upper airways, and changes in the architecture of sleep) can contribute to an increased risk of developing SDB among adolescents. Therefore, this age group needs specific evaluation methods and targeted diagnostic approaches.

The prevalence of sleep disorders in children across a range of geographic and demographic locations is well-recognized by researchers. However, it has been noted that there is also an extensive number of sleep disorders among children that remain undiagnosed and untreated as many of them are under diagnosed and treated using clinical assessments alone. Therefore, in order to objectively diagnose SDB, which may be difficult with clinical assessment alone, PSG (a sleep study that measures various physiological parameters during the night such as brain waves, eye movements, muscle tone, heart rate, respiratory movement, airflow, oxygen saturation and body movement)[4][5] has been established as the gold standard of diagnosis for SDB. In addition to providing a complete analysis of sleep structure, PSG provides a method for detecting and counting respiratory events, such as apnea and hypopnea, and therefore enables quantification of SDB severity, which is essential for making treatment decisions. [6][7]. Clinical utility of PSG has been demonstrated to provide a means of separating sleep disturbances from each other, specifically when symptoms are nonspecific.[8] PSG is also important because it can be used to distinguish between primary snoring and Obstructive Sleep Apnea (OSA), a distinction that is particularly important in adolescents who often display behaviors and symptoms that may appear to mimic those seen in behavioral or psychiatric disorders.

MATERIALS AND METHODS

Study Design and Setting

In this observational, cross-sectional study, data was collected at the inpatient and outpatient services at Dr. D.Y. Patil Medical College Hospital and Research Center in Pimpri, Pune, over the course of two years starting from February 2023 through to February 2025 after obtaining approval from the Institutional Scientific Ethical Committee (Ref. No. I.E.S.C./222/2023).

Study Population and Sample Size

Adolescents aged 14 to 18 who had presented with symptoms of sleep disordered breathing to the pediatric, otolaryngological, respiratory medicine and internal medicine departments constituted the study population. Utilizing an acceptable difference of five percent at 95% confidence, a sample size of thirty-five to forty participants was determined based upon the literature cited for the prevalence of sleep disordered breathing of four point three percent. A total of 36 adolescent subjects were recruited into the study.

Selection Criteria

Study inclusion criteria included adolescent patients aged fourteen to eighteen with symptoms of sleep disordered breathing, obesity, obstructive sleep apnea or enlarged tonsils / adenoids; in addition to providing written informed consent both the adolescents' guardians and the adolescents themselves. Study exclusion criteria included adolescent patients that required ICU admission for a

serious or end-stage condition; as well as having craniofacial anomalies, neuromuscular disorders, global developmental delay or chronic systemic diseases such as chronic kidney disease, congestive heart failure or liver failure.

Study Procedure

Participants (adolescents) that met the inclusion criteria were identified as part of an outpatient department (OPD) or inpatient department (IPD). The parents and adolescents were informed about the objectives of the study, the methodology involved in the study, the possible dangers associated with participating in the study, and the benefits of participating in the study in the participant's native language; therefore, the participants gave their written informed consent to participate in the study. Each participant underwent a preliminary screening for sleep issues by means of a primary sleep questionnaire and then participants with some indication of a potential sleep issue were further evaluated by way of a secondary sleep questionnaire for a complete evaluation of the sleep issues. A complete medical history regarding the participant's sleep pattern was taken; and a complete physical examination was performed. Body dimensions (height, weight, body mass index), anthropometric measures, were measured. A complete ear, nose and throat (ENT) examination was performed in order to evaluate for adenoid facies, tonsil size, turbinates enlargement, and a deviated nasal septum.

Polysomnography Procedure

Adolescents were recommended for an overnight pediatric sleep study (polysomnogram) when clinically indicated. Data from this study was collected using Level 3 polysomnography equipment (ApneaLink Air by ResMed). This data was obtained in two settings: bedside for inpatients, and in the participant's home for outpatients. The polysomnography monitored multiple aspects of a participant's respiration during sleep. These include airflow through the nose and mouth detected by flow sensors; respiratory movements of the thorax and abdomen detected by respiratory inductive plethysmography (belts); and continuous heart rate and peripheral oxygen saturation via pulse oximetry to the index finger.

