Sleep Disordered Breathing in an Orthodontic care seeking population

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DEDICATION

This thesis is dedicated to my mother Angela, my father Ashok Sr., brothers Alok and Angelo, and significant other Diane. I have been blessed through your unconditional love and support. And I am forever grateful.

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Foremost, I thank God for good graces. For without his blessing and guidance my path in life may have been different than what is today.

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ABSTRACT

Title: Sleep Disordered Breathing in an Orthodontic care seeking population
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Objective: To evaluate the prevalence of Sleep Disordered Breathing (SDB) in an adolescent Orthodontic population. SDB is a spectrum of breathing disorders ranging from primary snoring to Obstructive Sleep Apnea. **Methods:** The sample consisted of 303 care seeking healthy children (mean age, 14.41) who were patients in CWRU's orthodontic clinic. SDB Risk was assessed using the Pediatric Sleep Questionnaire (PSQ). The PSQ consists of 22 questions and high risk is defined as positive answers to 33% of the questions answered. Eighteen randomly selected patients repeated the PSQ one month after initial survey completion. **Results:** The percentage of high-risk patients was 7.3% (22 of 303). Low-risk patients composed 90.4%. Cronbach's Alpha for the repeated questionnaires was 0.852. **Conclusion:** The prevalence of SDB in an adolescent Orthodontic population was consistent with reports in the literature for other adolescent population groups. The PSQ can be used by orthodontists to screen their patients for SDB risk.

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LITERATURE REVIEW

Marcus et al. 2001 stated that sleep plays a significant biological role for processes like growth which implies an increase in size or magnitude facilitated by development. Enlow et al. 2006 in their comprehensive summary of Facial Growth, state that development is a maturational activity of cellular differentiation that supports biological processes. And the end product is life in the form of a complete living and breathing human organism. For proper development of the neonate, nearly two-thirds of the time is dedicated to sleep.

Although necessary, the prolonged resting period during the fragile state of infancy places significant demand on the chest wall to overcome the negative inward pressure exerted by the lung wall. Papastamelos et al. 1995 in their evaluation of chest wall compliance from infancy to childhood, stated that during first year of life an infant's chest wall compliance is nearly three times that of lung compliance. To counteract the excessive chest wall compliance and maintain end-expiratory lung volume (EELV), the newborn recruits

laryngeal adductor and diaphragmatic musculature. The upper airway is the primary channel that facilitates airflow into the lungs. Although protective mechanism exists, high chest wall compliance with and a decrease in upper airway muscle tone predisposes the child to upper airway obstruction (Arnes, Marcus 2004).

Durán et al. 2001 explained that in adults end-expiratory lung volume (EELV) is determined by the equilibrium between negative pressure exerted by the lung and the outward compliance of the chest wall. In adults, respiratory rates remain constant but minute ventilation can decline over 10% compared to wakefulness. Inadequate ventilation causes oxyhemoglobin desaturation and chronically symptomatic patients may experience pathological consequences. Evidence shows an increase in inflammatory biomarkers, hypertension during rest, stroke, and cardiovascular disease. These consequences are compounded during sleep. As respiration decreases and as one progresses through the four stages of Non-Rapid Eye Movement sleep, upper airway resistance increases as muscle tone declines. Lopes et al. 1983 explains that noteworthy consequences of increased demand for oxygen

are that essential developmental processes like tissue growth and regeneration occur during Non-REM sleep.

REM sleep, also known as Slow Wave Sleep (SWS), follows Non-REM sleep. During REM sleep, dreams occur and memories are formed. Skeletal musculature becomes flaccid which serves as a protective mechanism thereby preventing dreams from being enacted (Amer. Psyc., 2014). In this active state of sleep, breathing is often fragmented and erratic. In the adolescent, physiologic barriers in respiration are less cumbersome compared to infancy where neural system development manifests in cognitive and emotional change. During adolescence and the onset of puberty, the demand for sleep diminishes. Oftentimes, this diminished demand leads to daytime fatigue and sleepiness during the school week.

In their longitudinal study, Sadeh et al. 2009 concluded that over a two-year evaluation of adolescents, sleep quality is significantly delayed and considerably shortened. When school is not in session, sleep debt is repaid as the pre-teen or teenager wakes in the late morning or early afternoon. Growth constraint at such a critical time of development in a child or adolescent will likely have lasting implications into adulthood.

Interestingly, Fienberg et al. 2006 found that the decline in NREM delta is associated with age dependent synaptic reorganization. In utero, reorganization and maturation of the nervous system processes are synchronized chronologically. During adolescents, the process of synaptic pruning does not occur on a tightly regulated schedule but rather over an extended period of time. This progressive decline in neuroplasticity allows for the honing of other critical processes like information processing where lacking the appropriate amount of sleep has developmental consequences (Fienberg, 1982).

Evidence from previous studies demonstrates that sleep deficiency effects metabolism and these imbalances alter hormones necessary for essential biological processes (Spiegel, 1999). Within a normal range, feedback loops within the endocrine system are able to control metabolic fluctuations, however, long-term alterations have negative effects. In their systematic review and meta-analysis, Chen et al. 2008 demonstrated a clear association between short sleep duration and childhood obesity. The latter is a global health concern that industrialized nations like the United States are

dedicating significant time and attention (Baranowski, 2006). Of concern is that in clinical settings there is poor recognition of pediatric Sleep-Disordered Breathing (SDB). Blunden et al. 2003 explains that children who frequently snore are not being reported to their pediatrician.

SDB is a group of breathing disorders that occur during sleep and are described by extended periods of upper airway resistance and or partial or complete airway obstruction (Carroll, 2003). In the pediatric population, SDB can range from habitual snoring to complete upper airway obstruction, hypoventilation, hypoxemia and Obstructive Sleep Apnea (OSA). O'Brien et al. 2004 explains primary snoring is the cardinal symptom associated with pediatric SDB. And although common with adults, snoring is considered uncharacteristic in children. If not detected and referred early, young patients who snores are at elevated risk of developing Obstructive Sleep Apnea - the most severe form of SDB (Amer. Acad. Of Sleep Med.,2005).

Characteristic of this disorder are episodes of partial (hypopnea) or complete (apnea) obstruction of the upper airway that are secondary to collapse of anatomical

structures during inspiration. Bresnitz et al. 1994 explain that definitive diagnosis is made by both clinical examination and polysomnography (PSG) - an overnight research sleep test. Marcus et al. 2001 in clinical research, PSG is the gold standard due to the objective criteria used to evaluate OSA risk. According to Almeida et al. 2014, the mild severity is an apnea-hypopnea index (AHI) with either greater than 15 episodes per night or greater than 5 episodes with day or night symptoms. This is also the minimum necessary criterion for an OSA diagnosis. Moderate is defined as AHI between 15 and 30 and severe is defined as AHI greater than 30 episodes per night.

Castronovo et al. 2003 explained that prevalence rates vary according to the diagnostic tools used for measuring SDB. According to the literature, Montgomery-Downs et al. 2006 describe that many authors like Marcus et al. report prevalence rates of primary snoring in children at 10% and OSA at less than 3%.

Nieto et. al 2000 looked at the association between SDB and hypertension in a large sample of approximately six thousand university students with a near even subject male and female distribution. What they showed is that

snoring was present in 40% of the individuals surveyed. Of those individuals who snore, 47.5% had an AHI greater than 15 and 61.7% had an AHI greater than 30.

Peppard et al. 2013 report that prevalence rates of SDB in adults have drastically increased over the past twenty-five years with obesity being a major predictor. This causal relationship deserves attention due to the pathological consequences of this condition. Current estimates of SDB are approximately 13% in men and 6% in women. And early identification of risk factors may help curtail the health and economic impact of this epidemic later in life. Differences exist between SBD in children compared to adults.

Often reported in the literature, the current perspective is that adenotonsillar hypertrophy is the major cause of sleep related breathing disorders in children that are otherwise healthy. Hyperplastic pharyngeal tissue and enlargement of the soft palate are often present with enlarged tonsils and adenoids. From birth until 12 years of age the lymphoid tissue increases (Vaughn, 1983). And relative to airway size, peak incidence occurs between 2 and 8 years of age (Jeans, 1981). However, despite these physical barriers,

children have less collapsible airways compared to adults. This conclusion has been supported by Marcus el al. 1995 who proposed that an increased ventilator drive compensates for the reduction in airway size during adolescents.

In their meta-analysis, Baldassari et al. 2008 demonstrated that in pediatric patients with SDB where surgical intervention was necessary, there were significant quality of life improvements in caregiver concern, sleep disturbance, and physical suffering. With a curative rate ranging from 25% to 75%, surgical removal of the tonsils and adenoids is regarded as the first line treatment in pediatric patients (Guilleminault, 2004). There is an association of SDB with adenotonsillar hypertrophy, which alone is not due to enlarged lymphoid tissues. SDB is due to a combination of structural and neurogenic components with symptoms of SDB manifested during sleep (Marcus, 2000). According to Fernbach et al. 1983 patients who are awake do not experience apnea or hypopnea. This indicates that structural factors alone do not cause SDB. There are some children who present with enlarged tonsils and adenoids and no other confounding variables. Of this group, it has been reported in the

literature by Suen et al. 1995 that some of them are not cured by surgical intervention, which implies that neurogenic factors are not causal for SDB.

