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Association of Sleep Disorders of Breathing With Oral Health Findings Using the San Diego Sleep Survey and Pediatric Sleep Questionnaire

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Purpose: This prospective study investigates the relationship between the San Diego Sleep Survey (SDSS) and the Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire (SRBD-PSQ) with oral health findings. The aim is to assess how these questionnaires screen for sleep disorders related to dental traits in children.

Method: A total of 135 children age 1 to 14 years scheduled for a periodic examination at a hospital-based federally qualified health center dental clinic in San Diego, CA. Guardians completed a survey of demographic questions and the SDSS, which included the 22 items from the SRBD-PSQ. Ten dental parameters were assessed during the oral examination.

Results: The mean age was 9.84 years, with 54.8% of children identified as female. Most participants had a body mass index less than the 85th percentile and an American Society of Anesthesiologists classification of 2. Additionally, 64% were of Hispanic ethnicity. A significant correlation was observed between both surveys, especially for mouth breathing (SDSS: $P<0.01$; PSQ: $P<0.001$) and non-nutritive habits (SDSS: $P=0.01$; PSQ: $P=0.035$). Bruxism was only statistically significant in the SDSS ($P<0.01$).

Conclusion: This study found that specific dental traits were linked to results from two sleep questionnaires, suggesting that dental characteristics are associated with sleep disorders.

Clinical Implcations: Children typically visit the dentist every 6 months, uniquely positioning dentists to screen for sleep disorders such as sleep-disordered breathing. When paired with a clinical examination, questionnaires such as the SDSS can serve as effective screening tools, helping to identify early signs of pediatric sleep disorders.

Keywords: Sleep disordered breathing; non-nutritive habits; mouth-breathing; sleep hygiene; pediatric obstructive sleep apnea; bruxism; questionnaire; screening

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INTRODUCTION

Sleep is a biologic process that is essential for life and plays a critical role in brain function along with systemic physiology, including metabolism, appetite regulation, and the functioning of immune, hormonal, and cardiovascular systems.[1-3] Sleep-disordered breathing (SDB) is one of many sleep disorders that can lead to marked disruptions in physical health and well-being. SDB is an umbrella term for myriad sleep-related breathing disorders (SRBD) that include obstructive sleep apnea (OSA) among many other abnormalities of respiration during sleep that do not meet the diagnostic criteria for a disorder (such as snoring).[4]

The severity of obstructive sleep apnea syndrome (OSAS) in adults is categorized according to the patient's apnea-hypopnea index (AHI). An AHI of 5 to 15 events/h of total sleep time (TST) is categorized as mild OSAS, an AHI of 15 to 30 events/h TST is categorized as moderate OSAS, and an AHI higher than 30 events/h TST is considered severe OSAS. However, for children, the thresholds are lower. Mild OSAS is defined as an AHI between 1 to 5 events/h TST, moderate OSAS being 5 to 10 events/h TST, and severe OSAS being more than 10 events/h TST.[5] The nasopharyngeal airway is at its narrowest at 4.5 years of age, mainly because of adenoidal structures affecting upper airway patency. The adenoids typically reach their largest size in children age 7 to 12 years.[6] In addition, age 12 years is considered to be the time when 90% of facial development is completed.[7]

In the pediatric population, SDB can have overarching effects on a child's development and overall quality of life. Early diagnosis is key in helping pediatric patients with SDB, and guidelines have been established by the American Academy of Pediatrics to help identify and manage young patients with OSA. [8] In addition, the American Academy of Pediatric Dentistry's Policy on Obstructive Sleep Apnea recommends that all healthcare professionals screen patients for SDB, assess for tonsillar hypertrophy, evaluate tongue position, calculate body mass index (BMI), and identify key craniofacial aspects that may be associated with OSA. The clinician is also encouraged to refer the patient to a physician for further medical assessment (such as an otolaryngologist, sleep medicine physician, pulmonologist) for proper diagnosis and

treatment recommendations.[9]

The American Academy of Pediatrics Subcommittee on Pediatric Sleep estimates that 1.2% to 5.7% of children are affected by OSA alone.[10] Childhood obesity affects more than 107 million children worldwide and has a higher prevalence (>20%) in developed countries.[11] As the childhood obesity epidemic continues in the United States, it has resulted in an increase in the incidence of OSA in the pediatric and adolescent population. Not only is the physical and mental health of the child potentially affected by SDB, but disrupted sleep places the child at risk for growth disturbances, poor school performance, and behavioral challenges as well as developmental delay.[9,12] For these reasons, earlier recognition and treatment of SDB in children may have a lasting effect on normal childhood growth and development.

