THE IMPACT OF NON-NUTRITIVE SUCKING HABITS ON THE RISK FOR SLEEP DISORDERED BREATHING IN CHILDREN

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ABSTRACT

Tanya Al-Talib: Impact of non-nutritive sucking habits on the risk for sleep disordered breathing in children
(Under the direction of Lorne D. Koroluk)

Introduction: Sleep disordered breathing (SDB) is common in children and commonly treated with tonsillectomy and adenoidectomy. Another treatment modality may include CPAP. Pharyngeal muscle exercises may reduce the risk for SDB in children as it has been found to reduce the severity of obstructive sleep apnea (OSA) in adults. The aim of this study was to investigate the relationship between non-nutritive sucking (NNS) habits and the risk for SDB in children. **Methods:** A convenience sample of 84 children 4-12 years of age was recruited at the University of North Carolina pediatric dentistry clinic, otolaryngology clinic and neurology sleep lab. Subjects were categorized as high risk and low risk for SDB based on the Pediatric Sleep Questionnaire (PSQ) risk. The presence or absence of NNS was determined using a customized questionnaire which also gathered demographic information and past feeding practices. **Results:** There were no statistically significant differences between low risk and high risk children for SDB with respect to the history of non-nutritive sucking habits while there was a difference between children who were breastfed and bottle fed **Conclusions:** Non-nutritive sucking habits do not appear to reduce the risk of SDB while breastfeeding may reduce the risk for SDB in children.

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SLEEP DISORDERED BREATHING

Introduction and Prevalence

Sleep disordered breathing (SDB) is a group of conditions characterized by breathing difficulties while sleeping. Obstructive sleep apnea (OSA) is the most common of these disorders [1] and is defined as the presence of repeated episodes of complete or partial airway obstruction which may be associated with loud snoring and daytime sleepiness. Prevalence estimates of OSA in the adult population suggest that 9% of females and 24% of males are affected. [2] In children, the prevalence is estimated to be 1-10%,(8) but depending on diagnostic criteria used, may also be as high as 25%.[3] Bixler and colleagues reported that 15.5% of the children in their epidemiologic study had primary snore, 25% of children had mild apnea with an apnea/ hypopnea index (AHI) of greater or equal to one but less than 5 and 1.2% had moderate apnea with an AHI of greater than 5. [3]

Table1 Prevalence of SDB in children. [3]

Total Sample	**None**	**Primary snore**	**1≤ AHI < 5**	**AHI≥ 5**
(N=700)	58.3%(54.7, 62.0)[409]	15.5%(12.9, 18.3) [108]	25.0% (21.9, 28.3) [175]	1.2% (0.6,2.2) [8]
Age (years)				
5-8(N=306)	59.5% (53.9, 64.8) [182]	16.0% (12.3, 20.5) [49]	24.3% (19.7, 29.3) [74]	0.2% (0.1, 1.8) [1]
9-12 (N=394)	57.5% (52.7, 62.4) [227]	15.0% (11.7, 18.8) [59]	25.5% (21.6, 30.2) [101]	2.0% (0.9, 3.6) [7]
BMI percentile				
<85 (N=497)	62.6% (58.2, 66.7) [113]	14.5% (11.7, 17.9) [72	22.3% (18.9, 26.2) [111]	0.6% (0.2, 1.8) [3]
>=85< 95(n=102)	53.8% (44.3, 63.3) [55]	12.8% (7.6, 20.6) [13]	31.4% (23.2, 40.9) [32]	2.0% (0.6, 6.8) [2]

>= 95(N=101)	42.0% (33.3, 52.3) [43]	22.8% (15.7, 31.9) [23]	32.0% (23.4, 41.3) [32]	3.2% (1.1, 8.4) [3]

Sleep disordered breathing diagnosis:

The gold standard for diagnosing SDB is overnight polysomnography (PSG), during which an apnea of any length in children is scored as an apneic event. [4] While polysomnography is the gold standard, its limitations include the cost and challenge of administration to children as well as insufficient qualified staff in pediatric sleep.[5] Gozal believes that in children an overnight polysomnogram is not required to confirm a diagnosis of SDB; but rather, contends that having habitual snoring more than 3 times/week loud enough to be heard by parents along with one or more of other criteria of obstructive sleep apnea syndrome (OSAS) can assist in the diagnosis of SDB that requires treatment. Additional OSAS criteria include enuresis, learning problems, day time sleepiness, ADHD like symptoms, recurrent otitis media, tympanosomy, and a witnessed apnea. [5]

Table2: diagnosis of SDB in children. [5]

Major	Minor
Obstructive apnea and hypopnea index >2 events/hour of sleep(/hrTST)	CRP> 0.4 ug/ml
Respiratory arousal index>2/hrTST	HDL <40mg/dl
Nadir SpO2 <90%	LDL>80 mg/dl
Excessive daytime sleepiness	Fasting insulin>20 uIU/ml
	Elevated norepinephrine/ creatinine ratio(>85th percentile)
Academic difficulties	Recurrent otitis media and/ ors/p tympanosomy tubes
Hyperactive behavior	>5 visits to primary care physician/year for respiratory symptoms
Arterial blood pressure >85th percentile	Adenoids≥ +1

