RESEARCH PAPER

Prevalence and Risk Factors of Sleep Disordered Breathing in Adolescents Seeking Orthodontic Care – A Hospital Based Study

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Abstract

Background and Objectives: Sleep disordered breathing may be described as a group of diseases and conditions characterized by disrupted respiratory patterns during sleep with prevalence in children of 0.7 to 16.9%. However, there is noted prevalence with about 80% of people with SDB undiagnosed. The aim of this study was to evaluate the prevalence and risk factors of sleep disordered breathing in adolescents using the Pediatric Sleep Questionnaire (PSQ). This study also aims evaluate the clinical, cephalometric, and demographic risk factors associated with sleep disordered breathing.
Materials and Methods: Study included 130 adolescents participated and SDB was assessed with Paediatric sleep questionnaire (PSQ) and clinical evaluations. The SDB patients identified were evaluated by cephalometric risk factors like skeletal class, FMA, Hyoid bone position, upper and lower pharyngeal airway width and adenoid grade.
Results: Among 130 participants, it was found that 8 participants had SDB (prevalence of 6.2%). A lot of factors were found to be significant SDB risk such as airway class, Tonsil grade, skeletal classification, FMA, hyoid position, upper and lower airway width, and adenoid grade.
Conclusion: Results showed a prevalence of 6.2% for SDB in adolescents, and significant associations between clinical and cephalometric factors. Specifically, class II-IV airways, higher tonsil and adenoid grades, class II or class III skeletal patterns, increased or decreased FMA, lower hyoid bone position and attenuated upper and lower pharyngeal airway width were higher risks for SDB. Future studies are recommended to have higher precision
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INTRODUCTION

Sleep disordered breathing may be described as a group of diseases and conditions characterized by disrupted respiratory patterns during sleep. This is a complex group of disorders that occurs during sleep and is described by extended periods of upper airway resistance (snoring) at one end of the spectrum and partial or complete airway obstruction at the other,[1] recurrent nocturnal asphyxia, fragmented sleep, major fluctuations in blood pressure, and increased sympathetic nervous system activity. [2]

Insomnia and excessive daytime somnolence in adults, together with their impact on normal physiological functioning and quality of life, have been the subject of research about sleep disorders. Despite sleep disturbances affecting 20–30% of health issues reported by pediatric health care professionals, there

is a paucity of studies regarding the incidence of these disorders in children.[3] Sleep disorders can result in a number of comorbidities that can impair a child's long-term health and quality of life, such as abnormal growth and cardiovascular, immunological, and metabolic diseases. Common complaints include difficulty falling asleep; awakening throughout the night; snoring; severe daytime sleepiness; and difficulty working during the day. Usually, these complaints are signs of treatable sleep disorders.[4]Among the primary risk factors for sleep-disordered breathing (SDB), body mass index (BMI) serves as a significant predictor of the severity of sleep disorders.[5]

Multiple upper airway problems are included in SDB, including primary snoring (PS), obstructive sleep apnea (OSA).[6] PS is a respiratory sound
associated with normal sleep architecture, alveolar ventilation and blood oxygen saturation.[7] OSA occur in all ages and genders and its prevalence is highest in the preschool age group (3 to 5 years). Craniofacial morphology exhibits a link with sleep-disordered breathing, particularly obstructive sleep apnea. Children with craniofacial anomalies, down syndrome, or micrognathia are at heightened risk for obstructive sleep apnea syndrome (OSAS). [8]

Both clinical examination and polysomnography are used for a definitive diagnosis of sleep disordered breathing. The technical and economic barriers faced in the use of polysomnography led to the development of several questionnaires to assess patients at high risk of sleep disordered breathing. [9] Chervin RD et al.[10] developed a validated prospective Pediatric Sleep Questionnaire (PSQ) to evaluate sleep disordered breathing and the related symptoms in children and adolescents. Orthodontists generally see a lot more adolescent patients than their medical counterparts. In addition to educating the public, they also play a role in evaluating the risk of sleep disordered breathing and referring those at high risk to a sleep physician to correctly diagnose and treat. [9]The prevalence of SDB in children ranges from 0.7 to 16.9%; however, in the literature, PS ranges from 4.3 to 16.9% and OSA ranges from 0.7 to 3%.[11] An estimated 80% of SDB patients are undiagnosed and unaware of their condition. [12] The aim of this study was to evaluate the prevalence and risk factors of sleep disordered breathing in adolescents using the Pediatric Sleep Questionnaire (PSQ). This study also aims evaluate the clinical, cephalometric, and demographic risk factors associated with sleep disordered breathing.

