Association of Sleep Disordered Breathing with Oral Health Findings in Children

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Abstract

Study Objectives: This study examines the association of symptoms of sleep disordered breathing (SDB) with specific oral health indicators in children.

Methods: Between August-December 2018, 151 children aged 1-14 years were recruited by a pediatric dental resident during a dental appointment. The Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire (SRBD-PSQ) was used to screen for SDB. Demographic information, medical history, and clinical parameters (Brodsky score for tonsillar hypertrophy, bruxism, dental malocclusion, mouth breathing, non-nutritive sucking habits, previous tonsillectomy, and dental crowding) were assessed by a dentist blinded to the child's SRBD-PSQ score.

Results: Mean age±SD was 7.8±2.7y; 53% were female. Based on body mass index (BMI) percentile, 11% were overweight, 24% were obese, and 52% were healthy weight. SRBD-PSQ scores ranged from zero to eighteen (mean±SD=5.4±3.9). Linear regression analyses adjusted for age, sex and BMI, showed that Brodsky score I, II, III/IV vs. 0 for tonsils was negatively associated with SRBD-PSQ score (P=.04, P=.01, P=.04, respectively); whereas, bruxism, mouth breathing and prior tonsillectomy were positively associated with SRBD-PSQ score (Ps<.01). The Angle classification of first permanent molar relationship, ADHD, non-nutritive sucking habits, and dental crowding were not associated with SRBD-PSQ score. Associations were stronger for children aged >7 years.

Conclusion: Dental clinical parameters including bruxism, mouth breathing, and a history of tonsillectomy were associated with higher SRBD-PSQ scores.

Clinical Implications: Specific oral health assessment characteristics elicited on a dental examination may be associated with the SRBD-PSQ placing dentists in an important position to screen for SDB.

Keywords: Obstructive sleep apnea, oral health, pediatric sleep, pediatric sleep questionnaire, sleep disordered breathing, pediatric dentistry

Abbreviations:

ADHD (Attention deficit hyperactivity disorder)

ASA (American Society of Anesthesiologists)

AAP (American Academy of Pediatrics)

AAPD (American Academy of Pediatric Dentistry)

AT (Adenotonsillectomy)

BMI (Body mass index)

OSA (Obstructive sleep apnea)

PSG (Polysomnography)

SDB (Sleep disordered breathing)

SRBD-PSQ (Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire)

Introduction

Sleep disordered breathing (SDB) disorders, characterized by disturbed respiration during sleep, can have an impact on normal child development and well-being. Obstructive sleep apnea (OSA), a severe and common form of SDB, typically presents with frequent snoring and is characterized by prolonged periods of increased upper airway resistance leading to intermittent partial to complete obstruction of the upper airway during sleep.[1] Normal breathing can often be disrupted during sleep resulting in episodic oxyhemoglobin desaturation, hypercapnia, frequent arousals, and subsequent sleep fragmentation.[1] Audible snoring, a predictor of OSA, is highly prevalent during childhood, affecting as many as 34% of children. [2,3] Habitual snoring, defined as consistent snoring occurring at least 3 nights per week, affects approximately 3%-12% of all children and these children have a higher prevalence of OSA.[4] Epidemiologic studies estimate a prevalence of polysomnography (PSG) confirmed OSA ranging from 1% to 5% of all children (regardless of snoring status).[5]

Recent studies emphasize the importance of early detection of SDB in young children due to the potential associated health complications associated with this disorder.[6,7] Evidence suggests that SDB is associated with numerous comorbidities in children ranging from cardiovascular abnormalities, difficulty in weight gain for infants, as well as neurocognitive dysfunction including low school grades, low self-esteem, high levels of depression and worsened overall mood.[4, 8] Further, the effect of SDB on neurocognitive ability in children has the potential to lead to long-term permanent effects. [9] For example, in a study of 31 children, those with severe SDB had lower IQ scores, decreased executive function and lower test scores on memory.[9]