Enuresis	Tonsils≥ +1
Obesity (BMI zscore>1.67)	Asthma and/ or allergic rhinitis
Adenoids≥+2 ans/or tonsils ≥ +2	Family history of OSAS
	Nadir SpO2>90% but <93%

To address the challenges of using PSG to diagnose SDB in children, several screening

Questionnaires have been developed to identify at-risk children like the Pediatric Sleep Questionnaire (PSQ) and "*I'm Sleepy*". The "*I'm Sleepy*" questionnaire includes a child version and a parent version, each having eight questions. [6] This questionnaire has a sensitivity of 82% but a specificity of 50% and still needs to be validated. [6] The other commonly used pediatric screening tool is the Pediatric Sleep Questionnaire (PSQ), a parent-completed validated instrument for children ages 2-18 years that includes twenty-two questions. [7] The PSQ has a sensitivity of 0.85 and specificity of 0.87. [7] The PSQ investigates some of the signs of SDB including snoring, day time sleepiness, and behavior. [7] Signs of SDB may range from upper airway resistance to obstructive sleep apnea [8], mouth breathing, and observed apnea. [9]

Health Sequelae of sleep disordered breathing

Sleep disordered breathing in children can lead to secondary growth impairment, neurocognitive deficit, and less commonly cardiovascular problems [8]. It can also lead to behavioral issues, cor-pulmonale and possibly death. [10] In addition SDB in children can lead to craniofacial morphological changes due to altered tongue, jaw and head posture as a result of abnormal breathing. These resulting orofacial anomalies that can further increase the child's risk for SDB.

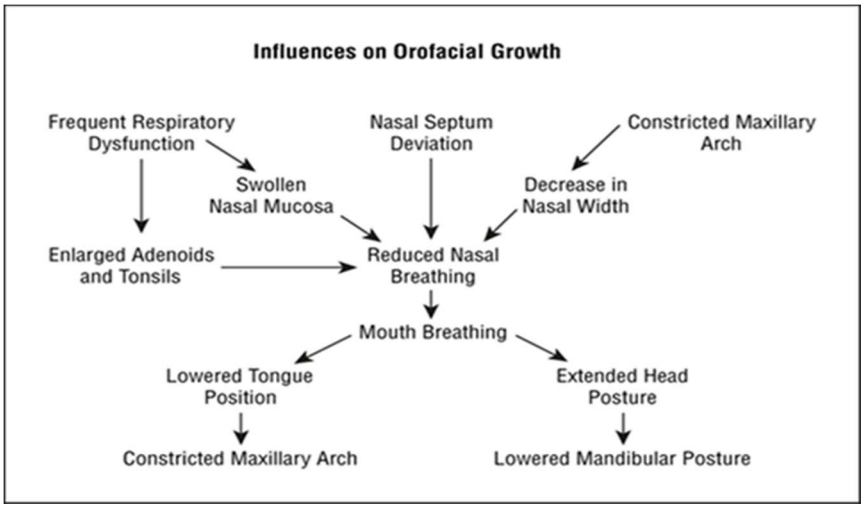

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Fig1. Influence of sleep-disordered breathing on orofacial growth [11]

Sleep disordered breathing risk factors

Risk factors for SDB in children include increased body mass index (BMI), African-American race, increased neck circumference, and the presence of upper and lower respiratory problems such as asthma. Predictors of SDB in children and adolescents include obesity and African-American race independently; after adjusting for obesity, SDB is higher in children with chronic allergies and continuous wheeze breathing. [12]

Table3. Risk factors of SDB in children [3]

	(Non-SDB)	(Primary snore)	1≤AHI<5 (Mild SDB)	AHI≥5 (Moderate SDB)	P
Female	51.0%	52.0%	53.2%	88.5%	0.191
Age(months)	111.2±1	108.1±2.1	111.9±1.6	121.1±6.0	0.221
Minority	18.4%	28.8%	34.4%	0.0%	<0.0001
BI percentile	58.5±1.4	63.9±2.9	65.2±2.2	67.5±14.0	0.041
Waist (cm)	63.5±0.4	66.3±1.2	66.4±0.9	73.4±5	<0.0001
Neck (cm)	28.6±0.3	28.7±0.4	29.5±0.4	29.5±0.5	0.325
Tonsil Size:					0.032
Abnormal	34.8%	48.5%	46.9%	28.8%	
Normal	58.1%	41.5%	45.3%	63.4%	

Removed	7.1%	10.0%	7.8%	7.8%	
Mouth Breath	4.8%	8.3%	9.5%	7.8%	0.185
Stretor	1.3%	4.8%	0.3%	0.0%	0.034
Nasal drainage	20.7%	33.7%	32.7%	7.8%	0.003
Turbinate Hypertrophy	13.9%	22.3%	28.4%	0.00%	<0.0001
Middle ear effusion	3.3%	4.6%	1.3%	0.0%	0.409
Cervical adenopathy	17.9%	28.1%	60.6%	19.3%	0.175
Long Palate	5.3%	7.7%	13.0%	28.8%	0.002
Abnormal palate	1.6%	2.7%	4.9%	0.0%	0.170
Abnormal Uvula	1.7%	5.0%	7.2%	0.0%	0.655
Macroglossia	1.5%	1.8%	3.0%	7.8%	0.439
Retrognathia	0.2%	0.0%	0.3%	0.0%	0.948
Chronis sinusitis	9.7%	10.6%	17.2%	7.8%	0.075
Chronic cough	6.1%	2.3%	6.3%	11.5%	0.367
Wheeze	10.4%	12.8%	11.5%	13.6%	0.897
Enuresis	10.8%	16.7%	12.5%	0.0%	0.258

