

Clinical Review

Sleep in children with attention-deficit hyperactivity disorder (ADHD): a review of naturalistic and stimulant intervention studies

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Abstract

Attention-Deficit Hyperactivity Disorder (ADHD) is the most common behavioral disorder of childhood. Multiple clinical and research reports suggest extensive sleep disturbances in children with ADHD, however, current data is contradictory. This paper reviewed 47 research studies (13 stimulant intervention and 34 naturalistic) on ADHD that were published since 1980. The main objectives of this review were to provide pediatric clinicians and researchers a clear and concise summary of published sleep data in children with ADHD, to provide a more accurate description of the current knowledge of the relationship between sleep and ADHD, and to provide current information on the effect of stimulant medication on sleep. Twenty-five of the reviewed studies used subjective reports of sleep, six were actigraphic studies, and 16 were overnight polysomnographic sleep studies (two of which also included Multiple Sleep Latency Tests). All participants were between the age of 3 and 19, and 60% were male. The results indicate high rates of parental reports of sleep disturbances in medicated and unmedicated children with ADHD, however, the majority of these findings have not been confirmed by objective sleep data. Although, agreement among objective studies is not absolute, the data suggest increased nighttime activity, reduced rapid eye movement sleep, and significant daytime somnolence in unmedicated children with ADHD when compared to controls. Data also suggest a possible increased prevalence of periodic limb movements in sleep in children with ADHD, however, little differences in sleep-disordered breathing. The limited number of studies, small and heterogeneous samples, and other methodological limitations make definite results difficult to determine. Future research will need to further clarify the relationship between sleep and ADHD and the effects of stimulants on sleep of children with ADHD.

Keywords: Sleep; Children; Attention-deficit hyperactivity disorder; ADHD; Stimulants; Review; Alertness

Original article

Attention-deficit/hyperactivity disorder with obstructive sleep apnea: A treatment outcome study

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Abstract

Background

Children diagnosed with attention-deficit/hyperactivity disorder (ADHD), based on Diagnostic and Statistical Manual of Mental Disorders, Fourth edition (DSM-IV) criteria, may also have obstructive sleep apnea (OSA), but it is unclear whether treating OSA has similar results as methylphenidate (MPH), a commonly used treatment for ADHD.

Methods

This study enrolled 66 school-age children, referred for and diagnosed with ADHD, and 20 healthy controls. Polysomnography (PSG) performed after ADHD diagnosis showed the presence of mild OSA. After otolaryngological evaluation, parents and referring physicians of the children could select treatment of ADHD with MPH, treatment of OSA with adenotonsillectomy or no treatment. Systematic follow-up was performed six months after initiation of treatment, or diagnosis if no treatment. All children had pre- and post-clinical interviews; pediatric, neurologic, psychiatric and neurocognitive evaluation; PSG; ADHD rating scale, child behavior checklist (CBCL) filled out by parents and teacher; test of variables of

attention (TOVA); and the quality of life in children with obstructive sleep disorder questionnaire (OSA-18).

Results

ADHD children had an apnea-hypopnea index (AHI) $> 1 < 5$ event/hour; 27 were treated with MPH, 25 had adenotonsillectomy, and 14 had no treatment. The surgical and MPH groups improved more than the non-treatment group. When comparing MPH to post-surgery, the PSG and questionnaire sleep variables, some daytime symptoms (including attention span) and TOVA subscales (impulse control, response time and total ADHD score) improved more in the surgical group than the MPH group. The surgical group had an ADHD total score of 21.16 ± 7.13 on the ADHD rating scale (ADHD-RS) post-surgery compared to 31.52 ± 7.01 pre-surgery ($p = 0.0001$), and the inattention and hyperactivity subscales were also significantly lower ($p = 0.0001$). Finally, the results were significantly different between surgically and MPH-treated groups (ADHD-RS $p = 0.007$). The surgical group also had a TOVA ADHD score lower than -1.8 and close to those obtained in normal controls.

Conclusion

A low AHI score of > 1 considered abnormal is detrimental to children with ADHD. Recognition and surgical treatment of underlying mild sleep-disordered breathing (SDB) in children with ADHD may prevent unnecessary long-term MPH usage and the potential side effects associated with drug intake.

Keywords: Attention-deficit/hyperactivity disorder; Methylphenidate; Adenotonsillectomy; Obstructive sleep apnea; Polysomnography; Outcome

[Sleep Medicine](#)

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Original Article

Subjective and objective measures of sleep in children with attention-deficit/hyperactivity disorder

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Abstract

Objective

To compare objective and subjective measures of sleep in children with attention-deficit/hyperactivity disorder (ADHD) and healthy control subjects.

Methods

Included were 107 unmedicated children with ADHD and 46 healthy control subjects, all aged 6–14. Sleep–wake patterns were monitored with actigraphy for at least five consecutive days. Subjects and parents completed daily electronic diaries assessing sleep and daytime behavior.

Results

Actigraphy data from 80 ADHD patients and 45 control subjects showed that, compared to the healthy control group, the ADHD group experienced shorter actual sleep time (defined as time in minutes [from sleep onset to final morning awakening] of all epochs scored as sleep [i.e., excluding total duration of all epochs scored as “wake”]) (489.39 vs. 460.30 min, $p = .001$), significantly fewer sleep interruptions (44.45 vs. 35.33, $p < .001$), but more total interrupted sleep time (44.49 vs. 56.70 min, $p = .002$). Child diaries indicated children with ADHD had significantly more daytime sleepiness and difficulty getting up and less refreshing sleep. Parent diaries indicated children with ADHD had significantly more behavioral difficulties than the control group.

Conclusions

Results suggest children with ADHD have reduced sleep quantity and more disturbed sleep on actigraphic measures, reduced sleep quality on the self report, and more problematic behaviors on the parent report. Clinical interventions for children with ADHD who present with sleep problems should include screening for etiologic and exacerbating factors, institution of behavioral-management strategies, and consideration of pharmacologic treatment targeted toward evening ADHD symptoms.

Keywords: Children; ADHD; Actigraphy; Behavior; Sleep patterns; Sleep problems

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Neurobehavioral implications of habitual snoring in children.

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OBJECTIVE: Current guidelines for the treatment of children with obstructive sleep apnea (OSA) suggest that primary snoring (PS) in children is benign. However, PS has not been well evaluated, and it is unknown whether PS is associated with serious morbidity. This study investigated whether PS is associated with neurobehavioral deficits in children.

METHODS: Parents of 5- to 7-year-old snoring children in public schools were surveyed about their child's sleeping habits. Children with a history of snoring and nonsnoring children were invited for overnight polysomnographic assessment and a battery of neurobehavioral tests. Only children who did not have a history of attention deficit/hyperactivity disorder and were not considered hyperactive by parental report were tested.