Predisposing factors to SDB include adenotonsillar hypertrophy, nasal obstruction, cleft palate repair, obesity and syndromic and non-syndromic related craniofacial disorders.[10] Because abnormalities such as tonsillar hypertrophy are observed in the oral cavity, a dentist may be one of the first health care professionals to identify children at risk.[5,8,9,10] SDB in children is associated with specific muscular, skeletal, and craniofacial characteristics including a dolichofacial pattern that can lead to upper airway narrowing, ultimately resulting in SDB.[5,8] Patients typically visit their dentist every six months for recall appointments, placing dentists in a unique position to routinely examine the oral cavity's hard and soft tissue for evidence of not only *plaque-mediated* pathology (e.g., caries and early periodontal disease), but also evidence of possible airway- related structural co-morbidities, while concurrently probing about sleep and mouth habits. [9,10,11] Thus, pediatric dentists may be able to identify children early who are at increased risk of SDB. [5]

Currently, the gold standard for diagnosing SDB is in-laboratory PSG. However, limitations in access to pediatric PSG labs has led to the development of validated questionnaires including the Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire (SRBD-PSQ)[11] to screen and identify children with signs and symptoms of SDB.

The purpose of this study is to examine the association of clinical oral health parameters, observed during children's routine dental appointments with symptoms associated with SDB.

We hypothesized that clinical oral health parameters clinical oral parameters such as elevated Brodsky score, bruxism, dental malocclusion, mouth breathing, non-nutritive sucking habits, absent history of tonsillectomy, and crowding would be associated with a higher SRBD-PSQ score, signifying symptoms of SDB.

Methods

Participants.

Participants were children aged 1-14 years who were seen by a pediatric dental resident at a federally qualified health center in San Diego, for a standard of care dental examination. Children were included in this study if their parent or guardian was aged 18 years or older, could speak or read English or Spanish, were willing to complete a survey distributed by the principal investigator about their child's sleep (SRBD-PSQ), and have their child clinically assessed. Only subjects who completed the entire survey were included.

This study was approved by NYU Langone Hospitals and San Ysidro Health's IRB Boards; all guardians gave written consent, and children aged 7-14 years gave written assent prior to data collection.

Procedures.

Participants were recruited at the dental clinic during a 3-month recall, 6-month recall or initial comprehensive exam. After the study was explained and written consent was obtained, guardians completed the SRBD-PSQ.[11] Clinical parameters were assessed during an oral examination performed by a dentist, blinded to the SRBD-PSQ score. Other characteristics such as age, weight and height were obtained from the child's dental chart.

Survey

The SRBD-PSQ is a 22-item, validated screening tool used to identify children with SDB.[11] Areas addressed in the SRBD-PSQ include sleeping habits (whether the child exhibits daytime sleepiness or hyperactivity), whether the child wakes up un-refreshed, mouth breathing, bedwetting, snoring habits (including cessation in breathing), and child's weight.[11] For all items, response choices were "no," "yes," and "don't know." One question from the SRBD-PSQ about bedwetting was inadvertently omitted, leaving only 21 items from the SRBD-PSQ available.

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. SRBD-PSQ scores were calculated by summing all "yes" responses.[1,12] A total of 8 or more "yes" responses is 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.

Outcomes

After completing the SRBD-PSQ, the dentist obtained information about the child's age and sex from their chart. Prior to 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/m^2). Based on the Centers for Disease Control and Prevention 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.[13] In addition, the child's history was reviewed with the guardian by the dentist to obtain information on the presence of bruxism, mouth breathing, non-nutritive habits, guardian report of a history of tonsillectomy, and guardian report of the presence of ADHD; using no/yes responses. This information was later validated by the child's dental chart for use in this study.

An oral examination assessed malocclusion (class I, class II, Class III), and crowding (no/yes). Brodsky scores were determined using the Brodsky grading scale where zero=absent tonsils; Brodsky I=tonsil occupies <25% of oropharynx; Brodsky II=tonsil occupies >25% to 50% of oropharynx; Brodsky III=tonsil occupies >50% to 75% of oropharynx; and Brodsky IV=tonsil occupies >75% of oropharynx.[14]

Statistical Analysis.