Marcus et al. 2013 showed that school aged children without prolonged oxyhemoglobin desaturation did not experience substantial improvement in higher cognitive functions. However, more subjective but equally important measures like behavior and quality of life did improve. Fernbach et al. 1983 describe that according to polysomnograph findings, early surgical intervention for adenotonsillectomy resulted in a 79% reduction in symptoms whereas watchful waiting for several months reduced symptoms by nearly 46%. Other studies, by contrast, have shown less remarkable improvement PSG normalization following adenotonsillectomy in obese children.

Mitchell et al. 2014 demonstrated that there are subsets of the population that benefit less from surgical intervention. Evaluating polysomnograph (PSG) data at baseline (T1) and following surgery (T2) show that African American and obese children normalize less frequently. Reporting this conclusion was the Childhood Adenotonsillectomy Trial (CHAT) that evaluated the

efficacy of early removal of tonsils compared to watchful waiting for several months. Another objective of the CHAT study was to discriminate OSA severity based on clinical findings, demographic data, and questionnaire responses. The results of the study were unremarkable for distinguishing between the different forms of sleep-disordered breathing. Furthermore, when data from the study were validated against PSG findings, less than 3% of SDB variability was explained by obesity and race. Findings of the CHAT study do however reconfirm that race and obesity are associated with SDB.

Redline et al. 1999 indicated significant associations of SDB with obesity, evaluated by BMI, and neck circumference in chidren. However, when considering the odds ratio, this impact was half of what significant associations are in adult populations and this variation could be attributed to children having lower BMI compared to adults. Additionally, children have more attuned ventilatory drive mechanisms compared to adults. Considering race, the criteria for assessing racial differences are more ambiguous compared to obesity with African-American children experiencing SBD nearly three times as frequently as Caucasian children. Although

progress has been made, the relationship between childhood and adolescent breathing disorders and general health implications is not completely clear. Marcus et al. 2013 explained that more severe baseline levels of OSA in African American and obese children were prevalent even when adjusting for race, household income, and behavior while an evidence-supported explanation for the racial difference remains unclear. When caregivers reported, some possible reasons for racial differences include parent's perception of their child's behavior and other factors unrelated to the diagnosis.

Although the literature does not currently provide an explanation for racial disparities, the evidence does reveal that these issues exist among a large cohort of children and adolescents. For orthodontists whose primary demographic is the adolescent population, it is imperative to have measures in place to identify the prevalence of Sleep Disordered Breathing. Many studies, including work done by Juliano et al., 2009 have been published on the craniofacial characteristics between patients symptomatic of SBD and healthy individuals.

Katyal el al. 2013 explain that during growth, disharmony within the craniofacial complex can create an

unfavorable environment leading to pediatric SDB. In Orthodontics and Anthropology, Cephalometrics have been used to evaluate growth in the sagittal and vertical dimensions. Nelson et al. 1997 describe how risk indicators visible on a lateral cephalogram are the relative dimensions and locations of the posterior airway, soft palate, maxillomandibular complex, and hyoid bone position. The interaction between hard and soft tissues of the craniofacial complex is multifaceted.

Cephalometric considerations may be useful for characterizing individuals who have the most severe form of Sleep Disordered Breathing - OSA. In a stepwise discriminate-analysis evaluating four anatomic variables (age, Body Mass Index, hyoid mandibular plane length, and tongue length), Hans et al. 2001, developed the Craniofacial Risk Index (CRI). The objective was to properly classify patients into two groups: Respiratory Distress Index (RDI) greater than 20, which is common in OSAS patients, or RDI less than 20. The CRI was applied to a group of sixty-six individuals with a history of heavy snoring who underwent an overnight sleep test. The results show that 72.3% of patients with low RDI and 78.7% of patients with a high RDI were classified

correctly. The utility of the CRI in clinical practice is that appropriately timed interventions can be made for classifying patients who are at increased anatomical risk of OSAS.

To determine the role of these risk factors, Nelson et al. 1997 stratified the results of obese and non-obese adult patients according to 13 anatomic variables using an overnight sleep test. The results showed that only approximately half of the variation in the respiratory distress index could be explained statistically. In either the obese or non-obese group, no variable alone accounted for the variation. The results of this study further support the notion that, independent of patient population, SDB is a multifactorial condition dependent on neurogenic, behavioral, and psychosocial elements.

According to Katyal et al.2013, there are inherent shortcomings in using two-dimensional lateral cephalograms to evaluate three-dimensional patients. Without consideration of the third dimension, errors in landmark identification and measurement flaws would skew measurement accuracy. In a systematic review and meta-analysis of the literature evaluating the relationship between craniofacial disharmony and pediatric SDB it was,

however, concluded that on lateral cephalograms children with SDB have increased ANB angles and reduced sagittal widths of the upper airway. Furthermore, Durán et al. 2001 explain that the significance of this potentially life-threatening condition becomes more apparent when upper airway narrowing is cofounded with adenotonsillar hypertrophy, craniofacial anomalies, genetics, and obesity.

Sa et al. 2001 explained that in adults, the relationship between SDB and associated risk factors such as age, obesity, cardiovascular disease, and mortality are well documented. This differs from the pediatric population where diagnosis, symptom manifestation, and therapeutic intervention are less recognized. Rosen et al. 2001 indicated that in addition to anatomical differences, one of the major contributors to the difference between SDB and risk factors is the absence of community awareness about SDB and underreporting of symptoms - particularly snoring. Adults who have clinical signs of SDB are aware of their symptoms and are able to articulate this to primary care providers. Baldassari et al. 2008 explained that parents of children with sleep disturbances may be less attuned to the detrimental

health consequences and therefore are less likely to look for signs. Furthermore, caregivers not sleeping in the same room may not be present to observe apnea like episodes that occur during stage 4 REM sleep. Hunt et al. 1982 described that without timely recognition and treatment, unchecked progression of SDB sequelae, at a critical time of adolescence, can result in stunted cardiovascular, respiratory, and growth development.

According to the literature, it is known that SDB is underreported in the pediatric population. Blunden et al. 2003 compared the frequency that snoring was reported by parents at a general practice visit compared to the frequency that snoring was confirmed by parents on questionnaire. Parents and their child's clinician were asked if snoring was discussed during a consultation over the previous 12 months. According to parent report, the results of the study showed that 112 or 18% of the 626 patients snored. Of concern is that only 20% of the adolescents with symptoms of SDB had consulted with their primary care doctor over the previous twelve months. And only 8 of the 112 who snore frequently, as reported on the questionnaire, were actually seeing their doctor for snoring. According to the results of this study,

underreporting may be the reason that 80% of symptomatic patients are not receiving proper medical help.

Sleep Disordered Breathing is a complex disorder with primary snoring, the cardinal sign, at one end of the spectrum and Obstructive Sleep Apnea (OSA) at the other. Stradling et al. 1990 said that in some clinical environments there is a notion that if the adolescent does not present with both snoring and OSA then morbidities such as cor pulmonale, delayed development, and hypertention are rare. However, Ali et al. 1996 explain that current evidence suggests that even mild SDB can have daytime impairments like attention deficit, memory loss, delayed learning, behavioral issues, and affected school performance. What complicates this matter is that there is a large percentage of the population that remains undiagnosed. Timely recognition of snoring is important for early intervention and prevention of OSA.

Polysomnograph is the gold standard for OSA diagnosis. However, due to limited accessibility, training time, and expense it presents barriers limiting access to care. Therapeutic modalities are functionally dependent on the diagnosis and the available resources. An evidence-based

approach to patient centered care should ultimately determine how resources are appropriated for SDB treatment. In their review of the literature Leptin et al. 2003 listed several treatment options ranging from adenotonsillectomy to systemic steroids and CPAP. Efficacy of these treatment options is largely centered on patient compliance. Overviews of treatment options are listed in further detail below.

Once a PSG diagnosis of OSAS is confirmed, removal of tonsils and adenoids is the first line of curative treatment. Following treatment, most patients report significant improvement in clinical symptoms. Of the twenty-one studies that were reviewed and nearly four hundred patients that were operated on, the overall curative rate was 80%. This indicates that the failure rate of T&A surgery is 20%.

Ethical considerations affect the methodology of how research studies are designed. According to the reviewed literature, it was not clearly depicted as to whether adenoidectomy, tonsillectomy, or a combination of the two surgical procedures would yield the highest success rate. Furthermore, using PSG to identify at-risk patients who

are less likely to respond to T&A would allow for proper follow up at clinical visits.

With the aim of evaluating the efficacy of systemic corticosteroids for treatment of adenoid and tonsillar hypertrophy secondary to OSAS, Al-Ghamdi et al.1997 treated ten otherwise health patients with oral Prednisone. The prescription for 1mg/kg was to be taken one time daily for five days. Results of the study were clinically and objectively, as defined by PSG, insignificant for improving symptoms in patients with OSA. The same group performed a later study assessing the benefit of intranasal steroids in patients with PSG confirmed OSA. Twenty-five randomly assigned children, with mild to moderate PSG confirmed OSA, were given a placebo or 50mcg Fluticasone intranasal spray. Instruction was for twice daily for one week followed by one time daily for five weeks. Results of the study show that mean AHI and oxygen desaturation levels decreased. However, when comparing symptom reduction and airway volumes, no significant differences existed between the experimental and control group. Intranasal steroids may offer symptom relief in patients diagnosed with mild OSAS. Leptin et al. 2003 explain that before widespread

application of this therapeutic approach, prospective and randomized longitudinal trials are needed to evaluate OSAS reoccurrence following discontinuance of intranasal steroids.