MATERIALS AND METHODS

This cross-sectional study was conducted after receiving approval from the institutional ethical committee (IEC No.: IEC/M/17/2019/DCK). The sample size for the study was computed from the formula $n = 4pq/d^2$ where $p = 0.7$, $q = 0.93$, $d = 0.05$ adopted from Rohra AK et al [9]. To enhance the power of the study, extra 25% additional samples were also taken into consideration. Hence, a sample of 130 was studied. It includes participants aged 12–17 years who have no prior history of orthodontic treatment and have provided consent before treatment. They must be healthy and not have underlying diseases that could affect treatment. Exclusion criteria prevent subjects with medical or
developmental conditions, such as children with cleft lip and palate or other craniofacial syndromes, which may affect treatment results or data consistency.

A validated prospective Pediatric Sleep Questionnaire (PSQ) developed by Chervin RD et al[10] to evaluate sleep disordered breathing and the related symptoms in children and adolescents was used in this study for evaluation of SDB (Fig. 1). The investigator asked the 22 questions in the Pediatric Sleep Questionnaire (PSQ) to the parents of patients who were willing to participate in the study, had fully completed the inclusion criteria, and had reported for orthodontic treatment. After obtaining consent from the parent and assent from the child (Annexure I, II, III & IV), the investigator explained all the questions in Malayalam and recorded their responses to each question. The PSQ offers response categories for all questions as "yes," "no," or "don't know," indicated by "?". The minimum index recommended for diagnosing patients with sleep disordered breathing (SDB) equals to 0.33 referred to 33% of ‘‘yes’’ replies. A proportion of yes replies equal to or exceeding 0.33 was deemed indicative of SDB; missing and "don't know" responses were omitted from the denominator in the prevalence estimation. After the first step (PSQ), allthe patients were clinically examined for the risk factors of SDB, and data recorded as follows (Fig.2). And data entered in the data collection proforma (Annexure V). Those patients who were positive in either steps (PSQ, Clinical examination) or both steps were further evaluated with cephalometric analysis. Skeletal Class (SNA, SNB, ANB, Wits, Beta Angle), FMA, Hyoid Bone Position, Pharyngeal Airway Width – Upper & Lower, Adenoid Grade were evaluated (Fig.3). Demographic data was also recorded for each participant. The data was statistically analysed using statistical package for social sciences (SPSS version 23, IBM Corporation, USA) for microsoft windows. For Descriptive statistics mean, standard deviation and proportion were calculated and for inferential statistics chi- square test was used.

RESULTS

The demographic details of the study participants are shown in Table 1. Among 130 participants, 64 (49.2%) were male and 66 (50.8%) were female. There are 59 participants above the poverty line (45.4%) and 71 participants below the poverty line (54.6%). The participants were categorized by residency into urban (21, 16.2%) and rural (109, 83.8%).

Table 1: Demographic characteristics of study participants.

		N	%
Age (in years)	14.72 ± 1.6		
Sex	Male	64	49.2
	Female	66	50.8
Socioeconomic status	APL	59	45.4
	BPL	71	54.6
Area of residence	Rural	109	83.8
	Urban	21	16.2

The study evaluated clinical risk indicators such as height, weight, BMI, neck circumference, airway (modified Mallampati Classification), and tonsil grade. The mean height was 148.16 ±8.4, weight was 45.45 ±6.542, and neck circumferences were 28.89 ±1.801. The airway classification showed 125 participants (96.2%) fell into class I, 3 (2.3%) into class II, and 2 (1.5%) into class III. Tonsil grading showed 127 participants (97.7%) in grade I and 2 (2.3%) in grade II. (table 2)

Table 2: Descriptive statistics of clinical risk assessment parameters.