Physical examination of a child is useful in identifying OSA. In particular, an oral examination that assesses dentition, mandible, tongue, tonsils, and hard and soft palate can identify children at risk for OSA because these clinical features can lead to upper airway obstruction during sleep.[13]

Because most patients typically visit their dentist every 6 months for recall appointments, dentists are in an opportune position to examine the oral cavity and airway, and probe about sleep habits.[5] There have been sleep questionnaires, such as the Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire (SRBD-PSQ), that have been beneficial in screening patients for SDB.[5,14]

Ideally, sleep surveys should be combined with clinical examinations to improve screening measures for sleep disorders.[5] The San Diego Sleep Survey (SDSS) was developed and used by the sleep medicine clinic at Rady Children's Hospital. This survey, in addition to evaluating for SDB by incorporating all questions of the PSQ, also encompasses several components of behavioral and other nonbehavioral sleep disturbances in children. Its use in a pediatric dental population is currently unknown, making this study a prime opportunity to screen for SDB or other sleep disorders and identify any oral clinical findings versus that of the SRBD-PSQ alone. Screening for pediatric OSA at each dental recall appointment could help with early intervention and diagnosis in the pediatric population.

METHODS

This study (IRB: s18-00756) was approved by the Institutional Review Board (IRB) of NYU School of Medicine in New York, NY. Patients between the ages of 1 to 14 years were recruited during their regularly scheduled dental appointments at San Ysidro's Children's Dental Center at Rady Children's Hospital and the Chula Vista Medical Plaza. The principal investigator provided information about the study to the guardian (age 18 years or older) of the child. Informed consent was obtained from the guardian of the child who agreed to participate in the study. There were no financial or in-kind incentives for the patients.

Guardians who consented to participate were instructed to complete the survey in the examination room during the child's appointment. Guardians were given the option of completing the survey in either English or Spanish. The survey contained all of the validated SRBD-PSQ questions (22 questions) plus an additional 30 questions about behavioral sleep disorders, and sleep hygiene including screen time, quality of life, weight, and nutrition from the SDSS. The survey contained a total of 52 questions that took participants an estimated 5 to 10 minutes to complete. Where the SRBD-PSQ uses a three-point Likert scale (yes, no, do not know), the SDSS uses a four-point Likert scale (usually, sometimes, never, do not know). If guardians answered 'usually' or 'sometimes', these answers were transformed to a 'yes', 'never' was converted to a 'no', and 'do not know' was unchanged. The principal investigator then filled out the clinical measures portion of the survey after the clinical exam was completed.

Surveys were scored based on the standard SRBD-PSQ scoring system with responses of yes = 1 point; no = 0 points; and do not know = missing. A total of eight or more "yes" responses was considered a positive screening for children at risk for SDB and is an indicator for when a clinician should consider referring the patient to a medical professional for a sleep evaluation.

General areas of concern addressed in the survey included child's bedtime routine, lack of sleep, dietary habits (including caffeinated beverages), restlessness during sleep, sleeping habits (including sleepwalking or waking up during the night), bedwetting, bruxism, snoring habits, use of electronics prior to bedtime, and irregular sleep habits. The survey also asked the parent/guardian to rate their child's overall quality of life as it relates to sleep and sleep irregularities.

After the patient's clinical dental examination was concluded, the principal investigator collected the following clinical measures from the patient's electronic dental record for the prospective chart review: age, sex, American Society of Anesthesiologists (ASA) status, ethnicity, bruxism, malocclusion, mouth breathing, attention deficit hyperactivity disorder (ADHD), history of tonsillectomy/adenoidectomy, Brodsky score, snoring history, dental crowding, non-nutritive habits (NNH), and BMI. Prior to the child being seated in the dental chair, a dental assistant measured each child's height and weight, which was used to calculate BMI (kg/m^2). Per the Centers for Disease Control and Prevention guidelines, children were categorized as having normal weight if their BMI was in the 5th to less than the 85th percentile, overweight if BMI was greater than 85th to less than the 95th percentile, and having obesity if BMI was greater than or equal to the

95th percentile for age and sex.[15]

All of the aforementioned clinical parameters that were collected were obtained during the routine dental examination that occurred on that same day. No data from prior clinical encounters were collected from the electronic dental record for this study. Data were immediately entered into the web application REDCap by the principal investigator.