Fig2 SDB predisposing factors [8]

Adenotonsillar hypertrophy
Nasal obstruction*
Craniofacial disorder **
Cerebral palsy
Obesity
Laryngomalacia (infant)
Gastroesophegeal reflux (infant)
Cleft palate following a laryngeal flap surgery
***Common cause of nasal obstruction is allergic rhinitis, septal deviation , chronic sinusitis, and nasopharyngeal stenosis**
**** common craniofacial disorders include Pierre Robin sequence, Crouzons syndrome, Apert's syndrome, Treacher Collins syndrome, and Prader Willie Syndrome, etc**.

Anatomic risk factors for sleep disordered breathing in children include nasal septum deviation, maxilla-mandibular retrognathia and hypertrophic tonsils.[8] Syndromes and systemic conditions associated with SDB include: cerebral palsy, reticulosis, glycogen storage disease, sickle cell disease, and achondroplasia. Patients with Pierre Robin syndrome [13] Prader Willie, Apert's, Down's, Crouzon's and Treacher Collins syndromes have all been shown to be at risk for SDB due to abnormal skeletal or neurological development. [13]

Sleep disordered breathing risk reduction

Montgomery-Downs found evidence of possible protective effects of infant breastfeeding on the development of pediatric sleep disordered breathing with an inverse relationship between duration of breast-feeding and SDB severity. [14] These investigators posited two possible mechanisms for this effect 1) the immunologic protection conferred by breast milk against early exposure to viral infections that may cause upper airway inflammation and hypertrophy of lymphadenoid tissues or 2) the mechanical effects of sucking on the development of structural tissues of the oral cavity and airway. Montgomery-Downs and coworkers found that breastfeeding for at least two months may protect infants from more severe SDB long term.[14] while breast feeding for more than 5 months did not add any additional benefit to the infant.[14] There is some evidence that early weaning alters the normal breathing pattern because it causes parting of the lips which makes children more susceptible to mouth breathing and subsequently increases the risk of recurrent respiratory infections, hypertrophied tonsils and adenoids, slobbering with excessive salivation, snoring, and ultimately sleep disordered breathing (SDB). [15] Breastfeeding has also been recommended for decreasing the incidence of Sudden Infant Death Syndrome (SIDS) [16], which is the sudden death of any infant or young child, that is unexpected by history, and in which a thorough post-mortem examination fails to demonstrate a definitive cause for death.[17] SIDS is one of the main causes of death in infants 1-12 months of age in developed countries with a prevalence of 2300 infants per year in the United States.[18] The incidence of Sudden Infant Death Syndrome (SIDS) was reported to be 1.5 per thousand live births in the United States compared with 3.5 per thousand live births in England. [19] It has been hypothesized that breastfeeding with its anti-inflammatory effect can reduce infections that can lead to SIDS.[16]

Sleep disordered breathing treatment:

Valera and colleagues proposed that tonsillar and adenoid hypertrophy are the second most common cause of obstructive sleep apnea in pediatric patients [20] with up to 25% [3] of children with hypertrophy being affected with obstructive sleep disorder. Traditionally adeno-tonsillectomy has been the first line of treatment in children diagnosed with SDB [13]with a 91% efficacy in treating snoring in children per parents reports and a cure rate between 78.4%-100% in some cases. [8] Adenotonsillectomy should not be performed randomly in children with tonsillar enlargement without signs of sleep apnea, obstruction or infection. [21] Alternative treatments have been developed depending on the etiology and severity of SDB. Another treatment of SDB in children is the delivery of continuous positive air pressure (CPAP) via a mask during sleep. CPAP is also commonly used when adenotonsillectomy is contraindicated or when patients demonstrates residual signs of SDB after adenotonsillectomy. [22] Rapid maxillary expansion (RME) has also been suggested as another means of treatment in patients with maxillary constriction and posterior cross bite. [23] RME should be the last choice of treatment in patients that do not have constricted maxilla. [23]Table 5 Treatment of SDB in children [8]

Non-Surgical treatment	Surgical treatment
Treatment of nasal allergy	Adenotonsillectomy
Treatment of acute inflammation	Uvulopalatopharyngoplasty
Treatment of reflux	Nasal surgery
CPAP	Revision of posterior pharyngeal flap
Rapid maxillary expansion	Distraction osteogenesis
Weight reduction	Tracheotomy
Abbreviation: CPAP continuous positive airway pressure	

NON-NUTRITIVE SUCKING HABITS

Prevalence:

