Association of Sleep Disorders of Breathing with Oral Health Findings using the San Diego Sleep Survey & Pediatric Sleep Questionnaire

Running title: Sleep Disordered Breathing and Oral Health in Children

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ABSTRACT:

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: 135 children aged 1-14 years scheduled for a periodic exam 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. 10 dental parameters were assessed during the oral exam.

Results: The mean age was 9.84 years with 54.8% identified as female. Most participants had a BMI < 85th percentile and an ASA 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 Implications: Children typically visit the dentist every six months, uniquely positioning dentists to screen for sleep disorders such as sleep disordered breathing. When paired with a clinical exam, questionnaires such as the SDSS can serve as effective screening tools, helping to identify early signs of pediatric sleep disorders.

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.[1,2,3] 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 a myriad of sleep-related breathing disorders (SRBD) which includes 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). AHI 5 to 15 events per hours of total sleep time (/hr TST) is categorized as mild OSAS, AHI 15 to 30/hr TST is moderate OSAS, and more than 30 AHI/hr TST is considered severe OSAS. However, for children, the thresholds are lower. For pediatrics, mild OSAS is defined as an AHI between 1 to 5/hr TST, moderate OSAS being 5 to 10/hr TST, and severe OSAS being more than 10/hr TST.[5] The nasopharyngeal airway is at its narrowest at 4.5 years of age, and is mostly due to adenoidal structures affecting upper airway patency. The adenoids typically reach their greatest size between ages 7 to 12 years.[6] In addition, age 12 is considered to be an age at which 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 (AAP) to help recognize and manage young patients with OSA. [8] In addition, the American Academy of Pediatric Dentistry (AAPD)'s Policy on Obstructive Sleep Apnea recommends that all healthcare professionals screen patients for SDB, assess for tonsillar hypertrophy, evaluate tongue position, calculate BMI, and

identify key craniofacial aspects that may be associated with OS. The clinician is also encouraged to refer the patient to a physician for further medical assessment (e.g. otolaryngologist, sleep medicine physician, pulmonologist) for proper diagnosis and treatment recommendations.[9]

The American Academy of Pediatrics (AAP) Subcommittee on Pediatric Sleep estimates that 1.2% to 5.7% of children are affected by OSA alone.[10] Childhood obesity affects over 107 million children worldwide and has 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 are the physical and mental health of the child potentially affected by SDB, but the disrupted sleep places the child at risk for growth disturbances, poor school performance, behavioral challenges, as well as developmental delay.[9,12] On this basis, earlier recognition and treatment of SDB in children may have lasting impact on normal child growth and development.

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

As a patient typically visits their dentist every six 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.[14,5]

Ideally, sleep surveys should be combined with clinical exams to improve screening measures for sleep disorders.[5] The San Diego Sleep Survey (SDSS) was developed and employed

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 non-behavioral 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 obstructive sleep apnea (POSA) 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 of NYU School of Medicine in New York, NY. Subjects between the ages of 1-14 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 (PI) provided information about the study to the guardian (aged 18 and 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 subjects.

Guardians who consented to participate were instructed to complete the survey in the exam 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, 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 5-10 minutes to complete.

Where the SRBD-PSQ uses a 3 point likert scale (yes, no, do not know), the SDSS uses a 4 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 PI 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 8 or more "yes" responses was considered a positive screen for children at risk for SDB and is an indicator of 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 sleep walking or waking up during the night), bed wetting, bruxism, snoring habits, use of electronics prior to bed, and irregular sleep habits. The survey also asked the parent/guardian to rate their child's overall quality of life (QoL) as it relates to sleep and sleep irregularities.