Means and standard deviations were calculated for all continuous variables, and rates were calculated for all categorical variables. Comparisons of differences in mean SRBD-PSQ scores and mean SDSS scores by category of each clinical parameter (bruxism versus no bruxism, malocclusion versus no malocclusion, dental crowding versus no dental crowding, mouth breathing versus no mouth breathing, previous tonsillectomy and or adenoidectomy versus no tonsillectomy and or adenoidectomy, NNH versus no habits, and ADHD diagnosis versus no ADHD) were performed using independent *t*-tests, and by BMI category and Brodsky score (O, I, II, III/IV) using analysis of variance. The coefficient of determination (R^2) was used to measure the correlation between the SRBD-PSQ and SDSS domain scores.

All of the aforementioned clinical measures are standard-of-care measures that were assessed by history and oral examination and recorded during all routine dental visits in the clinic.

RESULTS

A total of 135 children were included in this research study. A demographic summary is provided in Table 1. The mean age of participants in this study was 9.84 years (mean SD, 2.43%). There was a higher percentage of female participants (n = 74; 54.8%). The BMI of the participants ranged from morbid obesity to unanswered, with most (54.8%) at a healthy weight. A total of 34.8% of patients were classified as having either obesity or morbid obesity. Unattained weight was 0.7%, meaning that the participant's weight could not be obtained during the appointment because the child was uncooperative. Based on the ASA classification, most of the participants were classified as ASA 2 (47.7%) with the fewest classified as ASA 3 (11.9%). Most participants were of Hispanic ethnicity (63.7%), followed by 24.4% classified as Other, and 11.9% classified as White (Table 1).

Table 2 outlines the distribution of dental characteristics by total SDSS, highlighting differences in dental traits and total SDSS scores via a two-sample t-test/analysis of variance. Dental traits of bruxism (P<0.01), mouth breathing (P<0.01), Brodsky score (P<0.02), and NNH (P<0.01) showed a significant association with the SDSS. Table 3 shows the distribution of dental characteristics by SRBD-PSQ threshold. The results show that of the nine characteristics, there were two that were significantly associated with a positive SRBD-PSQ score— mouth breathing (PSQ threshold <0.33 is 4.8; >0.33 is 29.4; P<.001) and NNH (PSQ threshold less than 0.33 is 16.7; greater than 0.33 is 33.3; P<.035).

Dental characteristics by individual SDSS components are presented in Table 4. Bruxism and mouth breathing had a significant association (P<0.01) with four of the five SDSS components: sleep disorder, SDB, daytime symptoms, and insomnia. Bruxism was not significantly associated with sleep hygiene. The presence of malocclusion and dental crowding did not show any statistically significant association with any of the five components. The Brodsky score (P<0.01) was only significantly correlated with one of the five components—SDB; whereas NNH habits showed a statistically significant association with SDB (P = 0.03), and insomnia (P = 0.02). NNH were borderline significantly associated with sleep disorder (P=0.05) and daytime symptoms (P = 0.08).

There were no statistically significant associations with the SDSS for the presence of obesity, ADHD, and history of tonsillectomy and/or adenoidectomy, whereas obesity and a history of tonsillectomy and/or adenoidectomy was statistically significantly associated with a positive SRBD-PSQ score (see Supplemental Tables 1 through 3).

Figure 1 shows that this study found significant correlation and consistency between the SRBD-PSQ and SDSS (R^2 = 0.76). Figure 2 demonstrates the correlation of all SDSS domain scores with the PSQ, and it was noted that the correlation was greatest for the SDB domain (R^2=0.44), and the daytime domain (R^2=0.69). The results showed that the SRBD-PSQ score was not predictive of the Brodsky score and that the SDSS was stronger at predicting NNH.

DISCUSSION

Normal sleep is central to a healthy childhood and treatment of sleep disorders including OSA, which can have important ramifications to improving behavioral and physical health. Although there is evidence to support OSA being associated with hypertension, cardiovascular disease, metabolic disorders, obesity, and neuropsychiatric and developmental issues, the full scope of the effect of OSA on health remains underappreciated by many clinicians.[13] Furthermore, earlier recognition of OSA may help mitigate complications and possibly even reverse or prevent them.

The purpose of this study was descriptive. The intent was to assess whether sleep questionnaires used at the Rady Children's Hospital dental clinic were associated with the presence of certain dental traits/findings. The findings from this study show evidence that in addition to a thorough review of medical history along with a comprehensive oral examination, having the patient and/or the guardian of the

patient fill out a sleep questionnaire, such as SRBD-PSQ and SDSS in this case, provided a broader understanding of the patient's risk of the development of important sleep disorders. Although there is the existing SRBD-PSQ screening tool, this study also used the locally developed SDSS screening tool. The reason for using the SDSS is because it contains questions that encompass additional aspects of the potential for other sleep disorders. Being able to use these questionnaires as a guide allows the dental provider the ability to make a clearer judgment on the patient's condition in reference to sleep disorders including SDB.