RESULTS: Children with a history of snoring, an obstructive apnea index of <1 /hour of total sleep time (hrTST), an apnea/hypopnea index <5 /hrTST, and no gas exchange abnormalities were classified as PS ($n = 87$). Control subjects were defined as children without a history of snoring, an obstructive apnea index <1 /hrTST, an apnea/hypopnea index <5 /hrTST, and no gas exchange abnormalities ($n = 31$). Although means for both groups were in the normal range, the PS children were found to perform worse on measures related to attention, social problems, and anxious/depressive symptoms. In addition, although within the normal range, both overall cognitive abilities and certain language and visuospatial functions were significantly lower for the PS group than for the control subjects.

CONCLUSIONS: PS seems to be associated with significant neurobehavioral deficits in a subset of children, possibly related to increased susceptibility to sleep fragmentation. Larger studies are urgently required because current guidelines for treatment of snoring in children may require reevaluation.

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PEDIATRICS®

Sleep and Neurobehavioral Characteristics of 5- to 7-Year-Old Children With Parentally Reported Symptoms of Attention-Deficit/Hyperactivity Disorder

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Abstract

Objectives. This study examined the hypothesis that domains of neurobehavioral function would be selectively affected by sleep-disordered breathing (SDB). Therefore, we assessed potential relationships between objectively measured sleep disturbances and neurobehavioral function in children with reported symptoms of attention-deficit/hyperactivity disorder (ADHD) and also determined the incidence of snoring and other sleep problems in 5- to 7-year-old children in the local community and potential relationships to parental snoring and passive smoking.

Methods. Parents of 5- to 7-year-old children in public schools were surveyed about their child's sleeping habits using a validated questionnaire. The questionnaire also asked whether they believed their child to be hyperactive or have ADHD. Children with reported symptoms of ADHD and control children were randomly selected and invited to the Sleep Medicine Center for an overnight polysomnographic assessment and a battery of neurocognitive tests.

Results. The questionnaire response rate was 47.6% ($n = 5728$). Frequent and loud snoring was reported for 673 children (11.7%). Similarly, 418 (7.3%) children were reported to have hyperactivity/ADHD, 313 (76.5%) of which were boys. Eighty-three children with parentally reported symptoms of ADHD were invited for full evaluation at the Sleep Medicine Center together with 34 control children. After assessment with the Conners' Parent Rating Scale, 44 children were designated as having "significant" symptoms of ADHD, 27 as "mild," and 39 designated as "none" (controls). Overnight polysomnography indicated that obstructive sleep apnea was present in 5% of those with significant ADHD symptoms, 26% of those with mild symptoms, and 5% of those with no symptoms. In the cohort, no sleep variable accounted for more than a negligible proportion of the variance in domains of neurobehavioral function.

Conclusions. An unusually high prevalence of snoring was identified among a group of children designated as showing mild symptoms of ADHD based on the Conners' ADHD index identified from a community sample. However, whereas SDB is not more likely to occur among children with significant ADHD symptoms, it is significantly highly prevalent among children with mild hyperactive behaviors. Sleep studies further revealed that rapid eye movement disturbances are more likely to occur in children with significant symptoms, and they seem to impose significant but mild effects on daytime neurobehavioral functioning. We conclude that in children with significant symptoms of ADHD, the prevalence of SDB is not different from that of the general pediatric population and that rapid eye movement sleep in these children is

disturbed and may contribute to the severity of their behavioral manifestations. Furthermore, SDB can lead to mild ADHD-like behaviors that can be readily misperceived and potentially delay the diagnosis and appropriate treatment.

Key Words:

- [snoring](#)
 - [obstructive sleep apnea](#)
 - [periodic leg movement disorder of sleep](#)
 - [ADHD](#)
 - [cognitive function](#)
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Sleep disorders in children with Attention-Deficit/Hyperactivity Disorder (ADHD) recorded overnight by video-polysomnography

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Abstract

Objective

To outline specific sleep disturbances in different clinical subsets of Attention Deficit/Hyperactivity Disorder (ADHD) and to confirm, by means of nocturnal video-polysomnography (video-PSG), a variety of sleep disorders in ADHD besides the classically described periodic leg movement disorder (PLMD), restless legs syndrome (RLS) and sleep related breathing disorder (SRBD).

Methods

Fifty-five ADHD children (47 M, 8F; mean age = 8.9y) were included: 16 had Inattentive and 39 Hyperactive/Impulsive or Combined ADHD subtype. Behavior assessment by Conners and SNAP-IV Scales, a structured sleep interview and a nocturnal video-PSG were administered.

Results

Most children/parents reported disturbed, fragmentary sleep at night; complaints were motor restlessness (50%), sleep walking (47.6%), night terrors (38%), confusional arousals (28.5%), snoring (21.4%), and leg discomfort at night associated with RLS (11.9%). There is a significant difference (p value <0.05 or <0.001) in almost all the studied sleep variables between ADHD children and controls. International RLS Rating Scale scoring, Periodic Limb Movements during Sleep (PLMS) and Wake (PLMW) indexes, hyperactivity and opposition scores and ADHD subtype appear related. Different sleep disorders seem to address specific ADHD phenotypes and correlate with severity of symptoms as in sleep related movement disorders occurring in Hyperactive/Impulsive and Combined ADHD subtypes. Besides, an abnormality of the arousal process in slow wave sleep with consequent abnormal prevalence of disorders of arousal possibly enhanced by SRBD has also been detected in 52% of our sample.

Conclusions

This study underlines the opportunity to propose and promote the inclusion of sleep studies, possibly by video-PSG, as part of the diagnostic screening for ADHD. This strategy could address the diagnosis and treatment of different specific ADHD phenotypic expressions that might be relevant to children's symptoms and contribute to ADHD severity.

Keywords: Sleep disorders; ADHD; Children; Video-polysomnography; Restless legs syndrome (RLS); Disorders of arousal (DOA)

Adenotonsillectomy and Neurocognitive Deficits in Children with Sleep Disordered Breathing

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Abstract

Background

Sleep Disordered Breathing (SDB) is a common childhood disorder that encompasses a range of sleep-related upper airway obstruction. Children with SDB demonstrate significant neurocognitive deficits. Adenotonsillectomy is the first line of treatment for SDB and whilst this improves respiratory disturbance, it remains to be established whether neurocognitive gains also result.

Methods

A total of 44 healthy snoring children aged 3–12 years awaiting adenotonsillectomy (SDB group), and 48 age and gender matched non-snoring controls from the general community, completed the study. All children underwent polysomnography and neurocognitive assessment at baseline and after a 6-month follow-up (after surgery in the snoring group). Our primary aim was to determine whether neurocognitive deficits in snoring children were significantly improved following adenotonsillectomy.

Results

Wide ranging neurocognitive deficits were found at baseline in SDB children compared to controls, most notably a 10 point IQ difference ($P < .001$) and similar deficits in language and executive function. Whilst adenotonsillectomy improved respiratory parameters and snoring frequency at 6 months post surgery, neurocognitive performance did not improve relative to controls.