After the child-subject's clinical dental examination was concluded, the PI collected the following clinical measures from the patient's electronic dental record for the prospective chart review: Age, gender, ASA status, ethnicity, bruxism, malocclusion, mouth breathing, ADHD, history of tonsillectomy/adenoidectomy, Brodsky score, snoring history, crowding, non-nutritive habits (NNH), and body mass index (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 their body mass index (BMI = kg/m2). Per the Centers for Disease Control and Prevention (CDC) guidelines, children were categorized as normal weight if their BMI was in the 5th to < 85th

percentile, overweight BMI >85th to <95th percentile, and obese if their BMI was greater than or equal to 95th percentile for age and sex.[15]

All of the clinical parameters that were collected (above) were obtained during the routine dental exam that occurred on that same day. No data from prior clinical encounters were collected from the electronic dental record for this study. Data was immediately entered into REDCap by the PI.

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 vs. no bruxism, malocclusion vs. no malocclusion, crowding vs. no crowding, mouth breathing vs. no mouth breathing, previous tonsillectomy and or adenoidectomy vs. no tonsillectomy and or adenoidectomy, non-nutritive habits vs. no habits, and ADHD diagnosis vs no ADHD) were performed using independent t-tests, and by BMI category and Brodsky score (O, I, II, III/IV) using analysis of variance (ANOVA). The coefficient of determination (R^2) was used to measure the correlation between the SRBD-PSQ and San Diego Sleep Survey (SDSS) domain scores.

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

RESULTS:

A total of 135 children were included in this research study. Demographic summary is reported in Table 1. The mean age of this study was 9.84 years (mean SD of 2.43%). There was a higher percentage of female participants (n=74; 54.8%). The BMI of the participants ranged from

being morbidly obese to unanswered, with the majority (54.8%) being healthy weight. 34.8% of patients were either obese or morbidly obese. Unattained weight was 0.7% meaning that no weight was able to be obtained during the appointment due to child uncooperation. Based on the American Society of Anesthesiologists classification, the majority of the participants were classified as ASA 2 (47.7%) with the least being ASA 3 (11.9%). Most participants were of Hispanic ethnicity (63.7%), followed by 24.4% being Other, and 11.9% being White (Table 1).

Table 2 reports the distribution of dental characteristics by total SDSS highlighting differences in dental traits and total SDSS scores via a two sample t-test/ANOVA. 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 out of the 9 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; $P<.001$), non-nutritive oral habits (NNH) (PSQ threshold <0.33 is 16.7; >0.33 is 33.3; $P<.035$).

Table 4 shows the dental characteristics by individual SDSS components. Bruxism and mouth-breathing were significantly ($p<0.01$) associated with four out of the five SDSS components: sleep disorder, sleep disordered breathing, daytime symptoms, and insomnia. Bruxism was not significantly associated with sleep hygiene. The presence of malocclusion and crowding did not show any statistically significant association with any of the five components. The Brodsky score was only significantly ($p<0.01$) correlated with one of the five components— sleep disordered breathing; whereas, non-nutritive oral habits showed a statistically significant association with sleep disordered breathing ($p=0.03$), and insomnia ($p=0.02$). Non-nutritive oral

habits were borderline significantly associated with sleep disorder (p=0.05) and daytime symptoms (p=0.08).

There were no statistical significant associations with the SDSS for the presence of obesity, ADHD, and history of T/A whereas obesity and a history of T/A was statistically significantly associated with a positive SRBD-PSQ score (see Supplemental Tables 1,2,3).

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 the correlation was greatest for the sleep disordered breathing 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 the 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 shows 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 risks of important sleep disorders. Although there is already the existing SRBD-PSQ screening tool, this study also utilized the locally developed SDSS screening tool as well. The reason for the utilization of the SDSS is for its 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.

Our 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] Our study showed that with the SDDSS, bruxism had statistical significance with all components except sleep hygiene. The SRBD-SPQ, however, showed no statistical significance for bruxism. It is estimated that about 14% of the pediatric population are affected by bruxism.[17] Risk factors for bruxism include obesity, stress, smoking, alcohol use, high coffee consumption, certain classes of medication usage, and bruxism is also associated with psychological factors.[17] The systematic review by González et al. concluded that sleep bruxism (SB) and SDB had a concomitance of between 20-40% in both the adult and pediatric population.[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 between study to study differed. This can easily skew the true relationship between SB and SDB.[17]