Means and standard deviations were calculated for all continuous variables and rates were calculated for all categorical variables. Due to the inadvertent omission of the bedwetting question from the SRBD-PSQ, the SRBD-PSQ score was determined by summing the number of 'yes' responses considering the number of 'do not know' responses as missing. Comparisons of differences in mean SRBD-PSQ scores by category of each clinical parameter (previous tonsillectomy vs. no tonsillectomy, nutritive/non-nutritive habits vs. no habits, malocclusion vs no malocclusion, ADHD diagnosis vs no ADHD, and bruxism vs. no bruxism) were performed using independent t-tests, and by BMI category and Brodsky score (O, I, II, III/IV) using analysis of variance (ANOVA). The association of obesity (BMI category) with PSQ scores was examined using linear regression. The associations of each clinical parameter with SRBD-PSQ scores after adjustment for age, sex and BMI were examined using linear regression analysis. Sensitivity analyses were performed that examined the associations of each clinical parameter with SRBD-PSQ scores using linear regression analysis after dichotomizing the sample on age (≤7 years vs. >7 years).

Results

A total of 158 guardian/child pairs who were recruited, met the inclusion criteria and agreed to participate. Of these, 151 guardian/child pairs completed the survey and were included in the analyses. Slightly over half the children were female (53%); average age was

7.8±2.9 years. Based on anthropometric definitions, 10.6% were overweight, 24.5 % were obese, 52.3% were healthy weight, and 7.3% were underweight. Overall, 37% of parents reported mouth breathing in their child, and 9.3% of patients had a previous tonsillectomy (Table 1).

Mean PSQ score was 5.4±3.9 (range=0-18). There were no significant differences in SRBD-PSQ scores by sex (means=6.0±3.8 for boys, and 5.1±3.9 for girls, p=0.19) or by age (means=5.2 for children ≤7 years and 5.7±3.9 for children >7 years, p=0.42). Comparisons of SRBD-PSQ scores by each clinical parameter (Figure 1) showed that children with bruxism, ADHD, mouth breathing, and previous tonsillectomy had significantly higher mean SRBD-PSQ scores than children without those characteristics (means=7.3 vs. 4.7, for bruxism (p<0.01); 10.1 vs. 5.2, for ADHD (p<0.01); 7.1 vs. 4.3, for mouth breathing (p<0.01); and 9.4 vs. 5.0, for tonsillectomy (p<0.01)). Comparison of SRBD-PSQ scores by Brodsky score (Figure 2) also showed that children with Brodsky score=0 had significantly higher SRBD-PSQ scores than those with Brodsky I, II or III/VI (means=9.6 vs. 5.3, 4.6, 5.7, respectively, p<0.01).

Unadjusted regression analysis revealed that BMI category was significantly and positively associated with SRBD-PSQ scores (Table 2). Relative to healthy weight children, obese children had SRBD-PSQ scores that were 2.17 points higher on average (p<.01), but there were no significant differences in SRBD-PSQ scores between overweight and healthy weight children (p>.10). Age and sex were not significantly associated with SRBD-PSQ scores (p=.42 and p=.19, respectively.

Results of regression analyses evaluating the associations of each clinical parameter with PSQ score after adjustment for age, sex and BMI are shown in Table 3. Relative to those with Brodsky 0, children with Brodsky scores of I, II, III/IV each had significantly lower PSQ scores (Brodsky I: B= -4.0, p=.005; Brodsky II: B=-4.4 , p=.002; and Brodsky III/IV: B=-3.5, p=.01 respectively). After adjustment for covariates, only bruxism, mouth breathing, and prior tonsillectomy history remained significantly associated with SRBD-PSQ score (B's=2.9, 3.0, and 4.1 respectively, all ps<.01). Other clinical parameters (malocclusion, ADHD, non-nutritive habits and crowding) were not significantly associated with PSQ scores.