Marcus et al. 1994 state that many of the studies performed on Continuous positive airway pressure (CPAP) are retrospective. CPAP administers continuous positive pressure to the upper airway via a non-invasive mask which covers the both the nose and mouth. There is no difference is airway pressure requirements between children and adults. This suggests that CPAP is functionally dependent on the degree of airway obstruction as opposed to anatomical variation and chest wall compliance. Only within the last fifteen years CPAP has become the primary treatment option for adult patients with OSA. Marcus et al. 1995 explain that before this, adult patients with persistent OSA following tonsil and adenoid removal underwent tracheostomy. Pediatric OSA is under-reported and under-diagnosed. Also, complications from inadequate pediatric masks limited widespread use. The introduction of commercially available CPAP equipment over the past decade has significantly increased its use. McNamara et al. 1999

describe that in syndromic children and those with severe medical conditions, CPAP is effectively able to normalize sleep patterns and ventilation. Marcus et al. 1995 explain that to achieve significant quality of life improvements, substantial training is required on behalf of parents and children who have OSA. Compliance still remains the greatest limitation in both adults and children.

Clinical outcomes are, in part, dependent on Quality of Life evaluations and questionnaires have become clinically validated and practical options for prevalence assessment. Comparing pediatric OSA patients with those diagnosed with other chronic medical conditions, Baldassari et al. 2008, concluded that sleep related breathing disorders significantly impact the patient's Quality of Life. Furthermore, according to the Child Health Questionnaire and the Quality of Life Questionnaire (OSA-18), patients with OSA demonstrated lower QOL scores compared to patients with Juvenile Rheumatoid Arthritis. Following treatment for mild to severe obstruction, the greatest improvement was seen post-surgically following adenoid and tonsil surgery.

Barring the expense, time, and effort necessary for diagnosing patients with PSG, Chervin et al. 2000 sought to evaluate sleep related breathing disorders and the related symptoms in children. A validated prospective Pediatric Sleep Questionnaire (PSQ) was developed assessing snoring, sleepiness, and behavior disorders. Parents of adolescent patients being seen in the Sleep Laboratory at the University of Michigan were asked to complete the questionnaire. To determine reliability, data were included in the study only if PSG confirmed findings of SDB according to the apnea-hypopnea index. The conclusions drawn from this study is that the PSQ is a valid and reliable screening tool for assessing snoring, behavior, and daytime fatigue. Additionally, evidence of high sensitivity, specificity, and odds ratio demonstrates clinical applicability.

An objective evaluation of sleep related breathing disorders is necessary for proper diagnosis and PSG meets this objective criterion. For a holistic assessment of quality of life measures, subjective elements of the patients profile are important. In a multicenter CHAT trial, Rosen et al. 2015 used baseline PSG and questionnaire data to assess clinical relevance of the

survey type screening tool. Between the various medical societies, less work has been done in determining which factors besides PSG are of clinical value for patients with OSAS and how their quality of life will be following adenotonsillectomy. Examples of these quality of life measures subsequent to surgical intervention are: sleeping habits, breathing habits, attention, and behavior. The apnea-hypopnea index was the best predictor for both initial OSA severity and outcome following surgery and the best Pediatric Sleep Questionnaire (PSQ) indicator was the score. A study by Melendres et al. 2004, showed that OSA severity, confirmed by PSG, does not depict quality of life measures and outcome assessment following adenotonsillectomy. The PSQ, according to Rosen et al. 2015, is a subjective evaluation of an adolescent's symptom inventory according to parental response.

Franco et al. 2000 describe another quality of life assessment - the Obstructive Sleep Apnea-18. The five domains evaluated in the questionnaire include: sleep disturbance, physical suffering, emotional distress, daytime problems, and caregiver concerns. Scores range from 1 to 7 indicating none of the time to all of the

time respectfully. At the end of the survey parents are asked to rate their child's perceived quality of life on a scale of 1 to 10.

In children diagnosed with PSG confirmed OSA, Mitchell et al. 2004, used the OSA-18 to conduct one of the first prospective studies evaluating quality of life improvement following adenotonsillectomy. A conclusion from this study is that differences do exist between the way PSG and OSA-18 appraises patients post-surgery. Polysomnograph evaluates pathophysiological parameters such as Respiratory Distress Index (RDI), Apnea-Hypopnea Index (AHI), and oxygen desaturation while the OSA-18 relies upon the caregiver to provide information about the child's quality of life. One of the shortcomings in this subjective proxy approach is that the caregiver may not be available to witness apneic episodes that would likely show up on a polysomnograph. However, considering expenses, time involved with training, and the need for a sleep study facility, widespread plausibility of PSG is not a viable option. Furthermore, even though PSG does provide the most objective data for improvement following surgery, it does not quantify the quality of life improvements due to morbidity reduction. To evaluate

these effects before and after surgery, a well-designed and validated questionnaire like the OSA-18 is a useful tool.

In their evaluation of quality of life improvements Goldstein et al. 2002 asked parents to complete the OSA-18 and the Childhood Behavior Checklist before and after adenotonsillectomy. The primary reason for selecting the OSA-18 is that it is the only validated assessment tool that quantifies baseline and long- term quality of life indices. In 24 of the 64 participants in this study, a statistically significant ($P<.001$) quality of life change was seen between the pre-operative and post-operative results. Although questionnaires, like OSA-18, are not objectively diagnostic for sleep related breathing disorders, they provide insight into the patient's quality of life and the caregiver concern that is not attainable from PSG.

Children presenting for Orthodontic treatment should be routinely evaluated for sleep related breathing disorders. Early intervention may reduce the burden of care on patients, caretakers, and the healthcare system. Underreporting and current prevalence rates are not proportional to the utilization of health care services.

In a study looking at the utilization of healthcare services, Reuveni el al. 2004 noted a 226% increase in children with OSAS compared to a large sample of matched controls. Nearly 50% of this increase was due to inpatient admission, visits to the emergency room, and prescription drug consumption. And moreover, 80% of the prescriptions written were for respiratory tract medications. This represents a statistically significant, 4-fold increase compared to the control group. These numbers are alarming when considering that Sleep Disordered Breathing, according to Blunden et al. 2003, is underreported in the pediatric population. There is substantial evidence suggesting that early recognition, diagnosis, and intervention is cost-effective.

In the ten years prior to a confirmed diagnosis, Ronald et al. 1999, showed that adult patients with OSA utilized nearly 2-3.5 times more of healthcare services compared to healthy adult patients and costs of the increase were due to cardiovascular disease and obesity. Interestingly, these morbidities are similar to those seen in the adolescent population. Adequate and timely intervention would decrease the extent of systemic manifestations. Katyal et al. 2013 showed that Sleep

Disordered Breathing is a continuum of increasing upper airway resistance. At one end of the spectrum is no snoring which is followed by snoring without daytime symptoms, snoring with symptoms, obstructive hopopnea, and ultimately obstructive sleep apnea. Snoring children, who present with daytime symptom such as Attention Deficit Hyperactivity Disorder (ADHD), could quite easily be evaluated in a clinical setting for Sleep Disordered Breathing via the PSQ and OSA-18. Appropriate referrals can be made if results of the questionnaires indicate patients are at a high risk. Montgomery-Downs et al. 2004 explain that the objective of early intervention is to curtail progression of symptomatic snoring to OSA. The immediate and long-term healthcare consequences of morbidity associated with Sleep Related Breathing Disorders are significant. Utilization of healthcare services increases which impacts the burden families experience both psychologically and financially.

In summary, the following main areas have been investigated in this literature review:

1.) The physiology of sleep is a dynamic process that changes from infancy to adulthood

2.) Sleep Disordered Breathing (SDB) is a collective

group of breathing disorders that is definitively diagnosed via PSG. The spectrum of symptoms range from primary snoring to OSA

3.) Prevalence rates of SDB are underreported in the pediatric population but deserve more attention due to morbidity and the burden of care on patients, families, and the healthcare system

4.) The primary treatment option for OSA is adenotonsillectomy. Other options consist of nasal steroids and CPAP.

5.) Due to limitations using PSG in clinical practice, questionnaires such as the PSQ and OSA-18 have are instrumental resources for evaluating the prevalence of SDB; the risk of SDB; and quality of life measures.

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STATEMENT OF THESIS

The goals of this study are to evaluate the prevalence of Sleep Disordered Breathing (SDB) in an adolescent Orthodontic population.

We hypothesize that insight into patient's symptoms can be obtained from routine Orthodontic appointments through the use of a validated screening tool - Pediatric Sleep Questionnaire (PSQ).

We hypothesize that a patient's symptoms as reported on the questionnaire during routine Orthodontic appointments can identify children at high-risk for sleep disordered breathing and result in appropriate referrals for further advice and treatment, as needed.

We conclude that the prevalence of SDB in an adolescent Orthodontic population was consistent with reports in the literature for other adolescent population groups. The PSQ can be used by orthodontists to screen their patients for SDB risk.

Sleep Disordered Breathing in an Orthodontic Care Seeking Population

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INTRODUCTION

In their comprehensive analysis of facial growth, Enlow and Hans[1] explain that development is a maturational activity of cellular differentiation that supports biological processes. Marcus et al.[2] stated that sleep plays a significant biological role in growth whereby development is facilitated by an increase in size or magnitude. On average, nearly half of childhood is dedicated to this process. Over the past two decades there has been growing interest in upper airway morphology – the conduit facilitating oxygen flow from the environment into the lungs[3].