The findings from our 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 for 4 out of the 5 components, all except sleep hygiene; whereas NNH was significantly associated for 2 out of the 5 components, which are sleep disorder breathing, and insomnia. With the SRBD-PSQ, only mouth breathing and NNH were seen to be statistically significant. These findings give strong indications for the associations and links between certain pathological 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 shown to lead to serious clinical and developmental consequences.[18] A 2008 study done on children ages 3 to 9 showed that the main causes of mouth breathing were allergic rhinitis, enlarged adenoids, enlarged tonsils, and deviated septum, respectively.[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 are a dearth of studies linking NNH and its association with POSA, there are many studies instead linking dental and maxillofacial growth to risk of POSA. Schmid et al. did a systematic literature review where out of 2288 studies, 17 articles were selected for analysis.[21] 15 out of those 17 articles showed a strong association between anterior open bite and the use of a pacifier when compared with children not using a pacifier.[21] In 2022, Berwig et al. implemented a study that indicated that the presence of malocclusions with habits of non-nutritional sucking for a prolonged

period of time caused a reduction in the hard palate width measurements, while the oronasal breathing mode caused an increase in depth.[22] As NNH has been shown to have effects on the growth of the maxillofacial region and these changes may increase the risk of POSA, we can conclude based on the surveys utilized in our study that NNH can potentially be associated with increased risk of POSA.

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 linkage between SB and SDB; but numerous other articles [24,25,26,27] 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 (4 out of 5 domains).

Several strengths and limitations to this study must be noted. As a follow up to the DaRocha et al.[28] pilot study in 2022, this current study included the "bedwetting" question in the SRBD-PSQ, which was inadvertently omitted in the previous study.[28] This study also had a relatively large sample size and patient diversity. Another strength is its prospective study design, allowing us to compare risk factors. Lastly, 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, a majority of the patients are active patients of both the dental clinic and the children's hospital. As a result, the sample is biased towards patients with a greater number of comorbidities than may typically be found in the general pediatric population; which could elevate the likelihood

of having OSA. Also, the predominant pediatric population in this study was 64% hispanic which may influence the data to this one particular demographic. For instance, our group has 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 theis the study did not differentiate tonsillectomy or adenoidectomy from adenotonsillectomy. As there was no specification of these specific surgeries as being distinct from adenotonsillectomy, it is unsure what specific surgery the patient had a history of. In addition, our study was also limited in that there was overlap between some of our observed associations of dental clinical findings with questions from the questionnaires, including mouth breathing, Since both the SDSS and PSQ-SRBD probe about mouth breathing, we are not surprised by this association.

As this current study did not clarify on the severity of a participant's NNH, a positive finding for NNH may land on a wide spectrum of severity. Finally, a limitation of this study was the utilization of a non-validated survey, the SDSS, to develop the 'PSQ score'. Although all 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 T/A was statistically significant with the SRBD-PSQ, it would be interesting to see future studies focus on if 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 done to probe deeper into NNH to see if there is a threshold at which factors such as frequency and duration start to play a vital role in SDB.

Lastly, due to our sample size, the study was underpowered to perform multivariable regression analysis but in future studies, with larger cohorts, we hope to be able to perform a

multivariable logistic regression analysis. Our group in a separate study of >1000 patients in a sleep clinic population will report on reliability.

The role of the dentist in the area of SBD is essential in diagnosing and referring 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 3-6 months. Some vital information that dentists have the ability to obtain include 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.

Due to the unique interactive nature of the profession, dentists are also in the place to ask important and vital questions as it relates to SBD. During routine dental examination, 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, recurrent airway infections. The use of scaled pediatric sleep questionnaires aimed especially to 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 narrow face, small chin, tooth crowding, high-arched palate, tonsillar hypertrophy, and obesity.[32,6]

Being able to utilize 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, this 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 as these were pediatric dental patients coming

in for a routine comprehensive or recall examination where 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 (AASM ICSD) clearly indicates the presence of both clinical (snoring, labored breathing while asleep, or daytime sleepiness) and lab (PSG evaluation) criteria are required in diagnosing 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 send for a referral for a sleep study. One major way to utilize sleep questionnaires is to include it in every new patient paperwork and with every existing patient's updated health history paperwork that is required annually. Another approach may be that if any abnormal/pathological dental findings are evident at the new patient exam or the recall exam, it would warrant the guardians 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 larger comprehensive care of the patient as a whole can be rewarding.