Clinical risk assessment		*N*	*%*
Height (in cm)	148.16±8.4		
Weight (in kg)	45.45± 6.542		
BMI (in kg/m^2)	20.608±1.805		
Neck circumference (in cm)	28.89±1.801		
Airway (Modified Mallampati Classification)	Class I	125	96.2
	Class II	3	2.3
	Class III	2	1.5
Tonsil grade	Grade I	127	97.7
	Grade II	3	2.3

Out of 130 participants, 6.2% were identified as high-risk for SDB, with 122 questionnaires having no positive responses. The mean proportion of "yes" responses among high-risk patients was 38.63%, ranging from 35.76% to 41.5%. (Table 3)

Table 3: Proportion of yes responses more than 33% in participants.

	N (%)	Minimum (%)	Maximum (%)	Mean proportions (%)	Std. Deviation
Proportions of yes responses in SDB	8 (6.2%)	36.30	45.45	38.625	3.441

A study of 8 positive cases of SDB revealed that 25% had a Class I skeletal base, while 37.5% fell into the Class II and Class III categories. The Frankfort mandibular plane angle (FMA) decreased in 25% of patients, while 37.5% had an increased FMA. The hyoid position varied among patients, with 12.5% ranging between C2-C3, 25% between C3-C4, 50% between C4-C5, and 12.5% between C4-C5. All 8 individuals showed a decreased upper pharyngeal airway space (100%). The lower pharyngeal airway space was normal in 4 patients (50%) and decreased in the remaining 4 patients (50%).

Regarding adenoid grading, 2 (25%) patients had Grade I adenoids while 6 (75%) had Grade II adenoids. (Table 4)

Table 4: Cephalometric risk assessment indicators of SBD.

S.no	Cephalometric risk assessment			N	%
1	Skeletal classification	Class I		2	25
		Class II		3	37.5
		Class III		3	37.5
2	FMA	Decreased		2	25.0
		Increased		3	37.5
		Normal		3	37.5
3	Hyoid position	C2-C3		1	12.5
		C3-C4		2	25.0
		C4		4	50.0
		C4-C5		1	12.5
4	Pharyngeal airway analysis	Upper (Decreased)		8	100
		Lower	Normal	4	50
			Decreased	4	50

5	Adenoid Grading	Grade I		2	25
		Grade II		6	75

The study found a significant association between airway class and SDB risk (P-value = 0.001), with Class I individuals at low risk, while those with Class II and III airways were more likely to be at high risk. There was a significant associationbetween Tonsil Grade and the risk of SDB (P-value = 0.001). Individuals with Grade I tonsils were predominantly at low risk for SDB, while those with Grade II tonsils were more likely to be at high risk (Table 5).

Table 5: Association of SDB with clinical and cephalometric factors.

		SDB		P value
		Low risk	High risk	
AirwayClass	Class I	122	3	0.001*
	Class II	0	3	
	Class III	0	2	
Tonsil grade	Grade I	122	5	0.001*
	Grade II	0	3	
Skeletal classification	Class I	122	0	0.001*
	Class II	0	3	
	Class III	0	2	
	Normal	122	0	
FMA	Decreased	0	2	0.001*
	Increased	0	3	
Hyoid position	C2-C3	122	0	0.001*
	C3-C4	0	1	
	C4	0	2	
per airway width	Decreased	122	0	0.001*
ver airway width	Normal	122	0	0.001*
	Decreased	0	4	

Adenoid	Grade I	122	0	0.001*
	Grade II	0	2	
	Grade III	0	6	

*Chi-square test, significance level set at 0.05

There was a significant association between skeletal classification and the risk of SDB (P-value = .0001). Individuals with the Class I skeletal classification were predominantly at low risk for SDB, while those with the Class II and III classifications were more likely to be at high risk. The Pearson chi-square and likelihood ratio tests both showed significant results (P-value = 0.001), confirming the strong association between skeletal classification and SDB. (table 5). The study found a significant association between FMA and the risk of SDB; individuals with normal FMA were at a low risk, while those with decreased orincreased FMA were at a higher risk. Individuals with the hyoid position at C2–C3 have significantly lower risk for SDB (P-value =.0001)., whereas those with the hyoid position at C3–C4, C4, C4–C5, and C5 were more likely to be at high risk.