During the dynamic process of inspiration the upper airway collapses variably as a function of upper airway resistance and negative intraluminal pressure[4]. According to Starling's resistor model a tube inside of a chamber can demonstrate this collapsible behavior. Critical closing pressure (Pcrit) of the chamber can be greater or less than the pressure inside of the tube. When Pcrit is greater than zero the chamber pressure exceeds tube pressure and airway obstruction occurs. Conversely, when Pcrit is negative intraluminal pressure of the tube is greater than chamber pressure and the airway patency is maintained. In a defining study in 1978 Remmers and colleagues[5] explained that collapse of the upper airway is due to physiological imbalances between the negative pressure within the pharynx and opposing musculature of the upper airway. These imbalances differ between pediatric and adult patients.

Feinberg et al.[6] explains that in adolescence the demand for sleep diminishes and quality sleep is often delayed. A shorted sleep cycle and daytime fatigue in adolescents is manifested as behavior imbalances and cognitive impairment[7]. In adults however, the most prominent daytime symptom associated with Sleep Disordered Breathing is extreme daytime fatigue[8]. Due to variation of signs and symptoms between adults and children, pediatric Sleep-Disordered Breathing (SDB) is under-

recognized and under-reported in clinical settings. Snoring, the cardinal sign is not generally reported to pediatrician by parents of children with Sleep Disordered Breathing[9]. This complex group of disorders occurs during sleep and is described by extended periods of upper airway resistance (snoring) at one end of the spectrum and or partial or complete airway obstruction (OSA) at the other[10].

The current perspective is that adenotonsillar hypertrophy is the major cause of sleep related breathing disorders in children that are otherwise healthy. From birth until 12 years of age the lymphoid tissue increases[11]. And relative to airway size, peak incidence occurs between 2 and 8 years of age[12]. With a curative rate ranging from 25% to 75%, surgical removal of the tonsils and adenoids is regarded as the first line treatment in pediatric patients[13].

Bresnitz et al.[14] explains that definitive diagnosis is made by both clinical examination and polysomnography (PSG) – an overnight research sleep test. Prevalence rates vary according to the diagnostic tools used for measuring SDB. Marcus et al.[15] report prevalence rates of primary snoring in children at 10% and OSA at less than 3%. PSG is the gold standard for objective risk assessment. However, due to limited accessibility, training time, and expense it presents barriers limiting access to care.

Barring the expense, time, and effort necessary for diagnosing patients with PSG, many questionnaires have been developed to assess risk of Sleep Related Breathing Disorders (SRBD). However, variations in the ability to detect snoring for PSG confirmed OSA has limited the clinical utility of many screening tools[16]. Chervin et al.[17] sought to evaluate sleep related breathing disorders and the related symptoms in children. A validated prospective Pediatric Sleep Questionnaire (PSQ) was developed for patient patients 2-18 years old to assess snoring, observed apneas,

sleepiness, and behavior disorders. Results show that the PSQ is a valid and reliable screening tool. Furthermore, evidence of high sensitivity, specificity, and odds ratio demonstrates clinical applicability.

Marcus et al.[18] explain that prevalence rates for SDB are approximately 10% for primary snoring and 3% for OSA. However, these rates are under reported. For definitive diagnosis, clinical examination and overnight sleep test via PSG is required. However, widespread use is limited due to cost, time-consumption, and accessibility. Validated questionnaires have been developed to aid in the screening of pediatric patients with SDB by evaluating sleep quality, sleep duration, quality of life measures, and caregiver concerns. The primary aim of this study is to evaluate the prevalence of Sleep Disordered Breathing in an adolescent Orthodontic population.

MATERIALS AND METHODS

The Institutional Review Board at Case Western Reserve University (CWRU) in Cleveland, Ohio approved this study. In the department, all aspects of clinical Orthodontic are provided to address patients' needs. The services provided range from traditional Orthodontic therapy to multidisciplinary surgical and craniofacial treatment. The majority of clinical training in the Orthodontic residency centers on treatment of adolescents in the adolescent clinic. Approximately 200 hundred adolescent patients started treatment in the 2014-2015 calendar year. For purposes of this study, the study sample was recruited from adolescent clinic patients. Informed consent was obtained from all parents or guardians and verbal consent was obtained from the adolescents before data collection at the records appointment.

The records of 303 subjects between the ages of 9-18 years of age who were either active patients or who had completed Orthodontic treatment between January, 2014 and March, 2016 were examined.

Patients in the adult, surgical, and craniofacial anomalies clinics were excluded. Inclusion criteria for all participants consisted of:

1.) children interested in receiving Orthodontic treatment at CWRU

2.) adolescent patients between the ages of 9-18 at the beginning of orthodontic treatment

3.) completely filled out health history forms and study questionnaires

The PSQ was presented to parents or guardians for completion with a medical and dental history form at the time of the clinical examination.

PSQ Screening Questionnaire

From the PSQ, patient age, gender and race/ethnicity were collected. Racial and ethnic categories were defined according to National Institutes of Health[19]. An

additional category of "Other" was listed as the seventh option choice. The method for scoring and categorizing the results of the PSQ was reported in a previous study by Chervin et al.[17]. This well-validated 22-item questionnaire evaluates three categories. Questions in the first category inquire about snoring, the second about sleepiness, and the third about behavior (particularly inattention and hyperactivity).

The last six questions on inattention and hyperactivity were from the American Psychiatric Association's DSM-IV scale and matched with a well-confirmed 4-Level Likert format[20]. The questions are answered as either "yes" or "no". A "yes" response to 8 or more questions or a cutoff value greater than or equal to .33 indicates high risk of Sleep Disordered Breathing. Answering "yes" to 7 or less indicates a low risk. Missing and "don't know" responses are excluded from the denominator when estimating risk. When compared with Polysomnograph data, the PSQ has a sensitivity of 0.85 and a specificity of 0.87.

Test-Retest Reliability

To evaluate reliability of the PSQ in this study sample, eighteen participants repeated the PSQ approximately one month after the initial completion.

Statistical Analysis

All data were analyzed with the Statistical Package for the Social Sciences (SPSS) software (IBM SPSS Statistics 22.0). Descriptive statistics were used to calculate the mean and standard deviation for certain variables of interest.

PSQ scores were examined by gender and by race with a Mann-Whitney test. Correlation of PSQ scores with age were evaluated with a Spearman's rho. Cronbach's alpha was calculated for the test-retest reliability sample.

RESULTS

Patient Demographics - Proper selection was followed. With the inclusion criteria, 303 randomly selected healthy children ages 8-18 years who were patients in CWRU's Orthodontic clinic (152 males and 152 females) were included in this retrospective descriptive study. Complete questionnaires were missing from 2 subjects. The final sample size was 303 who fit the inclusion criteria. Sample size was determined from a theoretically unlimited population, 95% confidence level, and a ±5% confidence interval width.

Table 1 shows the study sample characteristics. The mean age of the study sample was 14.4 years (±2.0) with approximately an even distribution of males (50.2%) and females (49.8%). This study included 7 Asian subjects (2.5%), 13 African- American (4.6%) subjects, 17 Hispanic subjects (6%), 236 Caucasian subjects (83%), and 10 subjects listed in the other category (3.5%). Twenty subjects abstained from listing their race.

Reliability - Eighteen patients completed the PSQ approximately one month after the initial visit. The Cronbach's Alpha for the questionnaire was .852, which indicates high reliability (Table 2).

Questionnaire Results - The cut-off value to identify a patient with SDB as high-risk for OSA was .33 or 33% of responses as a "yes". The prevalence of SDB was 22/303 or 7.3% (Table 3).

The 95% Confidence interval (4.7%, 10.6%) are presented in Table 4. PSQ scores were compared by gender and race for the full sample and for the high-risk group. To evaluate differences in PSQ scores between race and gender, a Mann-Whitney test was performed (Table 5).

To examine the correlation between age and scores on the PSQ A Mann-Whitney test was performed (Table 6).

A second Mann-Whitney test was performed to analyze the association between race and the PSQ (Table 7).

DISCUSSION

The primary goal of this study was to assess the prevalence of Sleep Disordered Breathing in an adolescent Orthodontic population at Case Western Reserve University Department of Orthodontics. Many authors, including Blunden et al.[9], have emphasized that primary caregivers underreport Sleep Disordered Breathing. Underreporting is a contributing factor to under diagnosis. However, this problem is also due to lack of awareness.

Growth and development of the craniofacial complex is fundamental knowledge that Orthodontists use in diagnosing and treatment planning. Through proper risk assessment of SDB Orthodontists will be better prepared to address underlying factors that influence patient's clinical presentation. Furthermore, with the proper screening tool Orthodontists will be better positioned to screen patients who may be at risk for SDB.

Chervin et al.[17] developed the Pediatric Sleep Questionnaire (PSQ) based on PSG confirmed OSAS symptoms. This 22-item symptom inventory shows good reliability, internal consistency, and validity. As a supplement to medical history forms used the in the Department of Orthodontics at Case Western Reserve University, the PSQ was incorporated to further evaluate SDB in adolescent patients seeking Orthodontic treatment.

Variations in study design methodology impacts how prevalence rates are determined. Most authors, including Castronovo et al.[21], have reported prevalence rates of primary snoring and OSA to be 10% and approximately 3% respectively. In this study, the PSQ was the screening tool used to assess prevalence. Internal consistency of the PSQ was 85.2%. In social sciences, a coefficient of .70 or higher is sifficient[22]. Adolescents at a high risk for SDB were 7.3%. The response rate was

100%. This signifies that the PSQ is a screening tool that could easily be incorporated during the Orthodontic screening protocol to evaluate Sleep Disordered Breathing in adolescents.