CONCLUSION:

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

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

2- Because a patient typically visits the dentist at least every six months for recall appointments, it 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 exam, the SDSS and SRBD-PSQ may be a useful screening tool for identifying children at risk for sleep disorders including SDB in pediatric patients.

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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)

†Appendices: The following appendices must be attached to the protocol

Appendix A: Tables

Appendix B: Figures

APPENDIX A: Tables

Table #1: Patient Demographics

Variable	N (%)
Gender	
Male	61 (45.2)
Female	74 (54.8)

Age (mean SD)	9.84 (2.43%)
BMI	
Morbidly Obese	11(8.1)
Obese	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)

Table 2: Dental Characteristics of Total SDSS Scores (two sample t-test/ANOVA)

	SDSS scores (mean±SD)	***p-value***
Bruxism **No** **Yes**	 **58.62±12.41** **70.15±14.37**	**<0.01**
Malocclusion		**0.48**

I **II** **III**	**60.13±13.67** **60.19±12.34** **56.11±11.43**	
Crowding **No** **Yes**	 **60.42±14.06** **61.1±12.71**	**0.77**
Mouth Breathing **No** **Yes**	 **58.79±11.97** **73.95±15.79**	**<0.01**
Brodsky Score **IV** **III** **II** **I**	 **73.33±22.81** **65±15.7** **59.71±12.83** **56.69±10.52**	**0.02**
Non-Nutritive Oral Habits **No** **Yes**	 **59.26±13.51** **66.52±12.45**	**0.01**

Table #3. Distribution of Dental Characteristics by threshold SRBD-PSQ

Characteristic=Yes (%)	**PSQ threshold <0.33**	**PSQ threshold >=0.33**	***P*-value**
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)	
Crowding	38(45.2)	22(44.0)	1.000
Mouth-breathing	4 (4.8)	15(29.4)	<0.001
Brodsky			0.456
I	41(51.2)	17(45.9)	
II	27(33.8)	11(29.7)	

III IV	11(13.8) 1(1.2)	7(18.9) 2(5.4)	
Non-Nutritive Oral Habits	14(16.7)	17(33.3)	0.035

Table #4: Distribution of Dental Characteristics by individual SDSS Components

	Sleep Disorder	***p-value***	**Sleep Disordered Breathing**	***p-value***	**Daytime Symptoms**	***p-value***	**Hygiene**	***p-value***	**Insomnia**	***p-value***
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**
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 SDSS Scores (two sample t-test/ANOVA)

ADHD **No** **Yes**	 **60.96±13.76** **60.55±11.93**	**0.92**
History of T/A **No** **Yes**	 **60.47±13.45** **67.33±14.66**	**0.14**
Obese **No** **Yes**	 **60.78±13.95** **61.6±12.85**	**0.74**

Supplemental Table 2: Distribution of Additional Clinical Characteristics by threshold SRBD-PSQ

ADHD	5(6.0)	6(11.8)	0.331
History of T/A	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 SDSS Scores

	Sleep Disorder	*p-value*	Sleep Disordered Breathing	*p-value*	Daytime Symptoms	*p-value*	Hygiene	*p-value*	Insomnia	*p-value*
ADHD		**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 T/A		**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)