Conclusion

Adenotonsillectomy successfully treated the respiratory effects of SDB in children. However, neurocognitive deficits did not improve 6-months post-operatively.

Systematic Review of the Literature

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Sleep and Alertness in ADHD Children—Cortese et al

Disclosure Statement

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Study Objective: To review evidence on sleep and alertness in children with attention-deficit/hyperactivity disorder (ADHD) controlling for potential confounding factors.

Methods: A PubMed search. Studies using ADHD diagnostic criteria other than DSM-III-R or IV and studies not excluding or controlling for psychiatric comorbidity or medication status were not included in the review.

Results from objective studies were combined using meta-analysis.

Results: From the 46 studies located, 13 were retained. With regard to objective studies, the proportion of subjects who fell asleep during the Multiple Sleep Latency Test, the number of movements in sleep, and the apnea-hypopnea index were significantly higher in children with ADHD than in controls. We found no significant differences in other objective parameters (sleep-onset latency; number of stage changes; percentages of stage 1 sleep, stage 2 sleep, slow-wave sleep, or rapid eye movement sleep; rapid eye movement sleep latency; and sleep efficiency). Limited evidence from subjective studies suggests no significant differences in sleep-onset difficulties and bedtime resistance between children with ADHD and controls, after controlling for comorbidity and medication status. Data on sleep duration, night and morning awakenings, and parasomnias are still very limited.

Conclusion: Results from our systematic review suggest that children with ADHD have higher daytime sleepiness, more movements in sleep, and higher apnea-hypopnea indexes compared with controls. Given the limited number of studies controlling for confounding factors, further subjective and objective studies are needed to better understand alterations in sleep and alertness in children with ADHD.

Keywords: Sleep, alertness, ADHD, children, adolescents, meta-analysis

Citation: Cortese S; Konofal E; Yateman N et al. Sleep and alertness in

children with attention-deficit/hyperactivity disorder: a systematic review of the literature. *SLEEP* 2006;29(4): 504-511.

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Snoring and obstructive sleep apnoea in children: Why should we treat?

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Abstract

Frequent and loud snoring is a very frequent condition in prepubertal children affecting approximately 10% of all 2–8 year old children. If polysomnographical evaluations are performed in these snoring children, approximately $\frac{1}{3}$ will be diagnosed with obstructive sleep apnoea (OSA). The pathophysiology of OSA in children is still poorly understood. Indeed, while adenotonsillar hypertrophy is certainly a major contributor to OSA, other factors need to be implicated for OSA to develop. In recent years, it has become apparent that OSA and snoring are not as innocuous as previously thought. Indeed, epidemiological and pre-post treatment analyses have identified substantial morbidities that primarily affect cardiovascular and neurobehavioural systems, namely pulmonary hypertension, systemic elevation of arterial blood pressure, nocturnal enuresis, reduced somatic growth, behavioural problems that resemble attention deficit-hyperactivity disorder, as well as learning and cognitive deficits. These problems are associated with marked increases in healthcare-related costs. More importantly, if timely diagnosis and intervention are not implemented, some of these morbid complications may not be completely reversible, leading to long-lasting residual consequences.

Keywords: obstructive sleep apnoea; hyperactivity; snoring; learning; behaviour; neurocognitive; blood pressure; baroreceptor function; autonomic nervous system

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Pediatric Obstructive Sleep Apnea

Complications, Management, and Long-term Outcomes

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ABSTRACT

Obstructive sleep apnea (OSA) in children has emerged not only as a relatively prevalent condition but also as a disease that imposes a large array of morbidities, some of which may have long-term implications, well into adulthood. The major consequences of pediatric OSA involve neurobehavioral, cardiovascular, and endocrine and metabolic systems. The underlying pathophysiological mechanisms of OSA-induced end-organ injury are now being unraveled, and clearly involve oxidative and inflammatory pathways. However, the roles of individual susceptibility (as dictated by single-nucleotide polymorphisms), and of environmental and lifestyle conditions (such as diet, physical, and intellectual activity), may account for a substantial component of the variance in phenotype. Moreover, the clinical prototypic pediatric patient of the early 1990s has been insidiously replaced by a different phenotypic presentation that strikingly resembles that of adults afflicted by the disease. As such, analogous to diabetes, the terms type I and type II pediatric OSA have been proposed. The different manifestations of these two entities and their clinical course and approaches to management are reviewed.

Key Words: obstructive sleep apnea • adenotonsillar hypertrophy • treatment • inflammation, upper airway • snoring

Habitual snoring during sleep, the hallmark indicator of increased upper airway resistance, is an extremely frequent occurrence during childhood, with a median incidence of about 10% among preschool and school-aged children ([1–9](#)), with subsequent declines in frequency after 9 years of age ([10](#)). The exact polysomnographic criteria that differentiate between innocent snoring (i.e., habitual snoring that does not lead to gas exchange abnormalities, sleep disruption, and/or to any morbid consequences), and snoring that is associated with adverse consequences, have yet to be defined. Nevertheless, a consensus statement has been generated ([11](#)), and defines a set of empiric criteria, on the basis of which we currently estimate that of the many children with habitual snoring, approximately 2–3% will have clinically relevant disease ([12](#)). Therefore, the ratio between symptomatic habitual snoring and obstructive sleep apnea (OSA) is usually between 3:1 and 5:1.

Worthy of mention as well is the rather accelerated increase over the last two decades in the prevalence of pediatric obesity, which has led to substantial changes in the cross-sectional demographic and anthropometric characteristics of the children being referred for evaluation of habitual snoring. Indeed, whereas less than 15% of all symptomatic habitually snoring children were obese (i.e., body mass index z score > 1.57) in the early 1990s, more than 50% fulfilled such criteria among all clinical referrals for suspected OSA in the last 2–3 years at our sleep center (University Sleep Center, University of Louisville, Louisville, KY) ([13](#)). Considering that obesity can clearly play a role in the pathophysiology of upper airway obstruction during sleep, it is likely that the ratio between habitual snorers and those with clinically relevant OSA among obese children will differ from that in nonobese children ([14](#)). On the basis of the relative contributions to the pathophysiology of OSA by adenotonsillar hypertrophy and increased fat deposits in the upper airway structures, we have proposed that two distinct types of OSA exist in children, namely one associated with marked lymphadenoid hypertrophy in the absence of

obesity (type I), and the other associated primarily with obesity and with milder upper airway lymphadenoid hyperplasia (type II) (15) (Table 1). In this context, it would also be tempting to include an additional pediatric category in the nomenclature of OSA (i.e., type III), which would address some of the unique presentation and outcome features of children with a variety of craniofacial and neuromuscular disorders (e.g., Crouzon and Apert syndromes, Pierre Robin sequence, Down syndrome, Goldenhar syndrome, achondroplasia, myelomeningocele, and cerebral palsy). However, the evidence to justify the addition of such categorical subtype is not as well developed, and therefore careful meta-analysis of all these conditions will be required to delineate the unique clinical features and differential consequences that would justify this additional subtype. We further suggest that these proposed changes in the classification of pediatric OSA into two subtypes (possibly even three in the near future) may also have implications regarding the frequency and severity of several of the morbid consequences that can develop in children affected with this condition. Therefore, as we review the topics of interest in the remainder of this article, we point out potential disparities in the morbidities and treatment outcomes associated with type I and type II pediatric OSA.