This study showed that there were three main symptoms that had statistical significance: bruxism, mouth breathing, and NNH. Bruxism is defined by the National Institute of Dental and Craniofacial Research as "a condition where a person grinds, clenches, or gnashes his/her teeth; it can occur when awake or asleep."[16] This study showed that with the SDSS, bruxism had statistical significance with all components except sleep hygiene. The SRBD-PSQ, however, showed no statistical significance for bruxism. It is estimated that approximately 14% of the pediatric population is affected by bruxism.[17] Risk factors for bruxism include obesity, stress, smoking, alcohol use, high coffee consumption, and certain classes of medication usage; Bruxism is also associated with psychological factors.[17] A systematic review by González-González et al concluded that sleep bruxism (SB) and SDB had a concomitance of 20% to 40% in both the adult and pediatric populations.[17] Although this systematic review shows links between SB and SDB, more research is needed to show more scientific evidence.[17] Not all the studies included in the review had standardized criteria. In addition, their diagnostic criteria across studies differed. This can easily skew the true relationship between SB and SDB.[17]

The findings from the current study showed consistency in both surveys regarding the association between mouth breathing and NNH with the probability for sleep disorders. On the SDSS, mouth breathing was significantly associated with four of the five components, all except sleep hygiene; whereas NNH was significantly associated with two of the five components, which are SDB and insomnia. With the SRBD-PSQ, only mouth breathing and NNH were shown to be statistically significant. These findings provide strong indications for the associations and links between certain pathologic sleep symptoms with clinical dental findings.

Proper facial development includes nasal breathing, which is one of the key factors in oral cavity and airway development along with bone formation.[18] When nasal breathing is replaced with mouth breathing, it has been shown to lead to serious clinical and developmental consequences.[18] A 2008 study on children ages 3 to 9 years showed that the main causes of mouth breathing were allergic rhinitis, enlarged adenoids, enlarged tonsils, and deviated septum.[19] Some of the main clinical manifestations of mouth breathing are seen in the craniofacial malformations such as narrowing of the maxillary arch, protrusion of the anterior teeth, posterior unilateral/bilateral crossbite, posterior positioning of the mandible, and open bite.[18]

Additional risk factors for NNH include the use of pacifiers and/or finger sucking. Prolonged NNH is considered when the habit is occurring beyond the age of 3 years.[20] Although there is a dearth of studies linking NNH and its association with pediatric OSA, there are many studies instead linking dental and maxillofacial growth to risk of pediatric OSA. Schmid et al. conducted a systematic literature review in which of 2,288 studies, 17 articles were selected for analysis.[21] Fifteen of those 17 articles showed a strong association between anterior open bite and the use of a pacifier when compared with not using a pacifier.[21] In 2021, Berwig et al performed a study indicating that the presence of malocclusions with habits of non-nutritional sucking for a prolonged period caused a reduction in the width measurements of the hard palate, while the oronasal breathing mode caused an increase in depth.[22] Because NNH has been shown to affect the growth of the maxillofacial region and these changes may increase the risk of pediatric OSA, it can be concluded, based on the surveys used in the current study, that NNH can potentially be associated with increased risk of pediatric OSA.

Controversy exists around whether SB has a relationship with OSA. For instance, a 2014 systematic review by De Luca Canto et al[23] did not show a connection between SB and SDB, but other articles,[24-27] including the recent study by DaRocha et al[28] confirm a strong relationship between SB and SDB. Regardless, it would be prudent for the dentist to examine the oral cavity for signs of tooth wear and ask appropriate follow-up questions regarding sleep hygiene, as this current study also suggests significant correlation between bruxism and SDB through utilization of the SDSS survey (four out of five domains).

Several strengths and limitations of this study must be noted. As a follow-up to the DaRocha et al[28] pilot study, the current study included the "bedwetting" question in the SRBD-PSQ, which was inadvertently omitted in the study by DaRocha et al. The current study also had a relatively large sample size and patient diversity. Another strength is its prospective study design, allowing comparison of risk factors. Last, including the SDSS allowed for further probing into more behavioral factors, such as sleep hygiene.