It is estimated that 70-90 % of children 6weeks-9months old and 17-60% of 12-48 months old have a history of NNS, including pacifier use and digit-sucking. [24] Bishara found that between the ages of 1 and 5 years, the prevalence of pacifier sucking decreases from 40% to 1%. [25] In addition, the incidence of digit habits between 1 and 4 years of age is estimated to decrease from 31% to 12% and continued to decrease at a slower rate after the age of four years. [25] Oral habits have been related to increased over-jet, decreased overbite, and increased posterior cross bite in the deciduous dentition. [26] Katz and colleagues found that 67.9% of children had a NNS habit, 88.4% of the habit group used a pacifier while 49.7% of children with a NNS had a malocclusion.[27]. Montaldo found that 48% of children with a finger sucking habit have an anterior open-bite at age three and the prevalence increases to 65% if the habit lasted after age three years. In comparison 45% of children with a pacifier habit developed a posterior cross-bite if it ceased at age 3yr. [28] Another study found that a pacifier habit caused distal occlusion and a posterior cross bite, while finger sucking lead to distal occlusion, posterior cross bite and open bite. [29]

Pacifiers have been recommended as a strategy to reduce the incidence of Sudden Infant Death Syndrome (SIDS).[30, 31] Hauck showed that pacifier use during the first year can reduce the risk for SIDs.[30] On the other hand, Fleming and colleagues found no significant reduction in SIDS due to pacifier use (21) but did find increased arousal of infants with pacifier use. Odoi

and colleagues found no difference in the arousal of infants in a supine or prone positions with pacifier use.[18] Even though the mechanism of this possible protective effect of pacifier use in infants against SIDs is unknown, there has been an increase in recommending pacifiers for infants during sleep. [30]

Conclusion

It is our role as health care providers to have an understanding of the sleep disorder breathing literature to better diagnose and refer patients for treatment to specialized health care providers. Previous studies have shown that sleep disordered breathing is a serious issue among the pediatric population because of its effects on a child's mental and physiologic development. In addition, SDB diagnosis is costly and challenging in children as it usually includes overnight polysomnography. There are many risk factors for SDB in children including increased BMI, ethnicity, and certain diseases and syndromes. SDB treatment options include adenotonsillectomy, CPAP, or rapid maxillary expansion. The Pediatric Sleep Questionnaire has a sensitivity of 0.85 and a specificity of 0.87 but is considered to be too complicated and lengthy to be used by physicians for screening purposes.[7] Therefore the PSQ has been mostly limited to research. Also it has been validated in English only which limits its use to caregivers that understand English.

There have not been any published studies that evaluated the effect of pacifier use or NNS on the risk for SDB in children but oropharyngeal exercise have been shown to reduce the severity of SDB in adults by 39% [35]and effective in patients with moderate SDB.[36] Our study did not show any significant difference in habit history between high and low risk SDB patients. These findings may be due to parents' erroneous recall of prior habit behavior. In

addition, most caregivers reported a history of NNS but no current NNS which may indicate that any protective effects may occur while NNS is in effect and lost years later. Investigating the impact of active NNS habits on the risk for sleep disordered breathing in children may be indicated.

Furthermore, the current study showed that breastfeeding has a significant protective effect on the development of SDB in children which is similar to the findings of other studies [14] which showed that the severity of SDB in children is reduced by breastfeeding. The reduction of SDB severity in breastfed children may be the result of an immunological effect which reduces the number of infections and ultimately adeno-tonsillar hypertrophy

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THE IMPACT OF NON-NUTRITIVE SUCKING HABIT ON THE RISK FOR SLEEP DISORDERED BREATHING

Abstract

Objective: Sleep disordered breathing (SDB) is prevalent in children and commonly managed with tonsillectomy and adenoidectomy. The aim of the study was to investigate the relationship between non-nutritive sucking (NNS) habits and the risk of SDB in children.

Materials and methods: A convenience sample of 84 children 4-12 years of age was recruited for this study. Subjects were categorized as high risk and low risk for SDB based on the Pediatric Sleep Questionnaire (PSQ). The presence or absence of NNS was determined using a customized habit questionnaire.

Results: Relative to NNS, there was no statistically significant difference between children in the low risk and high risk groups for SDB ($p=0.2$), while the risk for SDB between breast fed (BF) and bottle fed children was significantly different ($p<0.001$).

Conclusion: NNS did not reduce the risk for SDB in the study groups, but breastfeeding dramatically reduced the risk.

INTRODUCTION

What is sleep disordered breathing (SDB)?

SDB is a group of disorders characterized by breathing difficulties while sleeping. Obstructive sleep apnea (OSA) is the most common of these disorders[1] and is defined as the presence of repeated episodes of complete or partial airway obstruction which may be associated with loud snoring and daytime sleepiness. The prevalence of OSA in children is estimated at 1-10%[2]; however, depending on diagnostic criteria used, it may be as high as 25%.(2) Bixler reported that 15.5% of the children studied had primary snore, 25% of children had mild apnea with an apnea/ hypopnea index (AHI) greater or equal to one but less than 5 and 1.2% had moderate apnea with an AHI of greater than 5. [3]

What the signs and symptoms are of sleep disordered breathing?

The signs and symptoms are of sleep disordered breathing include snoring, day time sleepiness, and aberrant behavior. [4] Signs of SDB may range from upper airway resistance to obstructive sleep apnea[5], mouth breathing, and observed apnea.[6] Risk factors for SDB in children include increased BMI, African-American race, increased neck circumference, and the presence of upper and lower respiratory problems such as asthma. Predictors of SDB in children and adolescents include obesity and African-American race independently; and after adjusting for obesity, SDB is higher in children with chronic allergies and continuous wheezing. [7]

SDB can lead to secondary growth impairment, neurocognitive deficits, cardiovascular problems [5], behavioral problems, and possibly death. [8] Additionally, SDB in children can lead to craniofacial morphological changes such as maxillary arch constriction and altered mandibular posture.