The mean PSQ score range by racial group was .95 (undisclosed) to 3.0 (African American). No group differences were present when factoring in the standard error.

Approximately 60 adolescent patients are treated per day at Case Western Department of Orthodontics. Patients are seen Monday through Thursday. With a prevalence of 7.3%, nearly 4-5 patients/day and 18 patients/week would be high risk for SDB. According to a 2011 report from American Association of Orthodontists (AAO) Member and Patient Census Survey, 50 adolescent patients are treated per day in a private practice. A prevalence of 7.3% translates to 4 patients/day and 15 patients/week (based on a 4 day work week) who are high risk for SDB. With the proper screening tool for evaluating SDB, Orthodontists would be better positioned to identify etiology of SDB and make appropriate referrals to the pediatricians, pediatric sleep specialists, or otolaryngology (ENT).

Proper protocol was following in conducting this project. Yet, limitations are an unavoidable. One drawback is that the study sample is not representative of the population demographic of Cleveland, Ohio. Lack of generalization is a factor. In the Childhood Adenotonsillectomy Trial (CHAT) Marcus et al.[18] reconfirmed that race and obesity are associated with SDB. Mitchell et al.[23] showed that African American and obese children normalize less frequently. Census data on adolescent African-Americans residing in Cleveland was not obtained for this study. However, the assumption can be drawn that the racial profile of the general population is higher than the 3.9% of African-Americans listed in this data.

Another limitation is the precision of the estimate. In this study, a 95% confidence interval and precision of 5% requires a sample size of 385 subjects. However, prevalence in the CWRU adolescent Orthodontic cohort was evaluated according to 303 subjects that fit the inclusion criteria on the PSQ screening. Time constrains were influential in obtaining the proper sample size. Based on the question of interest and the assumptions, smaller sample sizes impact statistical associations.

Data was self-reported is therefore subjective and a source of bias. A systematic plan was in place for gathering and synthesizing data to address the research question. However, self-reporting data can introduce bias.

At Case Western Reserve University Department of Orthodontics Hans et al.[24] developed the Craniofacial Risk Index (CRI) which evaluated four anatomic variables (age, Body Mass Index (BMI), hyoid mandibular plane length, and tongue length). The objective was to classify patients into two groups depending on their Respiratory Distress Index (RDI). High risk = RDI>20 is common in patients with Obstructive Sleep Apnea (OSA). Low risk = RDI<20. A future study may involve using the results of the PSQ to identify the highest and lowest risk patients. By using CBCT data to analyze if anatomical differences exist between the high and low risk groups the results may demonstrate another way to evaluate adolescent patients seeking Orthodontic treatment.

CONCLUSION

Sleep Disordered Breathing is an underdiagnosed multifactorial problem characterized by upper airway obstruction. The spectrum ranges from the cardinal symptom of primary snoring to complete cessation of oxygen flow. The impact of this disease on patients, their families, and the healthcare system warrants increased attention. In clinical Orthodontic settings, screening tools should be standard armamentarium for SDB risk assessment. The PSQ is a validated and user-friendly questionnaire designed specifically for adolescents. The results, according to the PSQ, indicate that 7.3% of the adolescent patients were considered high risk for some form of SDB. Long-term evaluation and greater sample heterogeneity may provide added insight into the prevalence of sleep related breathing disorders in adolescent orthodontic populations.

Table 1: Descriptive Summary on profile demographics

		Frequency	Valid Percent (%)
Age (years)	14.4 ± 2.02		
Gender	Female	151	49.8
	Male	152	50.2
Race	Asian	7	2.5
	Black	13	4.6
	Hispanic	17	6.0
	White	236	83.4
	Other	10	3.5
	Total	283	100.0

Table 2: Intraclass Correlation Coefficient (ICC) for PSQ

Cases	N	Percent (%)	**Reliability (Cronbach's Alpha)**
Valid	18	100	.852
excluded	0	.0	

Table 3: PSQ risk frequency

PSQ	Frequency	Percent
Low risk	281	92.7
High risk	22	7.3
Total	303	100.0

Table 4: Confidence Interval for high-risk prevalence

Confidence Interval Summary

Confidence Interval Type	Parameter	Estimate	95% Confidence Interval	
			Lower	Upper
One-Sample Binomial Success Rate (Jeffreys)	Probability (OSAS=high risk).	.073	.047	.106

Table 5: Association between gender, race, and the PSQ

Race	Gender	High risk	Significance P value
Race			.766
	Female	9	
	Male	11	
Asian			.629
	Female	3	
	Male	4	
Black			.050
	Female	4	
	Male	9	
Hispanic			.733
	Female	11	
	Male	6	
White			.109
	Female	119	
	Male	116	
Other			.690
	Female	5	
	Male	5	

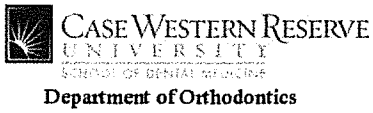
Table 6: Correlation between age and the PSQ

Correlation (Spearman's rho)	**Age**
PSQ risk	
Correlation coefficient	.098
Significance P value	.090
N	303

Table 7: Race and PSQ

Race	**Valid**	**PSQ score (mean)**	**Std. error**
Undisclosed	20	.95	1.4
Asian	7	1.1	1.6
Black	13	3.0	1.2
Hispanic	17	2.0	1.1
White	236	2.0	3.5
Other	10	2.5	1.3
TOTAL	303		

FIGURE 1: Pediatric Sleep Questionnaire



Department of Orthodontics

Obstructive Sleep Apnea Screening
PATIENTS UNDER 18 YEARS OF AGE

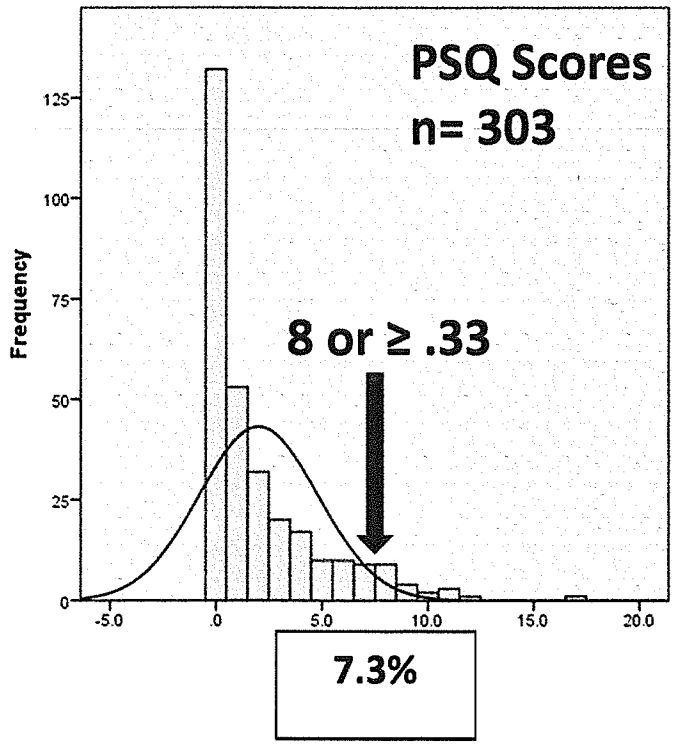
Last Name ..... First Name .....
DOB ..... Gender ...M / F Ethnicity ..... Date .....

Please answer on behalf of your child for the past month. If you don't know, circle "?"

Does your child have any of the following: **Please circle eg**	**Yes / No / ?**
• **A constant blocked or runny nose?**	**Yes / No / ?**
• **Recurrent chest infections/pneumonia?**	**Yes / No / ?**
• **An airway narrowing or abnormality?**	**Yes / No / ?**
• **A syndrome or other major health problem?**	**Yes / No / ?**
Type	
• **Does your child have large tonsils?**	**Yes / No / ?**
• **Has your child had their adenoids or tonsils removed?**	**Yes / No / ?**

While sleeping, does your child...	
1. snore more than half the time?	Yes / No / ?
2. always snore?	Yes / No / ?
3. snore loudly?	Yes / No / ?
4. have trouble breathing, or struggle to breathe?	Yes / No / ?
5. have "heavy" or loud breathing?	Yes / No / ?
6. have you ever seen your child stop breathing during the night?	Yes / No / ?
Does your child . . .	
7. tend to breathe through the mouth during the day?	Yes / No / ?
8. have a dry mouth on waking up in the morning?	Yes / No / ?
9. occasionally wet the bed?	Yes / No / ?
10. wake up feeling unrefreshed in the morning?	Yes / No / ?
11. have a problem with sleepiness during the day?	Yes / No / ?
12. has a teacher commented that your child appears sleepy during the day?	Yes / No / ?
13. is it hard to wake your child up in the morning?	Yes / No / ?
14. does your child wake up with headaches in the morning?	Yes / No / ?
15. did your child stop growing at a normal rate at any time since birth?	Yes / No / ?
16. is your child overweight?	Yes / No / ?
My child often . . .	
17. does not seem to listen when spoken to directly.	Yes / No / ?
18. has difficulty organizing task and activities.	Yes / No / ?
19. is easily distracted by extraneous stimuli.	Yes / No / ?
20. fidgets with hands or feet or squirms in seat.	Yes / No / ?
21. is 'on the go' or often acts as if 'driven by a motor'.	Yes / No / ?
22. interrupts or intrudes on others (e.g. butts into conversations or games).	Yes / No / ?