A limitation of this study includes the research population that was recruited. Because the federally qualified health center clinic is located on the campus of Rady Children's Hospital premises, most of the patients are active patients of both the dental clinic and the children's hospital. As a result, the sample is biased toward patients with a higher number of comorbidities than may typically be found in the general pediatric population, which could

elevate the likelihood of OSA in these children. Also, the predominant pediatric population in this study was 64% Hispanic, which may influence the data to this one particular demographic. For instance, the authors of the current study recently reported that among adolescent patients, the prevalence of OSA and more moderate-severe OSA was found to be higher among Hispanic adolescents.[29] Another limitation is that this study did not differentiate tonsillectomy or adenoidectomy from adenotonsillectomy. Because there was no specification of these specific surgeries as being distinct from adenotonsillectomy, there is uncertainty about which specific surgery the patient had a history of. In addition, the current study was also limited in that there was overlap between some of the observed associations of dental clinical findings with questions from the questionnaires, including mouth breathing. Because both the SDSS and PSQ-SRBD probe about mouth breathing, this association is not surprising.

Because the current study did not clarify the severity of a participant's NNH, a positive finding for NNH may reveal a wide spectrum of severity. Finally, a limitation of this study was the utilization of a nonvalidated survey, the SDSS, to develop the 'PSQ score'. Although all of the questions of the SRBD-PSQ were included within the SDSS, it was modified to add more questions in order to encompass broader characteristics on sleep disruption.

Because the history of tonsillectomy and/or adenoidectomy was statistically significant with the SRBD-PSQ, it would be interesting to find out if future studies focus on whether a participant had one or both surgeries completed for greater data accuracy. Because the association of NNH was also statistically significant, as seen in the results for SDSS, further studies could be performed to probe deeper into NNH to see whether there is a threshold at which factors such as frequency and duration start to play a vital role in SDB.

Because of the sample size, the current study was underpowered to perform multivariable regression analysis. In future studies with larger cohorts, it is hoped that a multivariable logistic regression analysis can be performed. The authors of this study, in a separate study of more than 1,000 patients in a sleep clinic population, will report on reliability.

The role of the dentist in the area of SBD is essential in the diagnosis and referral of patients for further evaluation in a sleep clinic and/or laboratory.[30] Because SDB etiology is multifactorial, especially as it relates to the head and neck, dentists can play a pivotal role in aiding in the discovery of SDB. Dentists, especially pediatric dentists, commonly see children starting at infancy and routinely every 3 to 6 months. Some vital information that dentists have the ability to obtain includes feeding difficulties in infancy,[30] mouth breathing habits as toddlers/children, tonsil-to-airway and tongue-to-oral cavity sizes, and skeletal growth of the maxilla and mandible.

Because of the unique interactive nature of the profession, dentists are also in the position to ask important and vital questions related to SBD. During routine dental examination of a patient, the pediatric dentist should pay attention to the following signs and symptoms: poor ability to concentrate, poor school performance, failure to thrive, mouth breathing, nasal speech, and recurrent airway infections. The use of scaled pediatric sleep questionnaires aimed especially at the guardians may be recommended.[14,31] In addition, the pediatric dentist should pay attention to various craniofacial and oral abnormalities such as an elongated or narrow face, small chin, tooth crowding, high-arched palate, tonsillar hypertrophy, and obesity.[6,32]

Being able to use questionnaires such as the SRBD-PSQ or the SDSS can greatly improve the ability for the dentist to better clinically assess for relevant sleep disorders. Coupled with the evaluation of the mouth and craniofacial features of the child's face, the use of these questionnaires could lead to earlier recognition of sleep problems in children and place pediatric dentists in a unique advantage to facilitate the necessary medical referrals for the management of the child's systemic health.

This study is specifically a descriptive study because these were pediatric dental patients presenting for a routine comprehensive or recall examination during which they were also screened for SDB. It must be stressed that screening is not a definitive diagnosis of SDB, as that would need to be determined using the gold standard PSG.[9] The American Academy of Sleep Medicine International Classification of Sleep Disorders clearly indicates that the presence of both clinical (snoring, labored breathing while asleep, or daytime sleepiness) and laboratory (PSG evaluation) criteria are required in the diagnosis of pediatric OSA.[33]

Questionnaires such as the SDSS and the SRBD-PSQ allow the dentist to ask sleep-centered questions that help focus on vital answers that may lead the dentist to request a referral for a sleep study. One major way to use sleep questionnaires is to include them in the paperwork for every new patient and with updated health history paperwork for every existing patient, as an annual requirement. Another approach may be that if any abnormal/pathologic dental findings are evident during the new patient examination or the recall examination, the guardian would be required to fill out a sleep questionnaire. There are many ways that sleep questions can be incorporated into a dental practice and although it may seem exhaustive at times, the consequence of being part of the comprehensive care of the patient can be rewarding.