How is sleep disordered breathing diagnosed?

The gold standard for diagnosing SDB is overnight polysomnography during which an apnea of any length in children is scored as an apneic event. [9] Limitations of polysomnography (PSG) include the costs and challenge of its administration for children and a paucity of qualified personnel in pediatric sleep medicine.[10] To address the challenges of using PSG to diagnose SDB in children, several screening questionnaires have been developed to identify at-risk children. A commonly used screening questionnaire is the Pediatric Sleep Questionnaire (PSQ), a parent-completed validated instrument for children ages 2-18 years with a sensitivity 0.85 and specificity 0.87. [4]

How to reduce sleep disordered breathing?

Montgomery-Downs and coworkers found that breastfeeding (BF) for at least two months may offer infants protection from severe long term SDB.[11] This study also suggested that breastfeeding through three months reduced the respiratory arousal index, through month four decreased the AHI, and through month five increased the SpO2 Nadir. [11] These findings may be due to the immunologic effect of breast milk which reduces risk for infection leading to less adenotonsillary hypertrophy and therefore less risk for SDB. [11]

Seventy to ninety percent of children have a history of a non-nutritive sucking habit including pacifier use and digit-sucking. [12] Pacifiers have been recommended as a strategy to reduce the incidence of Sudden Infant Death Syndrome (SIDS). [13, 14] The exact mechanism is unknown but it has been thought to increase arousability and, decrease the likelihood of rolling into a prone position. [15] Furthermore, pacifiers are thought to decrease acid reflux as well as preserving airway patency and reducing sleep apnea.[15] As a result, there has been an increase in recommending pacifiers for infants especially during sleep. [16]

Guimaraes and colleagues found that exercises involving the soft palate, tongue, and lateral pharyngeal wall in adults decreased the severity of the sleep apnea with a 39% decrease in the apnea/hypopnea index (AHI). [17] In addition, Puhan has shown that playing a musical wind instrument such as a didgeridoo can be successful in the treatment of moderate obstructive sleep apnea. [18] Steele attributed the improvements in severity of obstructive sleep apnea to decreased collapsibility of the pharyngeal structures during sleep. [19] NNS habits including pacifier use may decrease the risk for SIDS [13] but may possibly decrease the risk for sleep disordered breathing by increasing muscle tone and decreasing the collapsibility of pharyngeal structures.

The aim of the study was to investigate the relationship between non-nutritive sucking (NNS) habits and the risk of SDB in children.

MATERIALS AND METHODS

Patient recruiting

Subjects were recruited from the pediatric dentistry, pediatric otolaryngology and neurology sleep clinics at the University of North Carolina for enrollment in this Institutional Review Board approved investigation. Caregivers of children between ages 4- 12 years of age who could read and understand English were invited to participate during their child's clinical appointment. Caregivers were excluded if their child had a diagnosed syndrome. Written informed consent was obtained and caregivers completed the following questionnaires:

1. Pediatric Sleep Questionnaire (PSQ): which includes three sections investigating [4]:
    a. Snoring: Yes answers were scored as (1) and No answers were scores as (0). Don't know was discounted and subtracted from the denominator

b. Daytime sleepiness: Yes answers were scored as (1) and No answers were scored as (0). Missing or don't know answers were discounted from the denominator.

c. Behavior: Four level Likert responses. Definitely applies most of the time and applies quite a bit were scored as (1) and applies just a little and does not apply were scored as (0).

The Sleep Related disordered Breathing (SRDB) score is the mean of all answered 22 questions and the resulting value ranges between 0-1. An SRDB score less than 0.33 is classified as low risk for SDB while a score of 0.33 or greater is high risk for SDB. [4]

2. A customized Habit History Questionnaire which included the following sections:

   a. Demographic data which included the gender of the child and caregiver, ethnicity, and date of birth.

   b. Health history data including tonsillectomy history, the child's height and weight as measured by the investigator which along with the child's date of birth was used to calculate body mass index (BMI) percentile and determine the BMI category (underweight, normal, overweight and obese) using an online Center of Disease Control and Prevention BMI calculator.[20]

   c. Habit history data including the presence or absence of non-nutritive sucking habit, duration of habit and frequency.

   d. Feeding history data including the incidence and duration of infant feeding practices.

Statistical Analysis

Bivariate analysis using the Cochran-Mantel-Haenszel general association statistic was used to the assess differences between the low and high risk groups with respect to BMI category, gender, non-nutritive (NNS) habit, and primary feeding practice. Logistic regression

was used to determine the effect of primary feeding practice, NNS habit, gender, race, tonsillectomy, and BMI category on risk for SDB. All analyses were conducted using SAS version 9.3 [21] with the level of significance set at 0.05.

Results

Demographic data of the 84 enrolled caregivers are illustrated in Table1. The average age of the caregivers was 38 years of age. The average age of the children was 8 years and 48% of the children were female and 60% Caucasian. Thirteen percent of the children were classified as overweight and 28% as obese.