Statistical Analysis

The data that was collected was entered into Microsoft Excel and then analyzed by using IBM Statistical Package for Social Sciences version 26. All of the categorical variables were analyzed with a Chi-Square Test; if the results were statistically significant ($p < .05$) at a 95% Confidence Interval, they would be noted as being statistically significant. All of the continuous variables were analyzed with the Spearman Rank Correlation method to determine the level of correlation between each variable pair; the correlation coefficient along with the 95% CI was also computed for each variable pair.

RESULTS

Demographic Characteristics

Beginning with the demographic characteristics of the sample population (i.e., gender, age, geographic location, SES, BMI) the data show there is a larger number of males than females in this study sample (ratio = 1.4:1; M = 21, F = 15; 58.4% male, 41.6% female) and the majority of the subjects are from the middle SES group (66.7%). In terms of geographic location, 55% of the adolescents lived in urban areas and 45% lived in rural areas. Based upon body mass index (BMI) classifications, 52.8% of the adolescents have normal weight, 33.3% are overweight, 11.1% are underweight and 2.8% are obese.

Clinical Presentation

Regarding clinical symptoms of sleep apnea, the most common complaints expressed by the adolescents included mouth breathing (reported by 66.7% of the participants), followed by nocturnal awakenings (58.3%), snoring (52.8%), daytime sleepiness (44.4%), difficulty falling asleep (44.4%) and difficulty rising in the morning (38.9%). Upon physical examination, enlarged tonsils (36.1%), adenoid facies (75%), a deviated nasal septum (5.6%), and mouth breathing (66.7%) were found in many of the adolescents. Also, breathing difficulties during sleep (including gasps and pauses in breathing) occurred in 66.7% of the participants. Parental reports indicated that 44% of the parents felt their child received inadequate sleep and 55.6% felt the amount of sleep their child received was adequate.

Polysomnography Parameters

According to the Apnea-Hypopnea Index (AHI) severity classification for pediatric criteria, 36.1% of the adolescents had mild obstructive sleep apnea (OSA), defined by an AHI <5 events/hour. Approximately 28% of the adolescents had moderate OSA (defined as 5-10 events/hour), and 36.1% had severe OSA (defined by an AHI >10 events/hour). Comprehensively analyzing the polysomnography (PSG) parameters provided additional insights into the severity of each subject's sleep disturbances. The mean central apnea index (CAI) was .405 (SD = .725, Range = 0-2.8); the mean obstructive apnea index (OAI) was 1.875 (SD = 1.565, Range = 0-6); the mean oxygen desaturation index (ODI) was 9.69 (SD

= 6.851, Range = 0.6-26.9); and the mean respiratory index (RI) was 7.862 (SD = 6.324, Range = 0.7-24.6). Significant strong positive correlations existed between the AHI and the RI (ρ = .911, 95% CI = .831-.954, p < .0001), AHI and ODI (ρ = .901, 95% CI = .813-.949, p < .0001), AHI and OAI (ρ = .829, 95% CI = .688-.910, p < .0001), and AHI and CAI (ρ = .778, 95% CI = .605-.882, p < .0001).

Association Between Clinical Features and AHI Severity

The analyses of the associations among symptom severity also provided valuable insights into the nature of sleep apnea in adolescents. Specifically, it was found that there was a significant association between the presence of hypertrophied tonsils and the severity of sleep apnea (i.e., 69.2% of adolescents with severe AHI had hypertrophied tonsils, p = .0077). Additionally, a trend toward increasing severity of sleep apnea was noted in relation to increasing BMI, as all but one of the overweight adolescents and the single obese adolescent had severe AHI, whereas none of the underweight adolescents had severe AHI (p = .0887). Snoring, paradoxically, was inversely related to the severity of AHI (i.e., snoring was more common in those with mild AHI and less common in those with severe AHI), p = .0017). Similarly, breathing abnormalities during sleep were significantly associated with both the mild and moderate AHI groups (p = .0211).