CONCLUSION

Based on this study's results, the following conclusions can be made:

1-There is a strong correlation for bruxism, NNH, and mouth breathing with both the SRBD-PSQ and SDSS surveys.

2- Because a patient may typically visit the dentist at least once every six months for recall appointments, this puts dentists in a unique position to examine the oral cavity and airway, giving the dentist the opportunity to screen for SDB.

3- When administered with a clinical examination, the SDSS and SRBD-PSQ may be a useful screening tool for identifying children at risk for sleep disorders including SDB.

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ABBREVIATIONS

ADHD (Attention deficit hyperactivity disorder)
AHI (Apnea Hypopnea Index)
ASA (American Society of Anesthesiologists)
AAP (American Academy of Pediatrics)
AAPD (American Academy of Pediatric Dentistry)
BMI (Body Mass Index)
NREM (Non Rapid Eye Movement)
NNH (Non-Nutritive Habits)
OSA (Obstructive Sleep Apnea)
OSAS (Obstructive Sleep Apnea Syndrome)
POSA (Pediatric Obstructive Sleep Apnea)
PSG (Polysomnography)
QoL (Quality of Life)
REM (Rapid Eye Movement)
SRBD-PSQ (Sleep-related Breathing Disorder Scale of the Pediatric Sleep Questionnaire)
SB (Sleep Bruxism)
SDB (Sleep Disordered Breathing)
T/A(Tonsillectomy and/or Adenoidectomy)

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DISCLOSURE STATEMENT

The authors have no conflicts of interest to declare.

APPENDIX A: Tables

Table 1. Patient Demographics

Variable	N (%)
Sex	
Male	61 (45.2)
Female	74 (54.8)
Age (mean SD)	9.84 (2.43%)
BMI	
Morbid obesity	11(8.1)
Obesity	36(26.7)
Overweight	9(6.7)
Healthy Weight	74(54.8)
Underweight	4(3.0)
N/A	1(0.7)
ASA Classification (%)	
I	55 (40.7)
II	64 (47.4)
III	14 (11.9)
Ethnicity (%)	
Hispanic	86 (63.7)
White	16 (11.9)
Other	33 (24.4)

ASA = American Society of Anesthesiologists; BMI = body mass index; N/A = not applicable; SD = standard deviation

Table 2. Dental Characteristics of Total San Diego Sleep Survey Scores (two sample *t*-test/analysis of variance)

	SDSS scores (mean±SD)	*P*
Bruxism		**<0.01**
No	**58.62±12.41**	
Yes	**70.15±14.37**	
Malocclusion		**0.48**
I	**60.13±13.67**	
II	**60.19±12.34**	
III	**56.11±11.43**	
Dental Crowding		**0.77**
No	**60.42±14.06**	
Yes	**61.1±12.71**	
Mouth Breathing		**<0.01**
No	**58.79±11.97**	
Yes	**73.95±15.79**	
Brodsky Score		**0.02**
IV	**73.33±22.81**	
III	**65±15.7**	
II	**59.71±12.83**	
I	**56.69±10.52**	
Non-Nutritive Oral Habits		**0.01**
No	**59.26±13.51**	
Yes	**66.52±12.45**	

SD = standard deviation; SDSS = San Diego Sleep Survey

Table 3. Distribution of Dental Characteristics by Threshold Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire

Characteristic = Yes (%)	**PSQ threshold <0.33**	**PSQ threshold >=0.33**	***P***
Bruxism	13 (15.5)	14 (27.5)	0.120
Malocclusion			0.380
I	50 (60.2)	20 (48.8)	
II	23 (27.7)	13 (31.7)	
III	10 (12.0)	8 (19.5)	
Dental Crowding	38(45.2)	22(44.0)	1.000
Mouth breathing	4 (4.8)	15(29.4)	<0.001
Brodsky score			0.456
I	41(51.2)	17(45.9)	
II	27(33.8)	11(29.7)	
III	11(13.8)	7(18.9)	
IV	1(1.2)	2(5.4)	
Non-Nutritive Oral Habits	14(16.7)	17(33.3)	0.035

PSQ = Pediatric Sleep Questionnaire

Table 4. Distribution of Dental Characteristics by Individual San Diego Sleep Survey Components