As illustrated in table 2, 47% of the subjects were classified as low risk and 53% as high risk for SDB. The low and high risk groups were significantly different with respect to tonsillectomy ($p=0.04$), and primary feeding method ($p=0.001$). Females, who had had tonsillectomies and who were primarily bottle-fed were more likely to be in the high risk group. There was no significant difference between the two groups with respect to gender ($p=0.07$), ethnicity ($p=0.53$), NNS habits ($p=0.21$), or BMI category ($p=56$).

There were very few children who were exclusively breast-fed so primary bottle feeding was defined as children with a history of exclusive bottle feeding or with breast feeding up to six months of age. Primary breast feeding included a history of partial breast feeding or complete breast feeding greater than 7 months of age. Additionally, due to the small number of children that reported a digit sucking habit only, both habits (pacifier and digit sucking) were combined into a single habit category.

When controlling for gender, BMI percentile, race, tonsillectomy, age, and habit, the logistic regression analysis (Table3) showed that bottle fed children had 11.88 times greater risk for SDB compared to breast-fed children. When controlling for race, BMI percentile,

tonsillectomy, habit, age, and feeding practice, males had a greater risk for SDB compared to their female counterparts. When controlling for gender, BMI percentile, race, habit, age, and feeding practices, children with tonsillectomy had 0.075 greater risk for SDB. (Table3)

Table 6 Descriptive statistics

Variables	All subjects		Low Risk		High Risk		p value
Demographic	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	
Child age	7.95	2.64	8.05	2.79	7.86	2.53	0.40
Parent age	38.04	7.73	39	7.21	37	8.15	
BMI percentile	65.25	33.09	65.5	33.0	65.0	33.9	0.56

Table7 Bivariate Analysis

Variable	All subjects		Low Risk		High Risk		P value
	N	**%**	**N**	%	N	%	
Gender							
Female	40	48.2	23	57.5	17	42.5	0.07
Male	43	51.8	16	37.2	27	62.8	
Race							
Caucasian	47	59.5	22	46.8	25	53.2	0.53
AA	16	20.25	6	37.5	10	62.5	
Other	16	20.25	7	43.75	9	56.25	
BMI	**N**	**%**	**N**	%	N	%	
Normal Weight	49	59	24	47	25	53	0.56
Over weight	11	13.3	6	54.5	5	45.5	

Obese	23	27.7	9	38.1	14	60.9	
Tonsils							
Tonsillectomy	11	14.3	3	27.3	8	72.7	0.04
No Tonsillectomy	66	85.7	33	50	33	50	
NNS habit							
Habit	52	64.2	27	51.9	25	48.1	0.21
No habit	29	35.8	12	41.4	17	58.6	
Feeding	**N**	**%**	**N**	**%**			
Bottle feeding	53	63.1	18	34	35	66	0.001
Breast feeding	31	36.9	22	71	9	29	

Table8 logistic regression-sleep disordered breathing risk

Effect	Odds ratio	95% confidence interval		P-Value
Bottle vs. breast	11.882	2.991	47.198	<0.001
Habit no vs yes	2.348	0.610	9.044	0.21
Gender F vs M	0.175	0.046	0.671	0.01

Race AA vs other	2.759	0.339	22.438	0.26
Race cauc. vs other	1.103	0.202	6.026	0.55
BMI normal vs overweight	0.654	0.156	2.743	0.83
BMI Overweight vs. obese	0.325	0.041	2.569	0.32
Tonsil no vs yes	0.075	0.006	0.890	0.04

Discussion

Sleep disordered breathing is a serious issue among the pediatric population because of its effects on cognitive and physical development. In addition, SDB diagnosis is costly and challenging in children. Risk factors for SDB in children include increased BMI, ethnicity, craniofacial syndromes and diseases such as sickle cell and glycogen storage disease.

Children with upper and lower respiratory problems also have a higher risk for SDB. [7] There are many other anatomical variations like deviated nasal septum and cleft palate that increase the risk for SDB. The options available for treatment include tonsillectomy and other surgical procedures which can be costly and associated with increased morbidity. The delivery of continuous positive air pressure (CPAP) through a mask is considered the most effective treatment of sleep apnea in adults.[22, 23] In some pediatric SDB cases, CPAP is recommended where adeno-tonsillectomy is contraindicated or in children with residual SDB after adeno-tonsillectomy. The CPAP treatment requires adjustment of the child to the mask as well the need for parent and child education.[24] Family and demographic factors such as maternal education play a major role in children's compliance with the CPAP treatment. [25] Ashok and colleague concluded that rapid maxillary expansion (RME) is an effective treatment of SDB symptoms in

children regardless of its severity. RME is indicated in children with maxillary constriction and a posterior dental cross-bite. [26] However RME should be the last treatment choice in children with SDB with normal maxillary width and no posterior cross-bite. [27]

The PSQ which is a widely accepted screening tool for SDB has a high sensitivity (0.85) and specificity (0.87) [4] [28]. Alternatively, the "*I'M SLEEPY*" questionnaire has a sensitivity of 0.82 with a specificity of 0.50 for obstructive sleep apnea. The PSQ has been validated for ages 4-12 while the "*I'M SLEEPY*" questionnaire and others have not been validated for use in children.[29] The PSQ is considered to be too complicated and lengthy to be used by physicians for screening pediatric patients with SDB [29]; accordingly its use has been limited primarily to research.