Figure 2: PSQ frequency distribution



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APPENDIX I: IRB Approval

NOTICE OF APPROVAL

CWRU IRB Protocol Number:	**IRB-2015-1365**
Protocol Title:	***The prevalence of Sleep Disordered Breathing in an adolescent Orthodontic care seeking population.***
Responsible Investigator (RI):	**Juan Martin Palomo**
Co-Investigator (CI):	**Ashok Rohra**
RI Department: **IRB - DEN - Orthodontics**	**Case Western Reserve University IBC and SBER**
Type of Review:	**Expedited**
Risk Level:	**Minimal**
Vulnerable Population(s):	**None**
Approval Date:	**12/30/2015**
CONTINUING	
REVIEW	
DEADLINE:	**12/15/2016 EXPIRATION DATE: 12/29/2016**

The CWRU Institutional Review Board (IRB) has approved the above new protocol through the **EXPEDITED** review process.

When conducting Human Subjects' Research, your responsibilities include the following:

1. Report all adverse events and unanticipated problems involving human subjects to the IRB Office, located in the Office of Research Administration (ORA), within three (3) business days of your knowledge of the occurrence.

2. Provide the IRB with a complete Continuing Review form (available in our electronic application system at http://sberirb-app.case.edu, or from the ORA) by the continuing review deadline noted above, and when the study is to be terminated.

3. Submit all proposed changes to the protocol to the IRB and wait for IRB approval before implementing any protocol change or modification.

4. Keep all research data and original consent documents in your possession for at least three (3) years after the study is terminated.

5. Note that completely de-identified data can be kept and used for research

indefinitely. The IRB is primarily concerned about identifiers/identifiable data. If you want to terminate your study, identifiers/identifiable data must be destroyed. This includes paper or electronic master lists, contact lists, codes/codebooks, transcripts containing identifiers and video and audio recordings.

6. If applicable, please use the most current IRB-approved consent forms. Feel free to use copies of these forms as long as they are identical to what was originally IRB approved. If you wish to change the forms or any other part of the study, you must submit an addendum request/protocol modification with revised copy(ies) of the relevant document(s) and wait for IRB approval before a modification can be implemented.

7. *Discontinue all work pertaining to this protocol if a continuing review approval is NOT finalized by the expiration date noted above.* No further work on this protocol is allowable until the proper continuing review materials or required revisions are approved by the IRB.

a. a. Please note that, if the continuing review materials or required revisions are not received by the expiration date, the RI and this study would be automatically placed on Administrative Hold for 30 days. This means that the RI loses their IRB privileges and research from this study must cease.

b. b. If after 30 days, the CWRU IRB still does not have the protocol for processing, this protocol will be administratively terminated and your IRB privileges will be revoked for all your protocols.

Thank you for your attention to this matter. Please contact the IRB office at 216-368-6993 if we can be of further assistance.

APPENDIX II: Obstructive Sleep Apnea-18

To assess quality of life measures, Mitchell et al.[13] explain that subjective elements of the patients profile are important. The five quality of life domains evaluated on the Obstructive Sleep Apnea-18 questionnaire include: sleep disturbance, physical suffering, emotional distress, daytime problems, and caregiver concerns. The OSA-18 is the only validated assessment tool that quantifies baseline and long- term quality of life indices[14].(Intro)

Franco et al.[15] developed the methodology for scoring the OSA-18 and determining its impact. The OSA-18 is the second questionnaire used in this study. This well-validated screening tool measures quality of life in 5 categories: sleep quality, physical suffering, emotional distress, daytime sleepiness, and caregiver concern. At the end of the fifth category, parents were asked to rate their child's quality of life on a scale of 1-10. Scoring is based on responses in the 5 categories. Scoring ranges from 18 -126. When the score is greater than 60, the patient is considered high risk. (Materials)

APPENDIX III: Raw Data

patient ID	Year	Months	DOB	gender	race	PSQ SCREENING SCORE	SDB QofL score	SDB QofL parent score	high risk
AM 16	15.00	11	4/15/2000	1	6	0	18	9	0
AM 21	13.00	4	11/21/2002	2	2	3	25	9	0.14
AN 116	14.00	1	4/6/2001	2	6	1	24	7	0.05
AN 117	13.00	1	1/4/2003	1	6	3	21	7	0.09
BA 346	16.00	5	10/20/1999	2	6	1	18	10	0.05
BA 348	13.00	6	9/8/2002	2	7	5	31	8	0.18
BA 349	13.00	10	5/31/2002	1	6	5	27	9	0.23
BA 352	15.00	1	1/9/2001	2	6	1	18	10	0.05
BA 354	17.00	0	2/2/1999	1	6	0	18	10	0
BA 355	14.00	4	9/26/2001	1	6	1	18	10	0.05
BA 356	16.00	8	7/15/1999	1	6	1	31	8	0.05
BA 358	16.00	2	1/26/2000	2	6	8	51	9	0.4
BA 378	15.00	4	10/10/2000	1	6	0	35	9	0
BE 282	10.00	2	2/1/2006	2	6	7	46	9	0.27
BI 90	13.00	9	7/3/2002	2	6	1	20	10	0.05
BO 203	17.00	9	5/7/1998	1	6	0	25	9	0
BO 210	13.00	7	8/21/2002	2	6	5	35	8	0.23
BO 212	13.00	5	10/9/2002	1	6	4	22	10	0.18
BR 320	14.00	3	10/24/2001	1	6	4			0.11
BR 324	13.00	2	1/30/2003	2	3	8	58	8	0.36
BR 396	14.00	1	1/8/2002	2	6	1	25	9	0.05
BR 410	13.00	0	3/15/2003	2	6	2	20	9	0.09
BR 411	11.00	11	4/26/2004	1	6	0	18	10	0
BR 419	10.00	2	2/21/2006	2	6	1	22	10	0.05
BU 207	16.00	4	9/27/1999	1	6	0	18	10	0
BU 224	13.00	7	7/13/2002	2		0	18	10	0
BU 193	17.00	7	8/29/1998	1	7	4	30	10	0.2
BU 196	15.00	8	7/13/2000	2	6	8	31	8	0.36
BU 197	15.00	8	7/13/2000	1	6	1	26	8	0.05
BU 207	16.00	6	9/27/1999	1	6	0	18	10	0
BU 212	15.00	1	2/6/2001	2	6	0	18	10	0
BU 230	14.00	3	1/11/2002	1	6	0	18	10	0
BY 27	14.00	6	7/26/2001	1	4	0	25	8	0
CA 362	14.00	9	6/12/2001	2	6	2	21	10	0.09

CA 385	10.00	9	6/23/2005	1	6	0	18	10	0
CA 386	12.00	8	7/17/2003	2	6	0	18	10	0
CH 220	13.00	3	11/8/2002	2	7	2	45	9	0.11
CH 159	16.00	6	9/28/1999	2	6	7	22	10	0.368
CH 207	14.00	0	3/24/2002	2	3	0	23	10	0
CH 208	12.00	9	6/16/2003	2	7	0	18	10	0
CO 408	15.00	6	8/3/2000	1	6	2	29	9	0.09
CO 292	13.00	11	3/1/2002	2	6	7	50	7	0.23
CL 105	12.00	2	11/24/2003	1	6	11	52	8	0.5
CO 291	17.00	3	10/27/1998	1	6	6	49	7	0.375
CO 302	14.00	8	7/21/2001	1	6	1	24	8	0
CO 349	15.00	0	3/14/2001	2	3	2	18	10	0.09
CO 382	17.00	5	10/19/1998	1	4	4	36	9	0.18
CO 409	11.00	1	3/19/2004	2	6	0	26	10	0
CR 127	16.00	6	9/9/1999	2	6	3	25	8	0.14
CR 133	13.00	9	5/8/2002	2	6	0	18	10	0
CZ 7	17.00	0	2/1/1999	2	6	10	67	7	0.45
DA 242	17.00	0	4/12/1999	1	6	0	18	10	0
DA 243	14.00	3	12/24/2001	2	6	0	18	10	0
DA 244	16.00	3	12/14/1999	1	6	0	19	10	0
DA 245	14.00	11	3/30/2001	1	6	0	19	10	0
DA 249	12.00	11	4/21/2003	1	4	2	25	10	0.09
DA 250	13.00	3	12/7/2002	2	6	0	20	10	0
DA 251	14.00	1	2/25/2002	2	6	0	18	9	0
DA 252	13.00	0	3/19/2003	2	6	0	18	10	0
DA 272	15.00	11	5/1/2000	1	4	0	31	9	0
DA 280	12.00	2	1/14/2004	1	6	0	19	10	0
DA 283	12.00	8	7/7/2003	2	6	4	18	10	0
DE 193	13.00	3	11/26/2002	1	4	0	18	9	0
DI 136	9.00	0	3/23/2007	1	6	0	41	6	0
DI 97	15.00	7	8/23/2000	2	4	0	19	10	0
DO 152	14.00	3	10/23/2001	2		2	19	9	0.09
DU 70	16.00	7	8/19/1999	2	6	0	18	10	0
DU 110	15.00	1	2/7/2001	1	6	1	24	10	0.05
DU 113	12.00	9	6/9/2003	1	6	0	18	10	0
EL 78	14.00	2	1/31/2002	1	6	0	27	9	0
EL 79	15.00	8	5/31/2000	2	6	8	30	8	0.36
EM 8	15.00	5	9/1/2000	2	6	7	34	9	0.18
FA 73	14.00	6	7/27/2001	2	6	9	42	9	0.40