	Sleep Disorder	*P*	Sleep-Disordered Breathing	*P*	Daytime Symptoms	*P*	Hygiene	*P*	Insomnia	*P*
Bruxism **No** **Yes**	4.71±1.31 5.7±1.56	<0.01	13.03±5.81 16.93±6.31	<0.01	18.66±5.32 22.63±7.01	<0.01	9.78±2.21 10.15±2.67	0.46	12.34±3.1 15.19±3.33	<0.01
Malocclusion **I** **II** **III**	4.93±1.28 4.89±1.37 4.17±1.69	0.1	13.39±5.72 13.36±5.97 12.44±6.03	0.82	19.1±6.02 19.42±5.54 17.72±4.43	0.57	10.13±2.44 9.53±2.12 9.72±2.35	0.43	12.57±3.38 13.06±3.13 12.11±2.63	0.57
Dental Crowding **No** **Yes**	4.88±1.51 4.9±1.25	0.93	13.58±6.14 13.92±5.99	0.75	19.5±6.4 19.37±5.28	0.9	10.08±2.39 9.53±2.18	0.17	12.5±2.69 13.28±3.85	0.17
Mouth Breathing **No** **Yes**	4.7±1.34 6.21±1.18	<0.01	12.94±5.29 19.11±7.94	<0.01	18.82±5.48 23.32±6.89	<0.01	9.76±2.26 10.42±2.57	0.25	12.53±3.12 15.26±3.72	<0.01
Brodsky **IV** **III** **II** **I**	5±1 4.94±1.66 4.92±1.26 4.59±1.28	0.58	23.67±9.45 16.11±6.47 14±5.29 11.36±4.86	<0.01	21.67±7.77 19.89±6.79 18.21±5.65 18.88±4.95	0.59	8.67±1.15 10.89±2.45 10.08±2.28 9.4±2.15	0.06	14.33±4.62 13.61±3.45 12.45±3.03 12.31±3.14	0.36
Non-Nutritive Oral Habits **No** **Yes**	4.78±1.37 5.35±1.5	0.05	13.17±6.15 15.94±5.48	0.03	18.97±5.88 21.08±5.71	0.08	9.77±2.27 10.13±2.46	0.45	12.54±3.22 14.16±3.47	0.02

Supplemental Table 1. Additional Dental Characteristics of Total San Diego Sleep Survey Scores (Two-Sample *t*-test/Analysis of Variance)

Attention deficit hyperactivity disorder **No** **Yes**	 **60.96±13.76** **60.55±11.93**	**0.92**
History of tonsillectomy and/or adenoidectomy **No** **Yes**	 **60.47±13.45** **67.33±14.66**	**0.14**
Obesity **No** **Yes**	 **60.78±13.95** **61.6±12.85**	**0.74**

Supplemental Table 2. Distribution of Additional Clinical Characteristics by Threshold Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire

Attention deficit hyperactivity disorder	5(6.0)	6(11.8)	0.331
History of tonsillectomy and/or adenoidectomy	2(2.4)	7(13.7)	0.027
Obesity	24(28.9)	23(45.1)	0.035

Supplemental Table 3. Additional Dental Visit Characteristics of Individual Components with San Diego Sleep Survey Scores

	Sleep Disorder	*P*	Sleep Disordered Breathing	*P*	Daytime Symptoms	*P*	Hygiene	*P*	Insomnia	*P*
Attention deficit hyperactivity disorder		0.66		0.24		0.2		0.62		0.45
No	4.93±1.44		13.99±6.23		19.26±5.8		9.82±2.29		12.98±3.36	
Yes	4.73±1.19		11.73±3.88		21.64±6.68		10.18±2.56		12.18±3.09	
History of tonsillectomy and/or adenoidectomy		0.5		0.37		0.08		0.73		0.31
No	4.89±1.39		13.68±6.14		19.21±5.74		9.83±2.32		12.83±3.35	
Yes	5.22±1.86		15.56±5.34		22.78±7.21		10.11±2.15		14±3.08	
Obesity		0.99		0.84		0.19		0.52		0.39
No	4.92±1.36		13.79±6.34		19±6.05		9.95±2.2		13.11±3.47	
Yes	4.91±1.54		14.02±5.6		20.4±5.53		9.68±2.52		12.6±3.08	

APPENDIX B: Figures

Figure 1. Correlation between the Sleep Related Breathing Domain-Pediatric Sleep Questionnaire (PSQ) and San Diego Sleep Survey (SDSS) scores (R^2=0.76).