Sensitivity analyses, in which children were stratified by mean age (7 years), were performed to determine whether associations of each clinical parameter and PSQ scores were similar for younger children (age ~~(~~≤7 years) with mostly primary dentition, compared to older children (age > 7 years) with mixed and adult dentition (Table 4). After adjustment for age, sex and BMI, among children aged less than 7 years, ADHD , bruxism and class two malocclusion were not significantly associated with SRBD-PSQ scores. In contrast, among children aged 7 years or older, Brodsky scores I, II, III/IV relative to Brodsky 0 were negatively associated with SRBD-PSQ scores (Ps=.0006, .0012, .0006, respectively), while bruxism (P<.001), mouth breathing (P<.001) and previous tonsillectomy (P<.001) were all positively associated with SRBD-PSQ scores.

Discussion

In this study of children presenting at a pediatric dental clinic, bruxism, ADHD diagnosis, mouth breathing, and history of tonsillectomy, were each significantly associated with higher scores on the SRBD-PSQ. ~~This~~ These associations ~~was~~ were independent of age, obesity and sex, and ~~was~~ were stronger for older children (age>7 years). Additionally, obesity was also significantly associated with increased SRBD-PSQ scores. These results suggest that children who present in dental offices as exhibiting these specific clinical parameters may have a higher risk for SDB and may benefit from further medical evaluation.

Results of this study are in accord with others who reported children with bruxism, ADHD, obesity and mouth breathing have higher rates of SDB. [2,4-8,10] Gozal et al[7] noted that obesity has been identified as a significant risk factor for SDB in children. Multiple studies have also described how chronic mouth breathing, a marker for orofacial muscle dysfunction, along with other various oral habits may place the child at risk for SDB. [4,5,15] Ohayon et al., noted that sleep bruxism typically does not appear by itself but often in conjunction with the presence of SDB, along with other symptoms such as daytime sleepiness. [16] Additionally, several studies [(18-24)], including a longitudinal study by Perfect et al., reported that SDB in children was associated with a greater number of parent-reported behavior problems such as ADHD. [(17-24)] In accord with others, this study found that guardian report of ADHD was significantly associated with SRBD-PSQ score for the sample as a whole. However, associations were not significant in stratified analyses, most likely due to the attenuated sample sizes.

In this study, we also assessed tonsil size using the Brodsky scale, as tonsillar hypertrophy is known risk factor for SDB in children. [25,26] However in our study, a Brodsky score of zero (likely reflecting a history of tonsillectomy) was associated with a *higher* SRBD-PSQ score, even following adjustment for obesity. This is in contrast to several previous studies that reported that adenotonsillar hypertrophy is a major risk factor for OSA in children. [2,4,5,27,28] Accordingly, surgical removal of tonsils and/or adenoids or adenotonsilletomy (AT) is considered first line treatment for pediatric OSA. [15] Several studies report resolution of OSA following AT.[5,4,7,29,30] For example, in a prospective randomized controlled trial of AT, parents of children treated with AT reported that quality of life and SDB symptoms were improved after AT compared to children not surgically treated. [15] Sivian et al., reported that in infants, clinical symptoms of OSA resolved or significantly improved after AT, but reoccurrence of symptoms was documented in 26% of infants. [31]

~~Notwithstanding~~ Regardless, our study found that absence of tonsils was associated with a higher SRBD-PSQ score. It is possible that there was residual SDB or the persistence of SDB following AT surgery in our cohort. In a multicenter retrospective study, Bhattacharjee et. al reported that residual OSA, as determined by post-surgical PSG, was high, with only 27% of patients having complete resolution of OSA following AT.[29] It is also possible that children with a history of previous tonsillectomy (Brodsky 0) are more likely to have a previous and possibly persistent symptoms of sleep disruption. Compared to a general dental population, who by design are not symptomatic with sleep complaints, parents of patients with tonsillectomy history are more likely to endorse sleep disruption resulting in a form of selection bias.