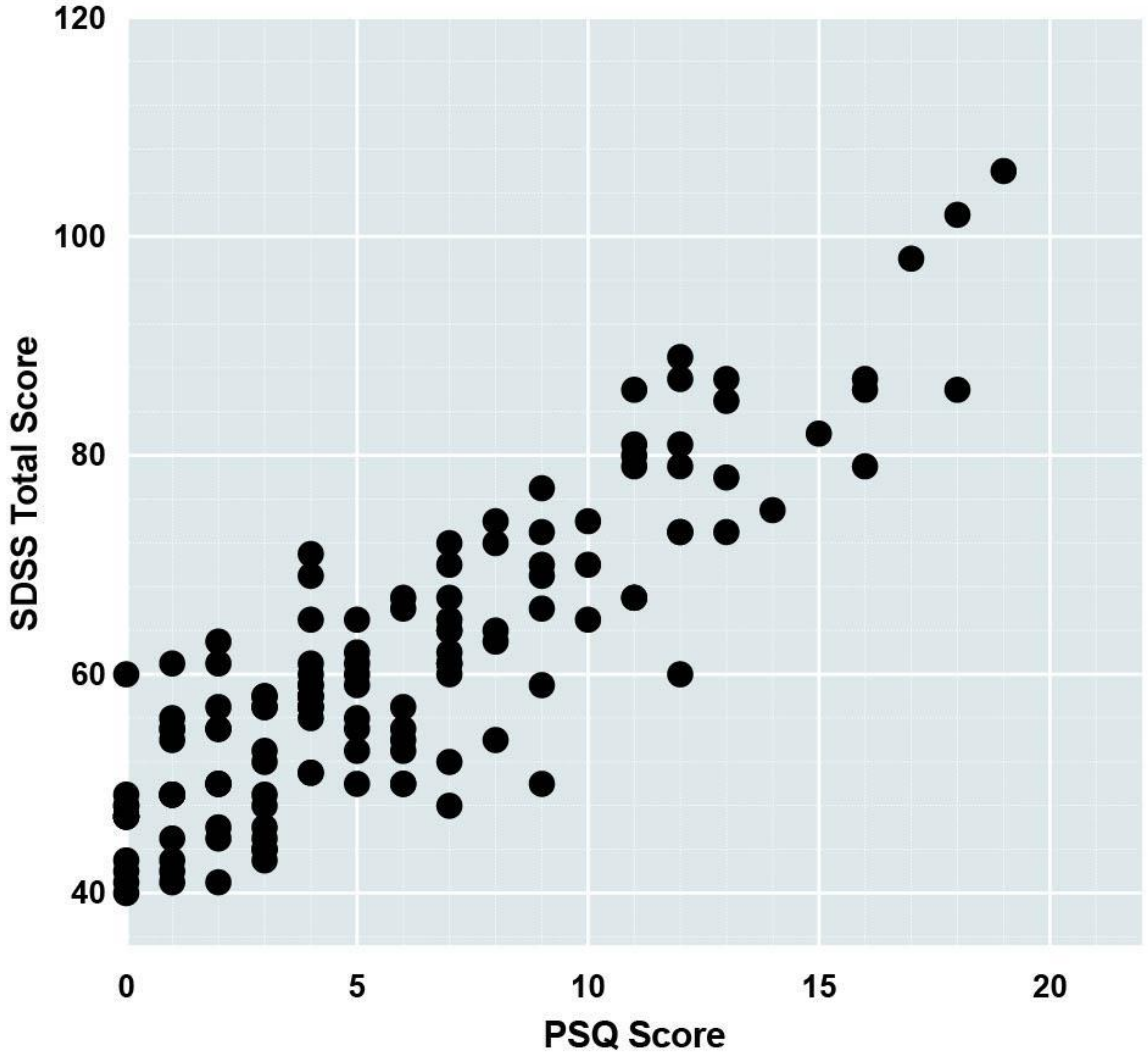

Figure 2. Correlation between the Sleep Related Breathing Domain-Pediatric Sleep Questionnaire (PSQ) and San Diego Sleep Survey (SDSS) domain scores.