TABLE 1. COMMON FEATURES AND DIFFERENCES IN THE CLINICAL PRESENTATION OF PEDIATRIC OBSTRUCTIVE SLEEP APNEA TYPES I AND II

Symptoms and Findings Similarly Frequent in OSA Types I and II
Habitual snoring (at least 3 nights/wk)
Agitated sleep with frequent awakenings
Diaphoresis
Night terrors and nightmares
Bedwetting
Breathing pauses reported by parents
Nasal speech pattern and stuffy nose
Mouth breathing and limited nasal airflow
Frequent visits to primary care physician for respiratory-related symptoms

Retrognathia

Symptoms and Findings Relatively Specific to OSA Types I and II

Symptom/Finding	OSA Type I*	OSA Type II*
Excessive daytime sleepiness	+	++++
Weight gain	—	++
Hyperactive behavior	++++	— or +
Attention problems	++++	+++
Truncal/visceral obesity	— or +	+++
Enlarged neck circumference	— or +	+++
Enlarged tonsils/adenoids	++++	++
Recurrent otitis media/tympanostomy tube placement	+++	+
Depression and low self-esteem	+	+++
Shyness and social withdrawal	+	+++
Left ventricular hypertrophy	++	++++
Systemic hypertension/altered blood pressure regulation	+	++++
Insulin resistance	—	++++
Serum lipid abnormalities	+	++++
Elevated C-reactive protein	++	++++
Elevated liver enzymes	—	++

* —: absent; + to ++++: infrequent to very frequent.

CONSEQUENCES OF PEDIATRIC OSA

We have begun to understand that sleep disorders in general, and more particularly, sleep-disordered breathing, can lead to substantial morbidities affecting the central nervous system (CNS), the cardiovascular and metabolic systems, and somatic growth, ultimately leading to reduced quality of life. On the basis of a series of elegant studies using rodent models of OSA ([16–33](#)), it is highly plausible that many if not all of these end-organ consequences impart

common pathogenic mechanisms triggered by the interactions of intermittent hypoxia and hypercapnia, repeated intrathoracic pressure swings, and episodic arousal.

CONSEQUENCES OF SLEEP DISRUPTION IN CHILDREN

Although experimental sleep fragmentation and its impact on daytime functioning have not been adequately studied in children, significant relationships have been identified between the degree of sleep disturbance or reduction and the magnitude of behavioral changes ([3](#), [34–37](#)). Daytime hyperactivity and inattention are associated with restless sleep, and conversely improved sleep patterns lead to better behavior ([38](#), [39](#)). Acute sleep restriction for one night promoted inattentive behavior ([40](#)), and more extended sleep restriction for seven nights led to oppositional and inattentive behaviors in children ([41](#)).

However, although total sleep duration may certainly alter behavioral patterns, it has become increasingly apparent that disruption of the sleep process, rather than total amount of sleep, may be one of the key factors underlying the behavioral alterations that accompany pediatric sleep disorders. In other words, sleep fragmentation, such as found in pediatric OSA and in other sleep disorders such as periodic leg movement disorder of sleep, may indeed promote the occurrence of impaired daytime functioning ([42](#), [43](#); and *see below*).

NEUROBEHAVIORAL CONSEQUENCES

Behavioral and neurocognitive dysfunction as well as reduced scholastic achievements are now well-characterized morbidities of OSA in children ([34](#), [44–48](#)), and associations between OSA and hyperactivity and inattentive behaviors as well as cognitive deficits have been identified ([37](#), [49–53](#)). In addition, parentally reported daytime sleepiness, hyperactivity, and aggressive behaviors can also develop, albeit to a lesser extent in children who habitually snore but in the absence of OSA ([54–60](#)). The major intriguing component of the association between OSA and cognitive functioning lies in the observation that not all children with OSA actually manifest cognitive morbidities, suggesting that other factors may be playing a role in this process.

One of our initial observations suggested that increased body mass index (BMI) would translate into increased cognitive vulnerability to OSA ([60](#)). Our group is now conducting a more extensive population-based assessment of this assumption, and attempting to identify the potential role of inflammation in the *a priori* enhanced cognitive susceptibility of obese children to OSA. Although obesity could be a marker rather than a cause of low academic performance ([61–64](#)), it is important to emphasize that both obesity and OSA are systemic inflammatory diseases ([65–67](#)). Under such a conceptual framework ([67](#), [68](#)), we have shown in a community-based study of snoring and nonsnoring school-aged children that OSA in children increases C-reactive protein levels and if such increases occur the probability for decreased cognitive performance is markedly elevated compared with control children ([69](#)). Thus, when the magnitude of the systemic inflammatory response to OSA in children is assessed as the circulating morning levels of C-reactive protein, the latter emerges as a potential risk marker for OSA-induced cognitive deficits in children. As further evidence of genetically determined vulnerability, we reported on the potential role of an allelic variant of the gene encoding apolipoprotein E ([70](#)). Indeed, the presence of apolipoprotein ϵ 4 has been associated with

increased risk for Alzheimer's disease and atherosclerosis, and increased incidence of cardiovascular disease, as well as with obstructive sleep apnea in adults (71, 72). We found that apolipoprotein ε4 is more likely to be present not only among children with OSA, but also among those with OSA who displayed reductions in cognitive performance during administration of standardized neuropsychological test batteries (70). The association of apolipoprotein E polymorphisms with pediatric OSA has since been confirmed by another group of investigators (73). In addition, it will be important to incorporate pertinent information regarding environmental elements such as nutrition (e.g., breastfeeding [74], saturated fat and trans-fatty acid content of food intake [28]), recurrent exposure to respiratory viruses, passive or active exposure to cigarette smoking, level of physical activity, and intensity of intellectual activity, because all these can affect both the pathophysiological risk for OSA as well as modify the susceptibility to the consequences of OSA (67, 74). Unfortunately, most of this important information is not routinely collected during clinical assessment of pediatric patients referred for evaluation of habitual snoring. The potential interactions between disease severity and potential genetic and environmental determinants of susceptibility are shown in [Figure 1](#).

Click on image to view larger version.