A significant association existed between upper airway width and the probability of sleep-disordered breathing (P-value = .0001). Individuals with a normal upper airway were mostly at low risk for sleep-disordered breathing, but those with reduced upper airway width were more likely to be at high risk.

Adenoid Grade was significantly associated with the risk of SDB (P-value =.0001). Individuals with Grade I adenoids were primarily at low risk for SDB, whereas those with Grade II and III adenoids were at higher risk.

In our study, 8 of the 130 participants were identified as having SDB, resulting in a prevalence of 6.2% (95% confidence interval: %-10.6%). For the eight people who were at risk of sleep disordered breathing (SDB), skeletal classification, FMA, hyoid position, pharyngeal airway width (upper and lower), and adenoid grades were all looked at. A statistical test of cross tabulation was performed on these cephalometric indicators, and the results revealed a significant relationship with SDB.

DISCUSSION

In the present study, the prevalence of SDB among adolescents was estimated as 6.2%. Literature revealed that SDB prevalence differs in different population groups related to different demographics. Rohra et al.[9] used the Pediatric Sleep Questionnaire, and it has been found that the high-risk SDB among 9–17-year-old orthodontic patients is approximately 7 percent, which is also almost similar to the present study. Similarly, there was a 9.7% averageprevalence of SDB in thirty-two patients aged 2–16 years (mean age of 7 years), as reported by Gabriele Di Carlo et al.[13] Bixler et al. [14] studied the prevalence of SDB in elementary school children by employing polysomnography, physical examination, and other diagnostic tests. Briefly, their studies indicated that 1.2% of the subjects were moderately affected by SDB, 25% had mild SDB, and 15.5% were primary snorers. The application of these sophisticated procedures may explain the disparity with the results obtained in the present investigation. Laila Baidas et al[15] assessed the prevalence of sleep-disordered breathing among Saudi primary school children in the age range of 6 to 12 years, using PSQ and found that around 21% of Saudi children are at risk of sleep-disordered breathing. The difference in geographic, cultural and racial characteristics of the population can be a reason for the difference from the current study. Risk factors for SDB were found in children with asthma by Tao M et al.[16], and the estimated prevalence was 21.6%. An important contributing factor to the higher prevalence than in the prsent study may be an underlying medical condition.

The current study reveals a significant association between Airway Class, as measured by the Mallampati Score (MMS), and the risk of sleep-disordered breathing (SDB) (P = 0.001). Patients with Class I airway have low propensity towards SDB, while patients having Class II, III and IV airway have high risk. Craig Hukins' [17] research validates these findings, demonstrating that Mallampati Classes II and III substantially elevate the odds ratio (OR) for obstructive sleep apnoea (OSA) (AHI ≥ 5), whereas Class IV is particularly linked to severe OSA (AHI > 30). Subsequently, Kim et al.,[18] revealed that there is a possible association between MMS, SDB risk, and compromised sleep quality especially in those patients with nasal obstruction. According to the present work, tonsil grade was found to be positively related with SDB (P = 0.001). Hence, while those in the Grade I category are a low risk of SDB, the rest with tonsils in the Grade II and above stand a higher risk. This was further supported by a cross-sectional study of Jara SM [19]

to show a significant relationship between OSA severity and increased palatine tonsil grades. Likewise, Wang J et al.[20]explained that children with larger adenoid and tonsils exhibit more severe OSA symptoms.