No published studies have evaluated the effect of NNS habit on the risk for SDB in children. Studies have demonstrated oropharyngeal exercises similar to speech therapy exercises have reduced the severity of SDB in adults by 39%, although such exercises needed to be continuous. Ideally, the healthcare provider needs to determine the intensity, duration, and frequency of such exercises to maximize their effectiveness in [17]in patients with moderate SDB.[18]

Our study did not find a significant difference in NNS habit between SDB low and high risk children. The caregivers reported a high prevalence of previous NNS in our sample but no current NNS habits which leads one to question the temporal effects of any protective benefits with respect to SDB. Possibly early NNS has some protective benefits which are lost over time as the habit is reduced or eliminated. Additionally, this study relied on parental recall with respect to past NNS habits, pacifier use and feeding practices that may be inaccurate or misleading. Several studies found that subject bias occurs in reporting an event especially when

the reporting occurs several years later. Russell demonstrated that self-reporting measures show bias especially when reports are made several years later. In addition, reporting may be influenced by subsequent events in the child's life. [30]

This study has also shown that breast feeding may have a significant protective impact on the development of SDB in children, a finding in concert with those of Montgomery-Downs[11] This effect may be due to the immunological benefit of BF that reduces the number of episodes of adenotonsillar infection and hypertrophy and ultimately reduces the risk of SDB. Breast feeding may also offer some benefit through the enhanced development of the oropharyngeal complex. The mechanical effect of a previous sucking habit may not have an effect on the current risk for SDB. NNS is very prevalent with about 70-90% of children 6 weeks-9months old and 17-60% of 12-48 months old having a habit. As the current study included children 4-12 years of age, any potentially positive effect of a NNS habit in early childhood may have been lost by 12 years of age. To examine the direct effect of NNS habits on SDB, a younger group of children with active habits could be investigated. [12] This study showed that females are at a slightly greater risk than males for SDB which is different than Li who reported a 1:1 male to female ratio [5] and Redline and colleagues who demonstrated a 2:1 male-female ratio for risk in adults[31] These differences may be due to study populations and sample size as most SDB studies include hundreds of subjects.[6, 31] Eleven subjects had a history of tonsillectomy while eight of those subjects were in the high risk group. Although tonsillectomy is the gold standard for treating high risk children, there is a chance of recurrence of SDB after the surgery. It has been shown that adenotonsillectomy improved SDB symptoms in 80% of subjects while there was a 78.4-100% improvement in sleep disordered breathing in subjects with an AHI less than five.[5] Another study by Kukwa demonstrated 89% of children with tonsillectomies remained

asymptomatic within the first year post surgery but with time the success rate decreased to 71%. Greater than 3 years post adenotonsillectomy, 24% of patients were not satisfied with the results of surgery. [32]

Limitations:

One limitation of the current study is the use of the PSQ as a substitute for polysomnogram data. As the PSQ is validated in English, its use excluded patients from other ethnicities. The study depended on the caregiver's recall of past feeding practices and habits that took place many years prior. The study sample may have been biased as high risk patients who were referred for sleep studies were recruited in a sleep lab.

Conclusions

Under the conditions of this study, non-nutritive sucking habits did not reduce the risk for SDB in children while breast feeding did appear to reduce the risk. This study also found that females with tonsillectomy who were bottle fed as infants were higher risk for SDB.

UNIVERSITY OF NORTH CAROLINA

SCHOOL OF DENTISTRY

Pediatric Sleep Questionnaire

ID: ☐☐☐☐

DATE: ☐☐ / ☐☐ / ☐☐☐☐

Directions: Completely fill in the *ONE* circle for each statement that best applies to your child.

While sleeping, does your child ...	**Yes**	**No**	**Don't know**
A1. ... snore more than half the time?	○	○	○
A2. ... always snore?	○	○	○
A3. ... snore loudly?	○	○	○
A4. ... have "heavy" or loud breathing?	○	○	○
A5. ... have trouble breathing or struggle to breathe?	○	○	○
Have you ever ...			
A6. ... seen your child stop breathing during the night?	○	○	○
Does your child ...			
A7. ... tend to breathe through the mouth during the day?	○	○	○
A8. ... have a dry mouth on waking up in the morning?	○	○	○
A9. ... occasionally wet the bed?	○	○	○

Does your child ...	**Yes**	**No**	**Don't know**
B1. ... wake up feeling unrefreshed in the morning?	○	○	○
B2. ... have a problem with sleepiness during the day?	○	○	○
B3. Has a teacher or other supervisor commented that your child appears sleepy during the day?	○	○	○
B4. Is it hard to wake your child up in the morning?	○	○	○
B5. Does your child wake up with headaches in the morning?	○	○	○
B6. Did your child stop growing at a normal rate at any time since birth?	○	○	○
B7. Is your child overweight?	○	○	○

PSQ - Page 2 | ID:

This child often ...	**Definitely Applies most of the time**	**Applies quite a bit**	**Applies just a little**	**Does Not Apply**
C1. ... does not seem to listen when spoken to directly	○	○	○	○
C2. ... has difficulty organizing tasks and activities	○	○	○	○
C3. ... is easily distracted by extraneous stimuli	○	○	○	○
C4. ... fidgets with hands or feet or squirms in seat	○	○	○	○
C5. ... is "on the go" or often acts as if "driven by a motor"	○	○	○	○
C6. ... interrupts or intrudes on others (e.g. butts into conversations or games)	○	○	○	○

UNC SCHOOL OF DENTISTRY

Participant Questionnaire

ID #: ☐☐☐☐

Date: ☐☐ / ☐☐ / ☐☐☐☐

Instructions: Please use a BLACK BALLPOINT PEN. Read each question carefully and provide your most appropriate response. Choose only ONE response per question unless otherwise indicated. Fill in circles completely or fill in the boxes as needed.