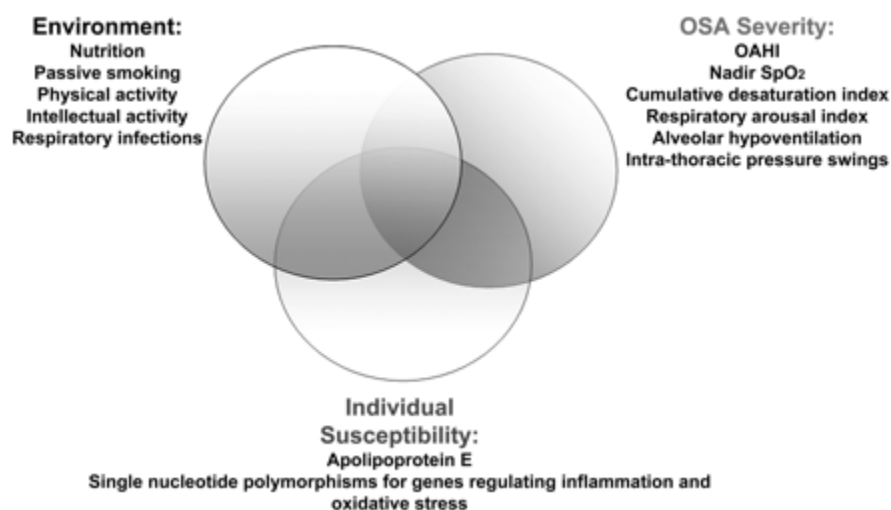


Figure 1. Potential interactions between pediatric obstructive sleep apnea (OSA), genetic factors, and environmental/lifestyle conditions in the pathophysiology of end-organ morbidity associated with the disease. OAHI = obstructive apnea–hypopnea index; SpO₂ = arterial oxygen saturation measured by pulse oximetry.

Notwithstanding these considerations, improved learning and behavior occur after effective treatment of children with type I OSA (45, 75–80), and such findings are therefore supportive of the putative partial to complete reversibility of the neurocognitive and behavioral deficits, provided treatment is administered in a timely fashion (81). However, no studies are available on the reversibility of such deficits on treatment in type II OSA, and we would propose that, based on the poorer outcomes pertaining to treatment (*see below*), the cognitive outcomes may similarly not be as favorable. Because

children with type II OSA are much more likely to present a phenotype resembling that usually seen in adults, the presence of obesity is highly likely, and as such, such overweight children will be more likely to display *a priori* significantly lower math and reading scores compared with nonoverweight children, and to be held back in grade ([61–63](#)), and therefore be increasingly susceptible to OSA.

In summary, both obesity and OSA may adversely affect cognitive functioning in children. Coincidence of these two conditions in the same patient, as would be anticipated in type II pediatric OSA, would be expected to promote and exacerbate the severity of the systemic inflammatory response separately elicited by each of these diseases, and further supports the legitimacy of the novel proposed taxonomy of pediatric OSA ([15](#), [60](#)).

It should be emphasized that we are unaware of any studies that have examined whether the duration of OSA before treatment modifies the overall reversibility of the outcome after effective treatment. It would be tempting to speculate that the longer the duration of symptoms, the less likely that complete reversibility will occur. Similarly, the effect of age at which OSA develops could also modify the frequency and severity of the morbid consequences, as well as influence the degree of reversibility after treatment. Thus, it is imperative that studies incorporating such important considerations be designed to provide us with critical definitions of elements that are operative within specific windows of vulnerability to OSA during childhood.

The exact mechanisms by which OSA elicits such neural deficits remain relatively unresolved. Most likely, both the sleep fragmentation and episodic hypoxia that characterize OSA lead to alterations within the neurochemical substrate of the prefrontal cortex with resultant executive dysfunction ([82–84](#)), and may also elicit neuronal cell losses ([17](#), [85](#)).

EXCESSIVE DAYTIME SLEEPINESS

The prevalence of excessive daytime sleepiness (EDS) in children with OSA is somewhat unclear, and probably depends on the perceptions of caretakers because children are unlikely to verbalize such symptoms. Parental reports concerning children being evaluated for suspected OSA initially indicated that only a small minority of these children (7%) presented with symptoms compatible with EDS ([86](#)). However, in more recent years, questionnaires that include more specific questions on behaviors associated with EDS indicate that the frequency of EDS may be much higher, and revolve around the 40–50% range ([87](#)). When sleepiness is measured objectively, using the Multiple Sleep Latency Test, approximately 13–20% of children fulfilling the criteria for OSA displayed EDS ([59](#), [88](#)). Furthermore, the presence of obesity appeared to increase the likelihood of EDS ([88](#)). We would also propose that, allowing for a substantial degree of overlap, the manifestations of EDS may somewhat diverge in children with type I OSA when compared with children with type II OSA. In the prototypic type I OSA, both inattention and hyperactivity would constitute the primary behavioral correlates of EDS (i.e., low modified Epworth scores) ([59](#)), whereas in type II OSA, increased Epworth scores along with reports of tiredness and falling asleep in school, car travel, or while watching television would be frequently found. One of the major questions emanating from the aforementioned studies is whether polysomnographic measures can provide insights and identify increased risk for EDS in children with OSA. To this effect, we examined the magnitude of sleep fragmentation induced by OSA in both children and adults and differentiated between spontaneous arousals and respiratory-related

arousals in a large cohort of more than 600 children and more than 300 adults, and found that the relative proportion of spontaneous arousals was increasingly reduced as a function of the OSA severity–related increase in respiratory arousals ([89](#), [90](#)). These findings suggested that both children and adults will attempt to preserve sleep homeostasis by reducing the number of respiratory arousals and that when a certain obstructive apnea–hypopnea index is reached, sleep pressure will start accumulating, albeit at different apnea–hypopnea indexes (AHIs) for children and adults ([89](#)). Of note, the sleep pressure numerical score derived from the arousal indices correlated with both cognitive and behavioral disturbances occurring in snoring children ([91](#)). Using similar assumptions, Chervin and colleagues showed the presence of respiratory cycle-related electroencephalographic spectral changes in patients with OSA that correlate with EDS ([92](#)).

CARDIOVASCULAR CONSEQUENCES

Similar to adult OSA, pediatric OSA has been now associated with a higher risk for cardiovascular morbidities, albeit with reduced severity of these manifestations, most likely the corollary of the increased compensatory vascular capacitance in children. For example, increased prevalence of altered blood pressure regulation ([93](#)), systemic hypertension ([94–96](#)), and changes in left ventricular geometry ([97](#), [98](#)) have all now been reported in children with OSA, and appear to be dose dependent ([99](#)). The mechanisms mediating cardiac and blood pressure changes are most likely associated with the increases in sympathetic activity and reactivity that progressively develop in the context of OSA ([100](#), [101](#)). In addition, evidence supports the assumption of potential endothelial dysfunction in children with OSA, as evidenced by increases in circulating levels of several adhesion molecules ([102](#)). Parenthetically, the endothelial dysfunction associated with OSA is most likely the result of initiation and propagation of inflammatory responses within the microvasculature ([103](#)). C-reactive protein, which has been traditionally linked to increased risk for cardiovascular disease even if such assumptions have been challenged ([104](#), [105](#)), provides a good systemic marker for the presence of inflammation. In a series of studies, plasma concentrations of C-reactive protein were elevated in a severity-dependent fashion among children and adolescents with OSA, even after correction for body mass index ([106–108](#)). Only one study by Kaditis and colleagues failed to identify these relationships in a study of Greek children ([109](#)).