Furthermore, in addition to obesity, older age (age >7 years) was also associated with residual OSA following AT. In accord with this, stratified analyses in our study showed that only children older than 7 years had higher SRBD-PSQ scores if they did not have tonsils (Brodsky score 0). Additionally, obese children had higher SRBD-PSQ scores, which is also in agreement with Bhattacharjee et al.[29]

It is plausible that other, unmeasured risk factors, contributed to elevated SRBD-PSQ scores in this pediatric sample. For instance, the presence of comorbidities as often delineated by determining ASA status, and ethnicity may impact SRBD-PSQ score and/or the presence of

SDB. De Luca Canto and colleagues reported that while adenotonsillar hypertrophy is usually the most common etiology of SDB, other risk factors such as obesity, craniofacial anomalies, asthma, local environment irritants, and preterm birth can all contribute to SDB.[2,30,] While many of these factors cannot be taken into account during a regular dental recall exam, some clinical features such as mouth breathing and bruxism should alert the dentist to the possible presence of SDB and prompt the dentist to adequately screen for this detrimental disease.

Administering a survey, such as the SRBD-PSQ, is relatively quick and inexpensive; positive results can prompt a medical referral to undergo formal diagnostic evaluation for SDB via PSG. Past research has examined whether screening using a physical exam can improve identification of SDB. Results of a systematic review and meta-analysis suggest that questionnaires such as the SRBD-PSQ, in combination with a physical examination, can improve the overall performance of the test in diagnosing SDB.[2] While the gold standard in the diagnosis of SDB relies on PSG, the application of validated questionnaires such as the SRBD-PSQ may facilitate earlier testing and recognition of SDB.[4] Early diagnosis is key in helping pediatric patients with SDB, and guidelines have been established by both the American Academy of Pediatrics (AAP) and the American Academy of Pediatric Dentistry (AAPD) to help recognize and manage young patients at risk for SDB.[4, 27]

Several limitations and strengths of this study should be noted. Results of this study are limited by the inadvertent omission of the bedwetting question on the SRBD-PSQ. However, this omission is likely to have introduced a conservative bias. Information regarding ethnicity and the presence of skeletal peculiarities and comorbidities were not obtained, thus we cannot determine if the observed associations vary by these characteristics. ADHD was based on guardian self-report rather than diagnosis by a physician, which may have also introduced conservative bias. Further, our study did not specifically identify the presence of outcomes such as neurocognitive dysfunction, reduced quality of life, reduced school performance, etc. Another limitation of our study was that we only sought parental report of tonsillectomy and did not ask for a previous history of adenoidectomy. Adenoidectomy alone or combined with tonsillectomy, is mainstay for surgical treatment of OSA. In addition, adenoidectomy may be performed to treat children with recurrent otitis media infections. As dentists are unable to assess the status of adenoidal tissue, unless aided by a lateral cephalometric radiograph or CBCT image where enlarged adenoid tissue can be clearly visualized, and given the other indications for adenoidectomy, we opted to only explore a history of tonsillectomy. Future studies should probe the presence of comorbidities, neurocognitive dysfunction, skeletal peculiarities and ethnicity in patients presenting specific dental hallmarks.

Nevertheless, our study had a number of strengths including the assessment of a large number of clinical parameters and a relatively large sample size. Additionally, the dentist being blinded to the child's SRBD-PSQ score when examining the child for clinical parameters and when data on clinical parameters were extracted from the chart is also a key strength in this study.

Clinical parameters such as bruxism, mouth breathing, history of tonsillectomy, ADHD diagnosis, and obesity were associated with higher SRBD-PSQ scores in a pediatric dental population. As many of these features are routinely identified by pediatric dentists, this study suggests that pediatric dentists and other dentists who provide oral care for children, are well positioned for identifying children at risk for SDB. Given the different dental phenotypes of younger vs. older children (e.g. primary versus permanent dentition), future studies using larger sample sizes that can afford stratification on multiple ages and other clinically significant factors are warranted.