Gender: ◯ Female ◯ Male **Date of Birth:** ☐☐ / ☐☐ / ☐☐☐☐ (month / day / year)

Race: ◯ African-American ◯ American Indian or Alaska Native ◯ Asian ◯ Caucasian ◯ Hispanic ◯ More than one race ◯ Other (please specify) _____

1. Does your child snore? ◯ Never ◯ Rarely ◯ Frequently ◯ Always

2. Have your child's tonsils been surgically removed? ◯ Yes ◯ No

3. Has your child been diagnosed with any of these medical conditions? (Choose ALL that apply)

◯ None ◯ Achondroplasia ◯ Apert syndrome ◯ Cerebral palsy
◯ Cleft Lip and/or Palate ◯ Crouzon syndrome ◯ Down's Syndrome ◯ Glycogen storage disease
◯ Prader-Willi syndrome ◯ Reticuloses ◯ Sickle cell disease ◯ Treacher-Collins syndrome
◯ I prefer not to answer ◯ Other (please specify) _____

Questionnaire - Page 2 | **ID #:**

INFANT FEEDING HISTORY

4. Did your child breast feed? ◯ Yes ◯ No - Skip to Question 4

a. If yes, how long did they breast feed?

◯ <1 mo ◯ 1-3 mos ◯ 4-6 mos ◯ 7-9 mos ◯ 10-12 mos ◯ > 12 mos

5. Was your child bottle fed? ◯ Yes ◯ No - Skip to Question 5

a. If yes, at what age did they stop?

◯ <1 yr old ◯ 1-2 yrs old ◯ 3-4 yrs old ◯ 5-6 yrs old ◯ > 6 yrs old

HABIT HISTORY

6. Did your child use a pacifier? ◯ Yes ◯ No - Skip to Question 6

a. If yes, at what age did your child start using the pacifier?

◯ <1 mo old ◯ 1-6 mos old ◯ 7-12 mos old ◯ 13-18 mos old ◯ > 18 mos old

b. At what age did your child stop using the pacifier?

◯ <1 yr old ◯ 1-2 yrs old ◯ 3-4 yrs old ◯ 5-6 yrs old ◯ > 6 yrs old

c. How long did your child use the pacifier during a typical day (24 hour period)?

◯ <1 hr ◯ 1-3 hrs ◯ 4-6 hrs ◯ 7-9 hrs ◯ 10-12 hrs ◯ > 12 hrs

7. Did your child suck a thumb or finger(s)? ◯ Yes ◯ No - Skip to Question 7

a. If yes, at what age did your child start sucking a thumb or finger(s)?

◯ <1 mo old ◯ 1-6 mos old ◯ 7-12 mos old ◯ 13-18 mos old ◯ > 18 mos old

b. Is he/she still sucking a thumb or finger(s)? ◯ Yes ◯ No

c. If no, at what age did they stop?

◯ <1 yr old ◯ 1-2 yrs old ◯ 3-4 yrs old ◯ 5-6 yrs old ◯ > 6 yrs old

d. How long did your child suck a thumb or finger(s) during a typical day (24 hour period)?

◯ <1 hr ◯ 1-3 hrs ◯ 4-6 hrs ◯ 7-9 hrs ◯ 10-12 hrs ◯ > 12 hrs

8. Does your child have any of the following problems? (Choose ALL that apply)

◯ Mouth breathing ◯ Noisy breathing while sleeping ◯ Tooth grinding

◯ Sore throat/tonsillitis ◯ None of the above

Thank you for your participation!

Risk Listing

idno	risk
1002	low
1003	low
1005	low
1007	low
1008	low
1009	low
1010	low
1011	low
1012	low
1014	low
1015	low
1017	low
1018	low
1025	low
1026	low
1027	low
1029	low
1030	low
1031	low
1032	low
1039	low
1040	low
1043	low
1053	low
1055	low
1056	low
1057	low
1058	low
1059	low
1060	low
1061	low
1063	low
1069	low
1070	low
1093	low
1096	low
1097	low
1098	low
1115	low
1119	low
1001	high

1013 high
1016 high
1028 high
1041 high
1042 high
1054 high
1062 high
1067 high
1068 high
1071 high
1072 high
1073 high
1074 high
1075 high
1076 high
1077 high
1078 high
1079 high
1080 high
1081 high
1082 high
1083 high
1084 high
1085 high
1085 high
1086 high
1087 high
1088 high
1089 high
1090 high
1091 high
1092 high
1094 high
1095 high
1099 high
1100 high
1101 high
1102 high
1103 high
1104 high
1117 high
1118 high
1120 high

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