The intermittent hypoxia during sleep that occurs in children with OSA may induce elevations of pulmonary artery pressures, at least during sleep, and such events may lead to some degree of right ventricular dysfunction. However, the prevalence of pulmonary hypertension in pediatric OSA has not been systematically examined ([110](#), [111](#)), and as such, we still have not defined the main sleep-related determinants of such potential occurrence.

QUALITY OF LIFE AND DEPRESSION

The cumulative evidence indicates that both OSA and obesity lead to significant decreases in quality of life in a large proportion of children, particularly when both obesity and OSA coincide ([15](#), [112–117](#)). Furthermore, quality of life is improved after treatment of OSA ([112](#)). It is also likely that the sleep disturbance associated with OSA will increase fatigue and lead to increased irritability, depressed mood, impaired concentration, and decreased interest in daily activities,

and that these impairments in daily functioning may in turn interfere with other aspects of the child's life, including relationships with family, school, and peers ([117](#)).

INSULIN RESISTANCE, TYPE 2 DIABETES, AND METABOLIC SYNDROME

The term "metabolic syndrome" has been used to describe the clustering of insulin resistance, dyslipidemia, hypertension, and obesity. Consensus criteria for the metabolic syndrome have yet to be defined in the pediatric age range ([118](#)). However, the risk of metabolic syndrome was nearly 50% in severely obese young children, and this risk increased with every 0.5-unit increment in BMI, when expressed as z score ([119](#)). In addition, it has become apparent that elevated fasting insulin levels and increased BMI during childhood are the strongest predictors of metabolic syndrome in adulthood ([120](#), [121](#)).

Similar to obesity, OSA has been identified as an important risk factor for the metabolic syndrome in adult patients ([122–124](#)). In young children, both insulin resistance (measured on the basis of the insulin:glucose ratio and homeostatic model assessment) and altered lipidemia (evidence of increased plasma triglycerides and decreased plasma high density lipoprotein concentrations) appear to be determined by the degree of obesity, and the contribution of OSA does not seem to be a major one ([125](#), [126](#)). However, similar to adults, when obesity and OSA coincide in children the risk for metabolic disturbances is further increased ([127](#), [128](#)). In a study of adolescents, the presence of OSA had a sixfold increase in the odds of metabolic syndrome compared with those without OSA ([129](#)). On a similar plane, obese children with OSA are at increased risk for development of nonalcoholic liver steatosis ([130](#)), a finding that is also present in rodents and adults with OSA ([131–135](#)).

One of the emerging issues associated with OSA in adults involves recruitment of visceral adipose tissue and alterations in the release of several active compounds from this tissue, collectively referred to as adipokines. Among the several adipokines, leptin has emerged as being modified by OSA and also as playing an important role in the regulation of appetite, sleep, metabolic homeostasis, and respiratory control ([136](#)). Several studies indicate that leptin levels are altered in adult patients with OSA ([137–139](#)). We have reported on elevations of circulating leptin levels, independent of the degree of obesity, in pediatric patients with OSA ([140](#)). Although the implications of such findings remain to be established, we should also emphasize that adiponectin levels were reduced in obese children but were not affected by OSA, and that resistin concentrations were not affected by either OSA or obesity ([140](#)).

SOMATIC GROWTH IMPAIRMENT

Although the initial descriptions of pediatric OSA included a disproportionate number of children with failure to thrive, this is not the case nowadays, with only 5% or less of pediatric OSA manifesting this problem ([141–143](#)). Interestingly, even obese children with OSA will demonstrate accelerations in weight gain after treatment of OSA ([144](#), [145](#)). Among the proposed mechanisms for somatic growth alterations in OSA, decreased levels of insulin-like growth factor-I, insulin-like growth factor-binding proteins, and possibly growth hormone release are most likely involved ([146](#), [147](#)).

MANAGEMENT OF SLEEP APNEA IN CHILDREN

The pathophysiology of OSA has been previously reviewed ([148, 149](#)), and in more updated detail in this symposium ([150](#)), and it is clear from this review and other sources that OSA in children is most commonly associated with adenotonsillar hypertrophy ([151](#)), even if obesity is now a markedly frequent occurrence, and requires a lesser degree of lymphadenoid size ([152](#)). The recommended initial treatment, even in obese children, consists of surgical removal of the adenoids and tonsils ([75, 153](#)). However, not all children who undergo adenotonsillectomy (T&A) for OSA are cured ([154–156](#)). In a meta-analysis of the published literature, the success rate for T&A in the context of OSA was approximately 85% ([157](#)). This figure may actually be lower, particularly among obese children with OSA ([158–162](#)), or among children with severe OSA ([158, 161](#)). These findings have prompted the recommendation for repeated overnight sleep studies after adenotonsillar surgery for OSA ([158](#)). Although long-term outcomes are lacking after T&A in children with OSA, emerging evidence would suggest that recurrence of OSA will occur in a subset of these patients ([163](#)), particularly in those with craniofacial issues or family history of OSA ([163–167](#)). Additional issues for which no conclusive data are available involve the surgical technique used for extirpation of the lymphoid tissue (e.g., cold surgery, coblation, harmonic laser); and the need for tonsillectomy and adenoidectomy, either one of these two surgical procedures alone, or tonsillotomy alone ([168–170](#)). These issues will need to be addressed in future.

For children in whom T&A does not lead to complete resolution of OSA and in whom the residual severity of sleep-disordered breathing is considered moderate to severe (i.e., obstructive AHI > 5/h), the only additional interventional option consists of the administration of nasal continuous positive airway pressure (CPAP) ([171–176](#)). Despite a relative paucity of size-appropriate masks, the overall adherence rates appear to be satisfactory ([177](#)), and such rates may be further improved by administration of behavioral interventions ([178](#)) and logistic support of the family.

The major gray zone regarding OSA therapy involves those children presenting with an AHI exceeding 1, but less than 5, events per hour of sleep. Indeed, whereas these patients are at significant risk for associated morbidity, the risk:benefit ratio of surgical adenotonsillectomy has not been conclusively defined, and CPAP is less likely to be beneficial and effective when applied to an airway that is partially blocked by enlarged lymphadenoid tissues. Such considerations have led to the search for therapeutic alternatives. One approach has consisted of the topical intranasal application of high-potency corticosteroids. In a series of studies, significant improvements in AHI and oxygenation have been demonstrated in a cohort of children with OSA and AHI greater than 5 or in children with enlarged adenoids ([179–182](#)). Those findings are not surprising considering the expression patterns of glucocorticoid receptors α and β in the upper airway, which suggest favorable therapeutic responses to topical corticosteroid treatment in children with OSA ([183](#)). In addition, the concentration of inflammatory mediators such as leukotrienes and the expression of their receptors were found to be increased in children with OSA ([184, 185](#)), and a leukotriene receptor antagonist was effective in mild pediatric OSA ([184](#)). Of note, antiinflammatory therapy was also effective in ameliorating residual OSA after adenotonsillectomy ([186](#)).