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Table 1. Demographic Characteristics (N=151)

	Overall
n	151
age (mean (SD))	7.87 (2.90)
gender (%)	
male	70 (46.4)
female	75 (49.7)
Missing	6 (4.0)
BMI category (%)	
Underweight	11 (7.3)
Healthy weight	79 (52.3)
Overweight	16 (10.6)
Obese	37 (24.5)
Missing	8 (5.3)
brodsky (%)	
No tonsils	11 (7.3)
Brodsky I	49 (32.5)
Brodsky II	49 (32.5)
Brodsky III/IV	24 (15.9)
Missing	18 (11.9)
ADHD diagnosis (%)	
No	142 (94.0)
Yes	8 (5.3)
Missing	1 (0.7)
malocclusion_right_side (%)	
class1	74 (49.0)
class2	23 (15.2)
class3	26 (17.2)
Missing	28 (18.5)
malocclusion_left_side (%)	
class1	71 (47.0)
class2	23 (15.2)
class3	28 (18.5)
Missing	29 (19.2)
mouth breathing (%)	
No	93 (61.6)
Yes	55 (36.4)
Missing	3 (2.0)

Table 2. Association* of obesity with PSQ-

	B	95% C.I.	P
Healthy weight	-	-	-
Underweight	0.78	[-1.61, 3.16]	0.52
Overweight	0.01	[-2.02, 2.05]	0.99
Obese	2.17	[0.69, 3.64]	<0.01

B= Coefficient, shows amount of change of PSQ score for that category of obesity
* Results of unadjusted regression analysis

Table 3. Association* of clinically assessed dental parameters, ADHD, and other characteristics with PSQ scores

	N	Coefficient	Beta	p-value
Brodsky	121			
0 (Ref)		---	----	---
I		-4.02	-0.5	0.005
II		- 4.45	- 0.55	0.002
III/IV		- 3.5	-0.35	0.02
Bruxism	138	3.12	0.36	0.000
ADHD	137	3.86	0.23	0.007
Mouth breathing	137	2.54	0.33	0.000
Non-nutritive habit	138	0.13	0.04	0.65
Tonsillectomy	137	4.45	0.34	0.000
Crowding	126	-0.34	-0.04	0.64

*Results of linear regression analysis adjusted for age, sex and BMI

Table 4. Associations* of clinically assessed dental parameters, ADHD, and other characteristics with PSQ scores after stratification by mean age

	Age <= 7				Age >= 7			
	N	Coefficient	Beta weight	p-value	N	Coefficient	Beta weight	p-value
Brodsky	50				71			
0 (Ref)		---	----	---		---	----	---
I		2.94	0.36	0.48		-5.35	-0.68	0.001
II		1.47	0.19	0.72		-5.35	-0.62	0.001
III/IV		4	0.42	0.34		-5.86	-0.58	0.001
Bruxism	57	1.97	0.24	0.07	81	3.89	0.44	0.000
ADHD	57	4.44	0.26	0.07	80	3.73	0.23	0.06
Malocclusion Rt side class I								
Malocclusion Rt side class II	47	2.57	0.23	0.14	66	0.34	0.04	0.79
Malocclusion Rt side class III	47	0.08	0.01	0.94	66	0.46	0.03	0.82
Malocclusion Left side class I								
Malocclusion Left side class II	46	3.26	0.28	0.08	66	1.97	0.22	0.09
Malocclusion Left side class III	46	0.7	0.1	0.53	66	- 1.13	- 0.09	0.49
Mouth breathing	56	0.54	0.07	0.60	81	3.73	0.47	0.000
Non-nutritive habit	57	-0.67	-0.09	0.52	81	0.88	0.11	0.34
Tonsillectomy	57	-1.91	-0.07	0.63	80	5.98	0.54	0.000
Crowding	53	-0.91	-0.11	0.42	73	-0.52	-0.06	0.62