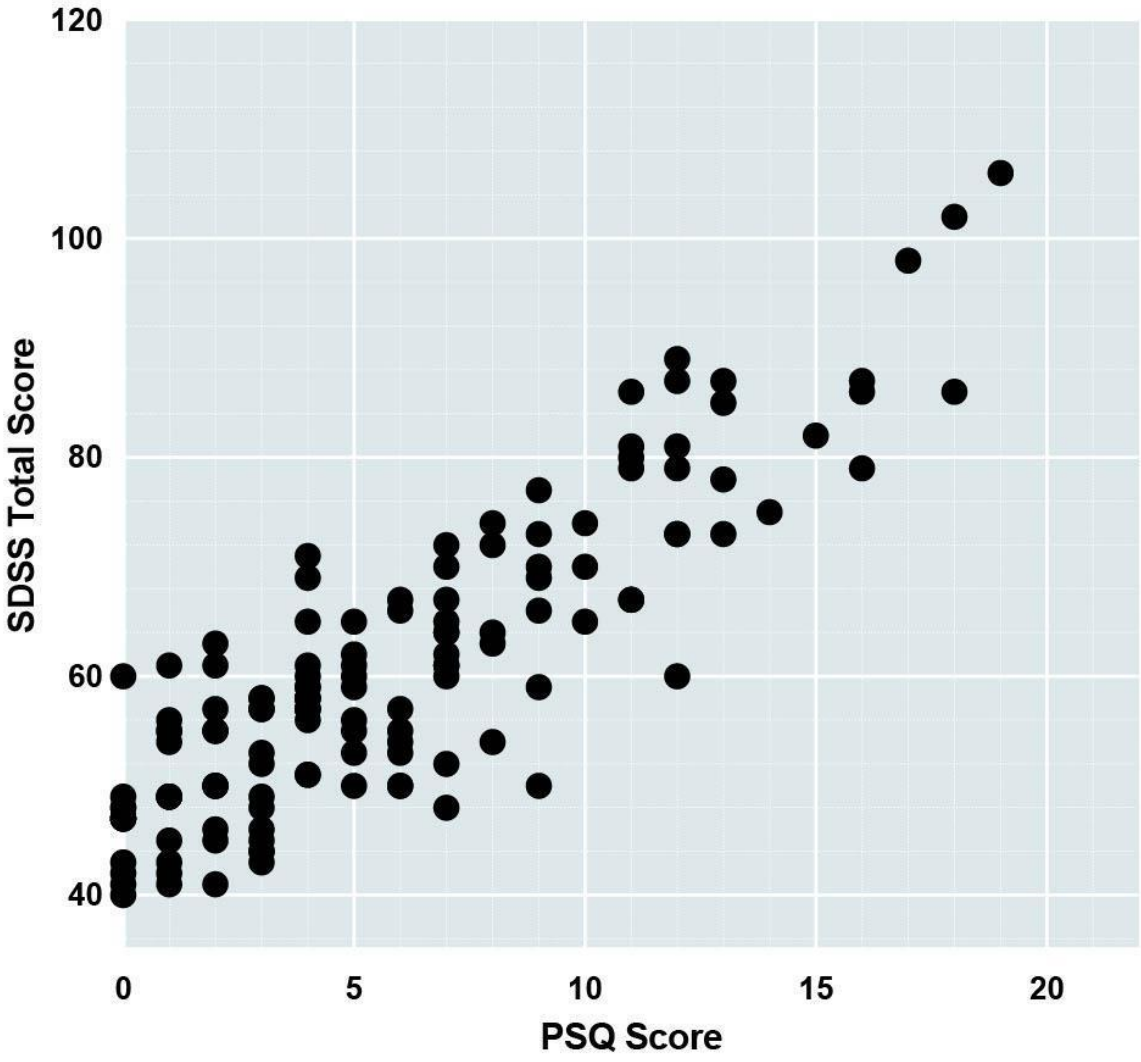

Figure 2. Correlation between the Sleep Related Breathing Domain-Pediatric Sleep Questionnaire (PSQ) and San Diego Sleep Survey (SDSS) domain scores. **A**, SDSS Disordered Breathing score versus PSQ score; R^2=0.44. **B**, SDSS Insomnia score versus PSQ score; R^2=0.25. **C**, SDSS Sleep Disorder score versus PSQ score; R^2=0.26. **D**, SDSS Hygiene score versus PSQ score; R^2=0.07. **E**, SDSS Daytime score versus PSQ score; R^2=0.69.