Oral appliances or functional orthopedic appliances have also been tried in the treatment of OSA in children, with some degree of success ([187–189](#)). It remains unclear, however, which selection criteria to use for identification of the candidates likely to benefit from this therapeutic option, and what the long-term results of this approach might be.

As can be rapidly deduced from the current compilation of the literature regarding the management of pediatric OSA, there is a paucity of information regarding short-term and long-term outcomes. Future studies particularly addressing these issues in the context of type I, II, and III pediatric OSA categories will be essential for optimization of the care provided to our patients and the sustained improvement in their long-term health and quality of life.

CONCLUSIONS

The spectrum of disease that encompasses habitual snoring and OSA in children is associated with increased prevalence of a variety of morbidities spanning the CNS and the cardiovascular and endocrine systems. The coexistence of obesity and OSA appears to yield not only increased morbidity rates and poorer responses to therapy, but is altogether associated with a distinct and overall recognizable clinical phenotype. Therapeutic options have somewhat expanded since the initial treatment approaches were conducted, to include not only surgical extraction of hypertrophic adenoids and tonsils, but also nonsurgical alternatives such as CPAP, antiinflammatory agents, and oral appliances. However, the efficacy and optimal application of each of these options await firmer recommendations derived from suitably designed, randomized trials.

FOOTNOTES

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PEDIATRICS®

Habitual Snoring, Intermittent Hypoxia, and Impaired Behavior in Primary School Children

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Abstract

Objectives. Sleep-disordered breathing is associated with impaired behavior and poor academic performance in children. We aimed to determine the extent of behavioral problems in snoring children, clarify the role of intermittent hypoxia, and test the reversibility of impaired behavior and poor academic performance.

Methods. In 1144 children, habitual snoring (HS; snoring frequently or always) and impaired behavior were assessed using parental questionnaires. Intermittent hypoxia (ie, presence of ≥ 5 arterial oxygen desaturations by $\geq 4\%$ or ≥ 1 desaturation to $\leq 90\%$) was investigated with pulse oximetry. Poor academic performance (grade 4–6 on a 6-point scale in mathematics, science, or spelling) was based on the last school report. HS, impaired behavior, and academic performance were reevaluated after 1 year. Adjusted odds ratios (ORs) were calculated using unconditional logistic regression.

Results. HS was significantly associated with hyperactive (OR: 2.4) and inattentive behavior (OR: 4.0), daytime tiredness (OR: 7.1), and sleepiness (OR: 2.6–4.8). These associations were independent of intermittent hypoxia. HS was also significantly associated with bad conduct (OR: 2.8), emotional symptoms (OR: 5.5), and peer problems (OR: 9.7). At follow-up, hyperactive and inattentive behavior but not academic success had significantly improved in children in whom HS had ceased.

Conclusions. We suggest that impaired behavior is a key feature of HS independent of intermittent hypoxia and improves when HS ceases.

[Pediatr Pulmonol.](#) 2004 Apr;37(4):330-7.

Reduced neurocognition in children who snore.

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Source

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Abstract

Obstructive sleep apnea syndrome (OSAS) has been associated with reduced neurocognitive performance in children, but the underlying etiology is unclear. The aim of this study was to evaluate the relationship between hypoxemia, respiratory arousals, and neurocognitive performance in snoring children referred for adenotonsillectomy. Thirteen snoring children who were referred for evaluation regarding the need for adenotonsillectomy to a children's hospital otolaryngology/respiratory department underwent detailed neurocognitive and polysomnographic (PSG) evaluation. PSGs were evaluated for respiratory abnormalities and compared with 13 nonsnoring control children of similar age who were studied in the same manner. The snoring children had an obstructive respiratory disturbance index within normal range (mean obstructive apnea/hypopnea index, 0.6/hr). Despite this, several domains of neurocognitive function were reduced in the snoring group. These included mean verbal IQ scores (snorers 92.6 vs. nonsnorers 110.2, $P < 0.001$), mean global IQ scores (snorers 96.7 vs. nonsnorers 110.2, $P < 0.005$), mean selective attention scores (snorers 46.4 vs. nonsnorers 11.8, $P < 0.001$), mean sustained attention scores (snorers 8.0 vs. nonsnorers 2.2, $P = 0.001$), and mean memory index (snorers 95.2 vs. nonsnorers 112.1, $P = 0.001$). There was a direct relationship between number of mild oxygen desaturations of $> \text{ or } = 3\%$, obstructive hypopneas with $> \text{ or } = 3\%$ oxygen desaturations, and respiratory arousals and severity of neurocognitive deficits, with the greatest effect being on memory scores. The disruption of sleep in snoring children produced by relatively mild changes in oxygen saturation or by increases in respiratory arousals may have a greater effect on neurocognitive function than hitherto appreciated. A possible explanation for these neurocognitive deficits may be the combination of the chronicity of sleep disruption secondary to

snoring which is occurring at a time of rapid neurological development in the first decade of life. Future studies need to confirm the reversal of these relatively mild neurocognitive decrements post adenotonsillectomy.

Neurobehavioral Morbidity Associated With Disordered Breathing During Sleep in Children: A Comprehensive Review

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Neurobehavioral Morbidity in Childhood SDB—Beebe

Disclosure Statement

This is not an industry supported study. Dr. Beebe has indicated no financial conflict of interest.

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Study Objectives: To comprehensively review research on the association between childhood sleep-disordered breathing (SDB) and neurobehavioral functioning.

Design: Qualitative and quantitative literature review.

Setting: N/A.

Patients or Participants: N/A.

Interventions: N/A.

Measurements and Results: The findings of 61 studies of the relationship between childhood SDB and neurobehavioral functioning were critically evaluated and synthesized. There is strong evidence that childhood SDB is associated with deficits in behavior and emotion regulation, scholastic performance, sustained attention, selective attention, and alertness. There is also evidence that SDB has minimal association with a child's typical mood, expressive language skills, visual perception, and working memory. Findings have been insufficient to draw conclusions about intelligence, memory, and some aspects of executive functioning. Mechanisms by which SDB might result in neurobehavioral morbidity are being explored, but clinical symptoms such as chronic snoring remain the best predictors of morbidity. Short-term SDB treatment outcome studies are encouraging, but the long-term outcomes are not known. Failing to treat SDB appears to leave children at risk for long-term neurobehavioral deficits.

Conclusions: Childhood SDB is associated with neurobehavioral morbidity. Applying commonly used guidelines for causal inference, even in the absence of a much-needed randomized clinical trial, there is strong evidence of association, consistent findings, and specificity of effect. There is suggestive evidence that this association fits the expected temporal pattern and that SDB is a biologically plausible cause of neurobehavioral deficits. Clinicians should be alert to the coexistence of SDB symptoms and concerns about a child's academic progress, attention, arousal, or behavior or emotion regulation.