*Results of linear regression analyses adjusted for age, sex and BMI

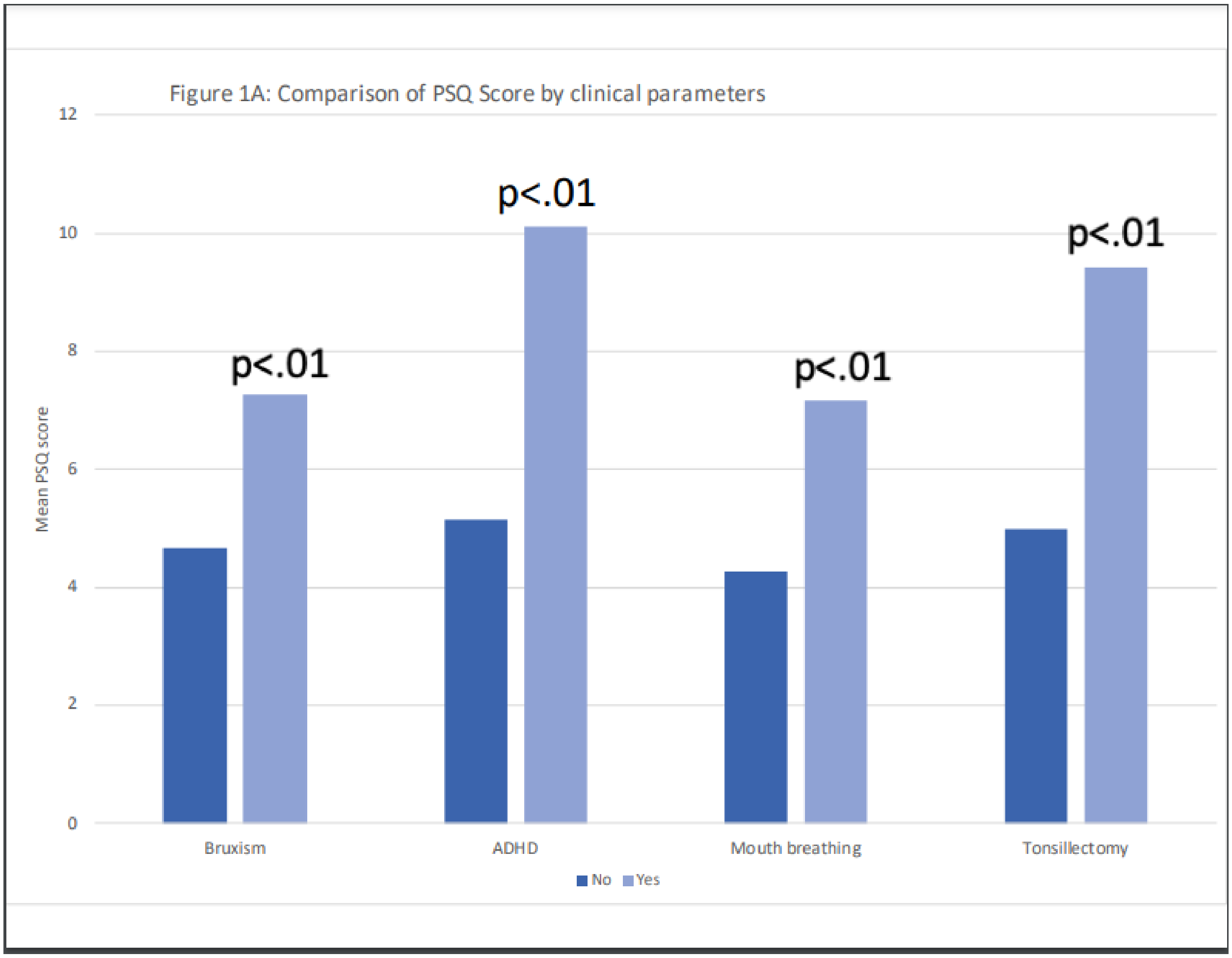
Figure 1A: Comparison of PSQ Score by clinical parameters
Mean PSQ score
12
10
8
6
4
2
0
p<.01
p<.01
p<.01
p<.01
Bruxism
ADHD
Mouth breathing
Tonsillectomy
No
Yes

Figure 2. Comparison of PSQ by brodksy parameters