FE 93	14.00	8	5/22/2001	2	6	0	18	10	0
FE 91	15.00	0	2/2/2001	1	4	0	19	10	0
FE 97	14.00	7	7/6/2001	1	6	1	20	10	0
FI 76	15.00	4	9/23/2000	1	6	0	18	10	0
FI 131	11.00	5	10/24/2004	2	6	1	22	10	0.05
FL 76	16.00	4	10/12/1999	2		0	18	10	0
FL 80	14.00	4	11/27/2001	2	6	0	21	10	0
FL 82	15.00	1	2/1/2001	1	6	2	31	8	0.09
FR 166	12.00	4	9/26/2003	1	6	1	30	8	0.05
FR 180	14.00	1	1/17/2002	2	6	0	23	8	0
FR 181	14.00	9	5/2/2001	2	6	0	26	9	0
FU 38	11.00	11	4/19/2004	2	6	0	18	10	0
GA 217	13.00	9	6/10/2002	1	2	4	18	10	0
GA 219	14.00	1	3/18/2004	2	6	2	25	10	0.09
GE 88	10.00	7	8/26/2005	2	6	0	24	10	0
GI 99	13.00	11	4/22/2002	1	6	0	18	10	0
GO 185	12.00	6	10/6/2003	2	6	1	19	10	0.05
GO 188	14.00	8	5/27/2001	2		1			0.05
GO 150	14.00	2	12/10/2001	1	4	0	18	9	0
GL 26	16.00	5	8/25/1999	2	6	5	45	5	0.23
GR 268	18.00	6	9/16/1997	2	6	7	28	9	0.32
GR 282	12.00	6	8/18/2003	2	6	0	19	10	0
GR 297	15.00	6	9/5/2000	2	6	0			0
GR 307	15.00	3	11/12/2000	1	6	4	25	9	0.14
GR 319	14.00	5	10/11/2001	1	3	0	18	10	0
HA 480	18.00	8	7/8/1997	2	6	0	18	10	0
HA 508	13.00	10	5/25/2002	2		2	28	9	0.11
HA 616	17.00	1	2/25/1999	1	4	3	26	10	0.14
HA 638	13.00	7	8/27/2002	1	6	0	24	10	0
HA 639	10.00	7	8/3/2005	1	6	0	26	10	0
HA 652	11.00	1	1/7/2005	1	6	5	24	10	0.14
HA 651	13.00	3	11/15/2002	2	6	0	29	10	0
HA 656	17.00	11	4/15/1998	1	6	1	18	9	0.05
HA 657	16.00	6	9/1/1999	1	6	1	21	10	0.05
HA 610	16.00	1	1/9/2000	2	6	2	23	8	0.05
HE 177	16.00	0	1/30/2000	1	6	0	18	10	0
HE 201	11.00	6	7/24/2004	1	6	0	18	10	0
HE 202	15.00	0	3/28/2001	1	6	0	18	10	0
HI 130	9.00	10	5/15/2006	1	6	0	18	10	0

HO 326	11.00	2	1/7/2005	1	6	0	18	10	0
HU 123	14.00	7	6/22/2000	2	6	3	31	5	0.14
HU 147	15.00	9	6/6/2000	2	6	1	18	10	0.05
HU 180	18.00	11	4/16/1997	1	6	1	18	10	0.05
HY 5	16.00	10	5/18/1999	2	6	2	32	8	0.09
HY 6	14.00	5	10/9/2001	1	6	2	23	9	0.09
IA 7	15.00	0	4/4/2001	2	6	0	18	10	0
IB 3	16.00	11	4/19/1999	2	7	4	44	9	0.21
JA 194	14.00	8	8/5/2001	1	6	8	44	9	0.36
JI 15	13.00	2	11/25/2002	2	2	0	18	10	0
JO 280	14.00	7	7/8/2001	2	6	0	25	9	0
JO 321	15.00	5	9/1/2000	2	6	3	36	9	0.14
JO 322	13.00	0	1/21/2003	2	6	5	34	9	0.15
JO 277	14.00	7	7/8/2001	1		0	25	9	0
JO 345	16.00	7	8/29/1999	2	6	4	28	8	0.2
JO 366	15.00	11	4/12/2000	2	6	1	24	9	0.05
KA 163	12.00	11	3/16/2003	1	6	1	18	9	0.05
KA 207	13.00	6	8/3/2002	2	6	0	18	10	0
KA 212	16.00	9	5/6/1999	1		1			0.05
KE 96	16.00	7	6/1/1999	2	6	1	21	10	0.05
KE 157	13.00	11	5/1/2002	2	6	1	20	9	0.05
KE 164	12.00	8	7/19/2003	1	6	2	36	9	0.05
KL 54	16.00	1	3/16/2000	1	6	6	23	9	0.23
KL 59	14.00	5	8/27/2001	2		0	18	10	0
KN 35	10.00	1	4/1/2005	1	6	0	18	10	0
KN 22	16.00	3	11/5/1999	2	6	1	20	10	0.05
KO 186	14.00	4	10/9/2001	1	6	0	20	9	0
KA 192	15.00	3	11/9/2000	1	6	10			0.45
KA 198	16.00	2	2/6/2000	2	6	0	18	10	0
KO 166	15.00	9	5/4/2000	2		4	23	9	0.14
KO 170	16.00	2	1/20/2000	1	6	0	26	10	0
KO 177	14.00	9	6/26/2001	1	6				
KO 191	9.00	3	12/16/2006	1	6	1	19	9	0.05
KR 96	17.00	2	1/24/1999	2	6	0	18	10	0
KR 97	12.00	6	8/9/2003	2	6	9	51	7	0.4
KR 100	15.00	2	1/21/2001	2	6	0	20	10	0
KU 55	14.00	10	6/7/2001	2	6	1	27	9	0.05
KU 58	16.00	10	5/19/1999	1	6	0	18	10	0
LA 156	16.00	1	2/18/2000	1	6	2	24	9	0.09

LA 174	13.00	11	4/12/2002	1	6	5	21	9	0.23
LA 209	16.00	0	4/25/2000	1	6	0	32	9	0
LA 208	18.00	9	6/19/1997	1	7	6	18	9	0.27
LA 215	15.00	11	4/25/2000	1	6	0	32	9	0
LA 216	14.00	8	7/13/2001	1	7	3	18	9	0.14
LE 228	14.00	6	8/16/2001	1	6	1	32	8	0.05
LE 161	14.00	4	9/18/2001	2	2	1	25	8	0
LE 173	15.00	7	9/9/2000	2	3	5	30	9	0.23
LE 226	15.00	11	4/15/2000	2	6	1	20	10	0.05
LI 111	16.00	5	8/21/1999	2	6	6	43	8	0.3
LI 26	13.00	4	10/9/2002	1	6	7	30	8	0.33
LO 143	11.00	5	10/5/2004	1	6	6	43	9	0.27
LO 149	13.00	9	5/14/2002	2	6	3	25	10	0.14
MA 456	14.00	11	4/26/2001	1	6	0	21		0
MA 503	15.00	8	5/21/2000	1	6	2	22	9	0.11
MA 531	18.00	4	9/19/1997	1	6	2	19	10	0.09
MA 532	17.00	1	1/7/1999	2	6	1	18	10	0.05
MA 533	15.00	4	10/3/2000	1		0	18	10	0
MA 554	14.00	5	9/5/2001	1	6	0	21	9	0
MA 572	13.00	3	11/8/2002	1		1	18	10	0.05
MA 573	11.00	7	7/7/2004	2	6	7	28	8	0.27
MA 574	13.00	3	11/8/2002	2	6	1	18	10	0.05
MA 578	13.00	7	6/25/2002	1	6	3	24	9	0.14
MA 587	10.00	7	8/23/2005	1	6	1	23	10	0
MA 594	9.00	1	2/13/2007	2	6	2	32	10	0.09
MC 238	16.00	7	8/25/1999	1	6	0	18	10	0
MC 284	9.00	5	9/4/2006	1	6	16	66	7	0.77
MC 290	14.00	8	7/23/2001	2	6	9	58	5	0.38
MC 296	14.00	2	2/2/2002	2	6	2	23	9	0.09
MC 298	9.00	3	12/22/2006	2	6	8	38	9	0.36
MC 307	12.00	5	11/16/2003	1	6	1	21	10	0.05
ME 166	15.00	8	5/26/2000	1	6	11	55	9	0.5
ME 175	13.00	8	5/27/2002	1		0	20	8	0
ME 174	16.00	1	3/22/1999	2	4	2	26	8	0.09
ME 139	16.00	7	7/9/1999	2		3	20	8	0.14
ME 171	12.00	9	6/6/2003	2	6	0	18	9	0
MI 206	15.00	0	3/3/2001	1	6	3	18	8	0.14
MI 274	13.00	4	9/21/2002	1	4	0	0	9	0
MI 308	13.00	0	3/12/2003	2	6	0	18	8	0