TABLE 1: DEMOGRAPHIC CHARACTERISTICS AND AHI SEVERITY

Parameter	Category	Mild AHI	Moderate AHI	Severe AHI	P-value
Age Group	14-16 years	9 (33.3 %)	7 (25.9%)	11 (40.7 %)	>0.05
	16-18 years	4 (44.4 %)	3 (33.3%)	2 (22.2 %)	
Sex	Male	7 (33.3 %)	6 (28.6%)	8 (38.1 %)	0.9166
	Female	6 (40.0 %)	4 (26.7%)	5 (33.3 %)	
SES	Upper	2 (66.7 %)	1 (33.3%)	0 (0%)	0.6710
	Middle	8 (33.3 %)	6 (25.0%)	10 (41.7 %)	
	Lower	3 (33.3 %)	3 (33.3%)	3 (33.3 %)	
Residence	Urban	7 (35.0 %)	5 (25.0%)	8 (40.0 %)	0.8484
	Rural	6 (37.5 %)	5 (31.3%)	5 (31.3 %)	
BMI	Normal	9 (47.4 %)	6 (31.6%)	4 (21.1 %)	0.0887
	Overweight	2 (16.7 %)	2 (16.7%)	8 (66.7 %)	
	Obese	0 (0%)	0 (0%)	1 (100%)	
	Underweight	2 (50.0 %)	2 (50.0%)	0 (0%)	

TABLE 2: CLINICAL SYMPTOMS AND EXAMINATION FINDINGS WITH AHI SEVERITY

Clinical Feature	Present	Mild AHI	Moderate AHI	Severe AHI	P-value
Mouth Breathing	24 (66.7 %)	8 (33.3 %)	7 (29.2%)	9 (37.5 %)	0.8859
Snoring	19 (52.8 %)	10 (52.6 %)	6 (31.6%)	3 (15.8 %)	0.0017
Nocturnal Awakening	21 (58.3 %)	7 (33.3 %)	6 (28.6%)	8 (38.1 %)	0.9747
Daytime Sleepiness	16 (44.4 %)	5 (31.3 %)	5 (31.3%)	6 (37.5 %)	0.8484
Difficulty Initiating Sleep	16 (44.4 %)	5 (31.3 %)	5 (31.3%)	6 (37.5 %)	0.8484
Breathing Abnormalities	24 (66.7 %)	11 (45.8 %)	8 (33.3%)	5 (20.8 %)	0.0211
Enlarged	13	2	2	9	0.007

Clinical Feature	Present	Mild AHI	Moderate AHI	Severe AHI	P-value
Tonsils	(36.1 %)	(15.4 %)	(15.4%)	(69.2 %)	7
Adenoid Facies	27 (75.0 %)	11 (40.7 %)	7 (25.9%)	9 (33.3 %)	0.6050
Deviated Nasal Septum	2 (5.6%)	0 (0%)	0 (0%)	2 (100%)	0.1536

TABLE 3: POLYSOMNOGRAPHIC PARAMETERS - DESCRIPTIVE STATISTICS

PSG Parameter	N	Minimum	Maximum	Mean	Median	SD	25th-75th Percentile
AHI (events/hr)	36	0.7	24.6	7.2	6.1	6.45	2.9-11.2
CAI (events/hr)	36	0.0	2.8	0.405	0.0	0.725	0.0-0.725
OAI (events/hr)	36	0.0	6.0	1.875	0.6	1.565	0.0-2.2
ODI (events/hr)	36	0.6	26.9	9.69	9.1	6.851	4.075-14.975
RI (events/hr)	36	0.7	24.6	7.862	6.6	6.324	2.95-10.925
Mean SpO2 (%)	36	96	99	97.8	98	0.89	97-98
Minimum SpO2 (%)	36	79	94	86.5	87	3.74	83-89
Mean Pulse (bpm)	36	59	88	73.2	73	7.42	68-78
Total Apnea Episodes	36	0	48	13.5	7	13.8	3-18
Total Hypopnea Episodes	36	2	50	20.4	10	13.6	8-32