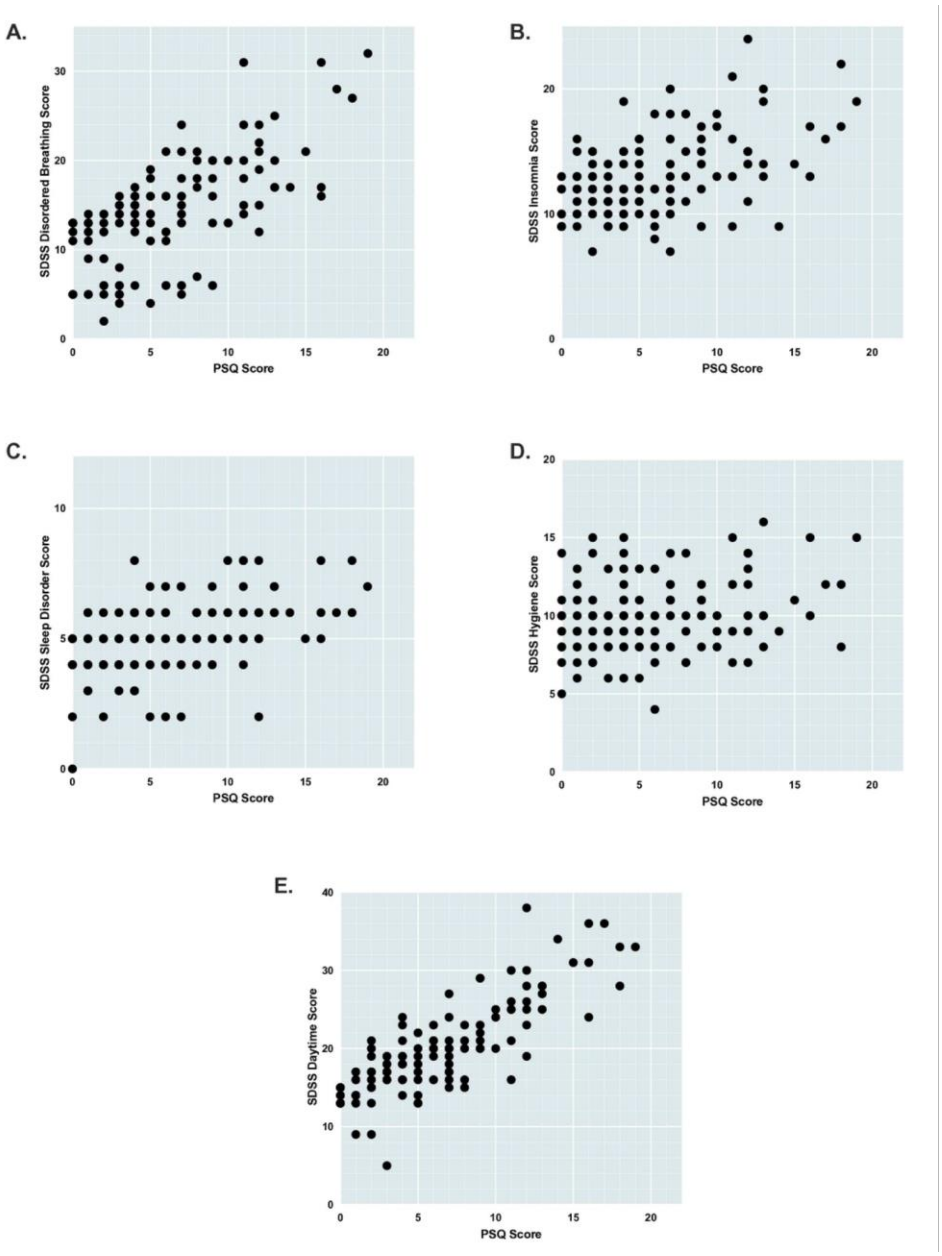

Figure 2 Legend. A. SDSS Disorder Breathing score vs. PSQ score; R^2=0.44. B. SDSS Insomnia score vs. PSQ score; R^2=0.25. C. SDSS Sleep Disorder score vs. PSQ score; R^2=0.26. D. SDSS Hygiene score vs. PSQ score; R^2=0.07. E. SDSS Daytime score vs. PSQ; R^2=0.69.