MO 263	15.00	1	1/7/2001	1	6	0	24	9	0
MO 296	17.00	4	10/1/1998	1	2	0	18	10	0
MO 328	13.00	1	5/22/2002	2	6	0	18	10	0
MU 119	15.00	10	5/29/2000	1	6	8	51	7	0.54
MY 29	12.00	10	5/10/2003	1	6	0	18	10	0
NA 87	13.00	10	5/5/2002	1	6	0	18	10	0
NI 65	14.00	7	7/3/2001	2		0	21	10	0
MY 29	12.00	9	5/10/2003	1	6	0	20	10	0
NA 89	13.00	5	8/24/2002	2	3	1	20	10	0.05
NA 88	13.00	5	8/24/2002	2	3	2	24	10	0.11
NE 110	15.00	1	2/11/2001	1	6	2			0.11
NE 113	16.00	0	3/11/2000	1	4	5	38	9	0.14
NI 59	13.00	3	12/24/2002	1	6	1	20	9	0
NI 64	12.00	2	1/24/2004	2	6	8	38	9	0.33
NI 75	17.00	5	10/17/1998	1	6	3	27	9	0.15
NI 76	8.00	10	5/24/2007	1	6	1	24	9	0
OB 25	16.00	0	1/29/2000	1	6	0	20	7	0
OB 26	13.00	5	7/19/2002	2	6	2	27	7	0.09
OL 32	16.00	6	8/2/1999	2	4	3	38	7	0.05
OL 37	14.00	6	9/8/2001	2	6	0	19	10	0
OR 37	16.00	2	1/20/2000	2	4	3	27	10	0.14
OR 44	13.00	9	6/5/2002	2	4	0	22	10	0
OS 31	16.00	3	12/29/1999	2	6	4	33	10	0.18
OS 35	13.00	0	3/18/2003	1	6	1	23	9	0.05
OW 24	14.00	8	9/2/2001	2	3	6	33	8	0.27
OW 28	14.00	6	9/2/2001	2	3	6	33	8	0.27
PA 315	13.00	7	7/17/2002	1	6	1	18	8	0.05
PA 201	13.00	9	5/5/2002	2	6	0	19	10	0
PA 225	13.00	2	12/31/2002	1	6	0	18	10	0
PO 164	12.00	11	4/9/2003	1	3	1	26	10	0.05
PO 184	15.00	1	4/15/2000	2	6	11	49	4	0.5
PO 187	12.00	5	8/19/2003	1	6	0	18	8	0
PO188	15.00	8	7/12/2000	2	6	0	18	10	0
PR 116	14.00	7	7/12/2001	2	6	2	18	7	0.09
PU 29	15.00	7	7/14/2000	2	6	0	23	10	0
PU 35	16.00	1	1/30/2000	2	6	2	33	7	0.1
RA 120	14.00	4	10/13/2001	2	6	0	24	9	0
RE 138	17.00	9	5/8/1998	2	4	0	28	9	0
RE 149	16.00	1	4/6/1999	2	6	1	18	10	0

RE 167	14.00	1	1/9/2000	2	6	5	36	5	0.27
RE 174	15.00	5	10/7/2000	2	6	1	18	10	0.05
RE 179	14.00	8	8/12/2001	2	6	0	18	9	0
RE 180	13.00	6	9/27/2001	1	6	0	18	10	0
RI 208	15.00	8	5/31/2000	1	6	2	20	9	0.14
RI 206	8.00	9	5/13/2007	2	6	7	19	9	0.18
RO 319	16.00	10	5/9/1999	1	6	0	21	8	0
RO 367	13.00	2	12/12/2002	2	6	1	24	10	0.05
RO 380	15.00	7	7/6/2000	1	6	0	22	9	0
RO 389	11.00	6	9/9/2004	2	6	4	24	10	0.18
RO 300	13.00	0	1/20/2003	1	7	1	23	10	0.05
RO 350	15.00	5	11/1/2000	1		0	21	10	0
RO 354	17.00	1	4/17/1998	1	6	0	18	10	0
RO 391	13.00	3	12/22/2002	1	3	0	18	10	0
RO 396	12.00	0	3/19/2004	2	6	0	31	9	0
RO 397	10.00	6	9/21/2005	2	6	4	30	9	0.18
RO 407	13.00	3	5/15/2002	2	6	0	18	10	0
SA 224	8.00	11	4/2/2007	2	6	0	24	10	0
SH 205	13.00	11	2/23/2002	1	6	1	18	10	0.05
SC 229	15.00	9	6/1/2000	2	6	0	25	9	0
SC 255	12.00	7	6/29/2003	1	6	0	18	9	0
SC 257	14.00	4	11/13/2001	1	6	0	27	9	0
SC 259	16.00	2	1/22/2000	1	6	0	18	10	0
SC 263	12.00	10	6/4/2003	1	6	0	18	10	0
SC 270	13.00	9	5/11/2002	1	6	1	24	10	0.05
SC 193	15.00	6	7/30/2000	1	6	0			0
SE 110	17.00	7	9/3/1998	1	6	0	19	10	0
SH 230	16.00	1	3/28/1999	1	7	0	18	9	0
SH 211	14.00	8	6/10/2001	1		1	32	8	0.05
SH 231	12.00	8	7/13/2003	2	6	0	18	10	0
SI 160	13.00	3	12/2/2002	2	7	0	21	9	0
SI 126	17.00	7	6/29/1998	1	6	0	18	9	0
SO 63	13.00	9	6/6/2002	1	6	1	21	10	0.05
SO 99	10.00	4	11/9/2005	2		0	18	10	0
SP 77	13.00	11	3/1/2002	2	6	0	21	10	0
SP 111	12.00	7	8/8/2003	2	6	2	20	9	0.09
ST 274	18.00	9	6/5/1997	2	6	0	18	9	0
ST 299	17.00	9	7/6/1998	1	6	3	20	9	0.14
ST 352	14.00	3	10/31/2001	2	6	0			0

ST 305	15.00	8	5/20/2000	1	6	0	18	10	0
ST 351	14.00	3	10/2/2001	2	6	6	30	7	0.23
ST 347	17.00	2	11/28/1998	1	6	0	18	9	0
ST 348	15.00	5	9/14/2000	1	6	2	18	10	0.1
ST 358	14.00	6	9/27/2001	1	6	2	22	8	0.09
ST 360	16.00	6	7/25/2002	1	6	2	26	10	0.09
ST 367	14.00	3	12/18/2001	2	6	1	18	10	0
ST 372	11.00	7	8/26/2004	1	6	3	27	8	0.14
ST 292	15.00	2	12/25/2000	1	6	4	34	8	0.2
SW 49	17.00	4	11/17/1998	2	6	3	36	9	0.14
SW 55	15.00	2	1/23/2001	2	6	1	35	9	0.05
SW 63	12.00	11	3/13/2003	1	6	0	18	10	0
SZ 24	16.00	4	10/8/1999	2	6	8	43	9	0.33
TA 172	15.00	6	8/7/2000	2	2	0			0
TO 121	11.00	1	11/6/2001	1	4	12	59	8	0.55
TU 94	147.00	9	6/26/2001	1	6	0	18	9	0
VE 61	13.00	0	1/25/2003	2	6	2	27	10	0.09
VI 57	8.00	9	6/24/2007	2	6	0	18	10	0
YO 67	16.00	0	2/6/2000	1		4	26	10	0.18
WA 309	15.00	8	6/1/2000	2	6	3	22	10	0.14
WA 280	15.00	7	8/3/2000	1	2	0	18	10	0
WA 289	14.00	5	9/8/2001	1	6	4	33	8	0.18
WA 310	14.00	8	7/23/2001	1	6	3	34	9	0.14
WA 321	13.00	8	6/2/2002	1	3	2	31	9	0.09
WA 332	10.00	8	8/3/2005	2	3	6	45	3	0.27
WE 217	15.00	10	5/22/2000	2	6	4	18	10	0
WE 232	11.00	10	5/29/2004	2	6	0	20	10	0
WI 374	17.00	8	7/22/1998	2	6	6	25	10	0.18
WI 375	16.00	4	12/2/1999	2	6	7	22	10	0.27
WI 410	16.00	8	6/17/1999	1	6	9	48	8	0.32
WI 362	15.00	1	1/15/2001	1		0	18	10	0
WI 416	15.00	7	8/5/2000	1	6	3	25	9	0.14
WI 452	13.00	1	1/13/2003	2		0			0
ZA 41	16.00	6	9/25/1999	1	6	0	25	9	0
ZA 59	13.00	10	5/23/2002	1	6	1	50	7	0.05
ZE31	14.00	7	8/22/2001	2	6	0	20	10	0

Test-retest reliability for high risk patients

patient ID	PSQ SCREENING SCORE	risk	OSA-18 Score	OSA-18 parent score	PSQ	risk	OSA-18	OSA-18 parent
BA 352	1	0.05	18	10	2	0.09	18	9
BA 354	0	0	18	10	3	0.14	27	5
BA 356	1	0.05	31	8	1	0.05	27	9
BO 210	5	0.23	35	8	0	0	18	10
BU 196	8	0.36	31	8	8	0.36	31	8
CO 409	0	0	26	10	3	0.14	23	9
CR 127	3	0.14	25	8	1	0.05	25	8
FA 73	9	0.40	42	9	9	0.4	42	7
FL 76	0	0	18	10	0	0	18	10
HA 651	0	0	29	10	2	0.09	25	9
LI 26	7	0.33	30	8	7	0.33	32	8
LI 111	6	0.30	43	8	2	0.1	19	10
MA 554	0	0	21	9	0	0	21	9
MO 263	0	0	24	9	2	0.09	24	9
MY 29	0	0	20	10	0	0	18	10
OB 25	0	0	20	7	0	0	18	10
OB 26	2	0.09	27	7	0	0	23	10
RI 208	2	0.14	20	9	0	0	26	8