TABLE 4: CORRELATION MATRIX OF PSG PARAMETERS

Variable Pair	Sample Size	Spearman's rho	95% CI	P-value
AHI vs RI	36	0.911	0.831-0.954	<0.0001
AHI vs ODI	36	0.901	0.813-0.949	<0.0001
AHI vs OAI	36	0.829	0.688-0.910	<0.0001
AHI vs CAI	36	0.778	0.605-0.882	<0.0001
CAI vs OAI	36	0.783	0.611-0.884	<0.0001
CAI vs ODI	36	0.673	0.442-0.820	<0.0001
CAI vs RI	36	0.581	0.311-0.763	<0.0001
OAI vs ODI	36	0.618	0.363-0.787	<0.0001
OAI vs RI	36	0.827	0.685-0.909	<0.0001
ODI vs RI	36	0.750	0.559-0.865	<0.0001

DISCUSSION

This study examined polysomnographic profiles and clinical characteristics of adolescents with sleep-disordered breathing, describing the distribution of the severity of obstructive events and examining the associations among body mass index, tonsillar size, and SDB severity. The results show that 64% of the subjects exhibited at least moderate obstructive sleep apnea (OSA), and AHI severity categories were nearly equally distributed among mild (36.1%), moderate (27.8%), and severe (36.1%). These findings are consistent with the report of Mitchell et al. (2017),[8], who noted that 68% of adolescents with OSA met criteria for severe OSA. Similarly, Combs et al.,[9] reported that 37% of a large cohort of adolescents exhibited moderate to severe OSA. The

elevated frequency of severe OSA in this study most likely resulted from selection bias, because all of the adolescents in the sample were symptomatic enough to require an evaluation by specialists. These findings contradict the misconception that OSA is typically mild in teenagers; therefore, comprehensive evaluations of adolescents suspected of having OSA are essential, as recently discussed in reviews emphasizing that even mild OSA can have important neurocognitive and cardiovascular effects.[10]

The study also described several clinically relevant associations between anatomical factors and OSA severity. Hypertrophic tonsils were associated with greater disease severity than were either BMI or nasal septum deviation. Specifically, 69.2% of the severe AHI cases were characterized by hypertrophic tonsils ($p=0.0077$). As previously reviewed,[11], adenotonsillar hypertrophy is the major anatomical risk factor for pediatric OSA. Therefore, the clinical relevance of this finding provides support for the current treatment paradigm; adenotonsillectomy remains the first line of treatment for children diagnosed with OSA and hypertrophic tonsils.[11,12]. Although there was a statistically significant trend toward an association between BMI and AHI severity, 66.7% of the overweight participants, and the single obese participant, exhibited severe OSA ($p=0.0887$). The fact that only the mildly underweight participants exhibited mild or moderate AHI suggests a protective effect of lower body weight, which is consistent with the report of Kohler et al.,[13], which found that different levels of obesity have different associations with OSA across pediatric age groups. Although statistical significance was not achieved due to the small sample size of obese participants, this trend is biologically plausible and consistent with established knowledge that obesity contributes to OSA through multiple mechanisms, including increasing pharyngeal soft tissue, reducing lung volume, and altering ventilatory control.

An additional aspect of this research was an interesting finding of the inverse relationship between snoring (or lack thereof) and severity of AHI; there were no severe OSA patients that had snored. The findings of this research indicate that clinicians can potentially underestimate the severity of OSA in adolescents when they rely only on the symptom of snoring as their sole criterion for determining the likelihood of OSA. Snoring has been shown in multiple previous studies to be a poor predictor of the severity of OSA in children. Wang et al.[14] (1998), demonstrated that while clinical evaluation, which includes snoring history, is a good initial assessment tool for evaluating potential OSA, it is a poor tool for accurately predicting whether or not a child will ultimately be diagnosed with OSA via PSG testing. Additionally, Bidad et al., [15], found that the prevalence of snoring does not correlate with the severity of OSA in adolescents in a linear fashion. As such, it is possible that the silent nature of the obstruction that occurs due to a complete collapse of the upper airway in the most severe cases of OSA is the reason that partial collapses that cause snoring are not observed in these patients. Therefore, the finding of this study supports the idea that snoring is not required to include OSA in the differential diagnosis, particularly when adolescents exhibit symptoms indicative of OSA such as witnessed apnea's, gasping during sleep, or daytime function impairment.