This study affirms that there is a statistical significant relationship between skeletal classification and SDB. Class I skeletal classification patients are considered to have low risk for SDB, while patients with Class II and III classifications are considered to have high risk. Galeotti et al.,[21] showed a positive correlation between OAHI and maxillomandibular mismatch by using ANB angle measurement. Like this, Anand [22]et al described that mandibular position (SNB angle) was another important cephalometric variable to predict the severity of OSA with significant Class II skeletally, high mandibular plane angle and hyper-divergent facial pattern. Kim et al.[23] also did not note much variability in adult OSA patient's skeletal patterns, however, there were no statistical assosiation between skeletal pattern and characteristics of OSA due to the high inter individual variability.

FMA was noted to be related with SDB in this study. The findings indicate that a normal FMA signifies a low risk for SDB whereas altered FMA either being high or low reveals increased risk of the condition. Kim SJ et al. [24] found that most OSA patients had a Class II skeletal pattern with a small mandible and an excessive vertical growth tendency. Similarly, Anand AM et al.[25]also observed higher mandibular plane angle and hyper-divergent facial profile in OSA patients. Moreover, the investigation of hyoid bone position also shows that there is a strong correlation with the risk of developing SDB (P = 0.0001).

The study reveals that people with hyoid bone at C2-C3 are relatively safe from SDB while those at C3-C4, C4, C4-C5 and C5 are likely to suffer SDB. Soares et al. [26] stated that in healthy individuals, hyoid bone is positioned from C3 to C4 whereas, in OSA patients, it is located lower from C4 to C6. Valarelli et al [27] also noted that hyoid position was lower in OSA patients and it regressed with OSA severity. But, there is a disagreement in the present study of Kurbanova et al [28] which shows that hyoid bone was positioned at C3-C4 levels irrespective of non-OSA and OSA individuals.

Thus, the present study could establish positive association between both upper and lower airway width with SDB. In decreasing width of upper and lower airways, people of normal width are at little risk and whereas those at high risk are with decreased widths in both upper and lower airways. Likewise, Chaturvedula et al. [29] noticed hyperdivergent subjects exhibit comparatively small UPA and LPA dimensions; backward and downward rotation of the mandible may narrow the airway and cause OSA in children. Suri et al.[30] also found that the OSA experienced significantly smaller upper airway dimensions than matched controls, patients' cephalometric measurements were dependent on the severity of OSA. These findings also reveal a positive correlation between adenoid grade as well as SDB. As for the patients with Grade I adenoids, the risk of SDB is low andincreased for the patients with adenoids Grade II and III. In the same regard, Kang et al [31] noted that adenoid size was positively correlated with AHI in toddlers, preschoolers and school going children but not in adolescent or young people. Tonsil grade was positively associated with AHI in both obese and non-obese children, while adenoid size was also related to AHI. In their study, Tagaya et al. [32] highlighted that there is a direct relationship between adenoid grade and apnea index in preschoolers, this has led to an understanding that adenoid hypertrophy is a primary cause of OSAS among normal-weight preschool children.

There are several limitations with the present study. It involved few participants of about 12-17 years old which might have reduced parental awareness of SDB symptoms because these individual do not share their bedrooms with their parents. Further, clinical examination data introduced bias and objective diagnostic methods like polysomnography were lacking, though PSQ serves the purpose of a standard test. SDB was present in 8 of the participants; 6.2% of the total participants, which could be connected to their low FMA. Hence, more research investigation into SDB and its risk factors should be carried out in different populations, different age, and different SES backgrounds. The studies in the future should use questionnaires, polysomnography, lung function tests and clinical and cephalometric evaluations and add new CBCT investigation.

CONCLUSION

This study identified a 6.2% prevalence of sleep-disordered breathing (SDB) in adolescents. There was significant association of sleep disordered breathing with numerous clinical and cephalometric factors. There were higher risks of SDB linked to Class II-IV airways, higher tonsiland adenoid grades, Class II and III skeletal patterns, increase or decrease in the Frankfort Mandibular Plane Angle (FMA), lower hyoid bone positions, and reduced upper and lower pharyngeal

airway widths. Further research with larger, more diverse populations and advanced diagnostic tools is recommended to validate these findings and provide a more holistic understanding of SDB, ultimately leading to better-targeted interventions and improved health outcomes for affected adolescents.

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