Furthermore, the study identified sleep quality as perceived by the parents as another major area of interest. The fact that forty-four percent (44%) of the parents thought their adolescent was not getting enough sleep illustrates that there is an overlapping problem of both the quality and quantity of sleep for many in this population. This perception is also consistent with the larger body of literature from epidemiologic studies which show that seventy (70) to eighty (80)% of adolescents do not get the recommended eight (8) to ten (10) hours of sleep per night.[16] However, the parents may have no idea that fragmented sleep, because of the child having obstructive sleep apnea (OSA), will contribute to the child not getting enough total sleep time beyond just the behaviors of going to bed too late at night and waking up too early in the morning. There has been research that shows that a parent being concerned is a good indicator of how severe the child's OSA is[17]. Similar patterns were noted in this study, with parents who expressed greater concern about their child's sleep had children who had a higher AHI. When parents report a significant amount of worry about their child's breathing while asleep, it most often means that there is actual pathology occurring instead of what would be considered typical events of normal sleep.[18].

Comprehensive PSG parameter analysis objectively confirmed SDB and provided insight into additional aspects of the disorder beyond the standard AHI measurement. Oxygen Desaturation Index (ODI) values correlated strongly with AHI ($\rho=0.901$, $p<0.0001$) with those subjects that had higher AHI values having the most frequent desaturations and the lowest AHI values having the fewest desaturations. This is consistent with recent research demonstrating that ODI may be as effective as AHI for assessing the

severity of pediatric OSA.[17]. Given the simplicity of measuring ODI via less expensive overnight oximetry devices, ODI could potentially serve as a screening tool although it will not measure arousals from non-hypoxic events. Respiration Disturbance Index (RDI) values measured were slightly higher than AHI in many subjects indicating that some subjects had flow limited breaths causing arousals that did not meet the formal definition of an apnea or hypopnea. This finding is consistent with the previously published research that found that using AHI alone may underestimate SDB severity in children with significant respiratory effort-related arousals. The analysis of obstructive versus central apneas confirmed that almost all respiratory disturbances were obstructive, and the mean central apnea index remained low (mean = 0.405 events per hour), supporting the premise that central sleep apnea syndrome is uncommon in otherwise healthy adolescents. This finding is consistent with the recent research suggesting that ODI is as reliable as AHI for assessing the severity of pediatric OSA, specifically in cases with severe OSA [19].

Finally, the study addressed several aspects concerning sleep hygiene and management of adolescents with SDB. The lifestyle modifications of weight loss, positional therapy, and avoiding sedatives represent the foundation for managing mild to moderate SDB. In the case of severe SDB, continuous positive airway pressure (CPAP) therapy is often the most appropriate treatment option although adherence to CPAP therapy is difficult for many adolescents. Surgical interventions, primarily adenotonsillectomy, are successful in treating SDB when adenotonsillar hypertrophy is recognized as the primary cause of the SDB. Current literature emphasizes the need for developing personalized treatment plans that take into account not only the severity of SDB, but also the specific needs of the patient including anatomical variability, comorbidities, and psychosocial issues. Follow-up PSG is recommended to assess the effectiveness of the treatment plan and to provide additional direction for future management if any SDB continues to exist.

CONCLUSION

Beginning with the conclusion from this research study, it has been shown objectively that sleep disordered breathing (SDB) in adolescent patients is a clinically significant and very much underdiagnosed condition which should be diagnosed by an objective polysomnogram. Though obesity and tonsillar hypertrophy can be risk factors for SDB, they do not rule out moderate-to-severe obstructive sleep apnea (OSA). Also, as this study found many children with very severe OSA did not exhibit loud snoring; therefore, relying on patient symptoms to determine the level of severity of disease is unreliable. Early identification of OSA through polysomnograms is crucial because of the now documented serious short and long term health and cognitive effects associated with untreated OSA, i.e., neurocognitive dysfunction, poor school performance, behavioral problems, and long-term cardiometabolic risks. The study highlights the need for a multidisciplinary team effort (pediatricians, otolaryngologists, sleep medicine specialists, and nutritionists) and increased education regarding SDB among caregivers and healthcare providers to close the large gap between recognizing symptoms and providing timely treatment.

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