Keywords: Pediatrics, obstructive sleep apnea, sleep-disordered breathing, neuropsychology, cognitive function, behavioral functioning
Citation: Beebe DW. Neurobehavioral morbidity associated with disordered breathing during sleep in children: a comprehensive review. *SLEEP*

2006;29(9):1115-1134.

PEDIATRICS®

Increased Behavioral Morbidity in School-Aged Children With Sleep-Disordered Breathing

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Abstract

Objective. To assess whether sleep-disordered breathing (SDB), ranging from primary snoring to obstructive sleep apnea (OSA), is associated with increased behavioral morbidity.

Methods. A cross-sectional study was conducted of school-aged children in an urban, community-based cohort, stratified for term or preterm (<37 weeks' gestation) birth status. A total of 829 children, 8 to 11 years old (50% female, 46% black, 46% former preterm birth) were recruited from a cohort study. All children had unattended in-home overnight cardiorespiratory recordings of airflow, respiratory effort, oximetry, and heart rate for measurement of the apnea hypopnea index (number of obstructive apneas and hypopneas per hour). SDB was defined by either parent-reported habitual snoring or objectively measured OSA. Functional outcomes were assessed with 2 well-validated parent ratings of behavior problems: the Child Behavioral Checklist and the Conners Parent Rating Scale–Revised:Long.

Results. Forty (5%) children were classified as having OSA (median apnea hypopnea index: 7.1 per hour; interquartile range: 3.1–10.5), 122 (15%) had primary snoring without OSA, and the

remaining 667 (80%) had neither snoring nor OSA. Children with SDB had significantly higher odds of elevated problem scores in the following domains: externalizing, hyperactive, emotional lability, oppositional, aggressive, internalizing, somatic complaints, and social problems.

Conclusions. Children with relatively mild SDB, ranging from primary snoring to OSA, have a higher prevalence of problem behaviors, with the strongest, most consistent associations for externalizing, hyperactive-type behaviors.

CHEST

Inability of Clinical History to Distinguish Primary Snoring From Obstructive Sleep Apnea Syndrome in Children

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Abstract

Study objective: To determine whether primary snoring (PS) could be distinguished from childhood obstructive sleep apnea syndrome (OSAS) by clinical history.

Design: Retrospective study of clinical history of 83 children with snoring and/or sleep disordered breathing who were referred for polysomnography.

Setting: Tertiary referral center; pediatric pulmonary sleep apnea clinic.

Measurements: We evaluated the ability of a clinical obstructive sleep apnea (OSA) score and other questions about sleep, breathing, and daytime symptoms to distinguish PS from OSAS in children. Parents were asked about the child's snoring, difficulty breathing, observed apnea, cyanosis, struggling to breathe, shaking the child to "make him or her breathe," watching the child sleep, afraid of apnea, the frequency and loudness of snoring, and daytime symptoms such as excessive daytime sleepiness (EDS).

Results: Based on polysomnography results, 48 patients were classified as PS and 35 as OSAS. Peak end-tidal CO₂ (49±3.2 vs 55±8.2 [SD] mm Hg); lowest arterial oxygen saturation measured by pulse oximetry (95±1.9 vs 82±14%); and apnea/hypopnea index (0.27±.3 vs 8.4±6 events/h) indicated that the diagnostic criteria for PS versus OSA were reasonable. There were no differences between PS and OSA patients with respect to age, sex, race, failure to thrive, obesity, history of EDS, snoring history, history of cyanosis during sleep, or daytime symptoms except for mouth breathing. There were no significant differences in sleep variables between PS patients and those with any severity of OSAS. The OSA score misclassified about one of four patients. Comparing PS and OSA patients, significant findings were daytime mouth breathing (61 vs 85%; p=0.024); observed apnea (46 vs 74%; p=0.013); shaking the child (31 vs. 60%; p=0.01); struggling to breathe (58 vs 89%; p=0.003); and afraid of apnea (71 vs 91%; p=0.028). However, none of these were sufficiently discriminatory to predict OSAS.

Conclusion: We conclude that PS in children cannot be reliably distinguished from OSAS by clinical history alone.

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C-reactive Protein, Obstructive Sleep Apnea, and Cognitive Dysfunction in School-aged Children

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Rationale: Obstructive sleep apnea (OSA) in children is associated with substantial neurobehavioral and cognitive dysfunction. However, not all children with OSA exhibit altered cognitive performance.

Objectives: To assess the magnitude of the systemic inflammatory response, as measured by high-sensitivity C-reactive protein (hsCRP) serum levels which may identify children with OSA at higher susceptibility for cognitive morbidity.

Methods: Habitually snoring children and nonsnoring children (total, 278; age range, 5–7 yr) were recruited from the community, and underwent overnight polysomnography and neurocognitive testing and a blood draw the next morning. Snoring children were divided into OSA and no-OSA groups, and children with OSA were further subdivided into those with two or

more abnormal cognitive subtests and into those with normal cognitive scores. Serum levels of hsCRP were also measured.

Measurements and Main Results: Among snoring children without OSA, mean hsCRP was 0.19 ± 0.07 mg/dl compared with 0.36 ± 0.11 mg/dl in those with OSA ($p < 0.01$). Furthermore, hsCRP was 0.48 ± 0.12 mg/dl in children with OSA and cognitive deficits, compared with 0.21 ± 0.08 mg/dl in children with OSA and normal cognitive scores ($p < 0.002$).

Conclusions: hsCRP levels are higher in children with OSA, and particularly in those who develop neurocognitive deficits, suggesting that the magnitude of the inflammatory responses elicited by OSA is a major determinant of increased risk for neurocognitive dysfunction.

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Metabolic Alterations and Systemic Inflammation in Obstructive Sleep Apnea among Nonobese and Obese Prepubertal Children

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Rationale: Obstructive sleep apnea (OSA) has been associated with a higher prevalence and severity of the metabolic syndrome in adult patients, even after controlling for obesity. In contrast, OSA in prepubertal children does not appear to correlate with the magnitude of such metabolic derangements.

Objectives: To further establish the potential mechanistic role of OSA in metabolic regulation in prepubertal children.

Methods: Fasting glucose, insulin, C-reactive protein, apolipoprotein B, and serum lipid concentrations were determined during the initial polysomnographic diagnosis of OSA and 6–12 months after adenotonsillectomy in both obese and nonobese children.

Measurements and Main Results: Sixty-two children with OSA (37 obese and 25 nonobese), age 7.40 ± 2.6 years (mean $\pm$ SD) completed the study. After adenotonsillectomy, significant improvements in apnea–hypopnea index and sleep fragmentation occurred, particularly among nonobese children. In nonobese children, adenotonsillectomy was associated with mild increases in body mass index z scores, no changes in either fasting glucose or insulin, significant increases in high-density lipoprotein and reciprocal decreases in low-density lipoprotein, and reductions in

plasma C-reactive protein and apolipoprotein B levels. In obese children, adenotonsillectomy did not result in body mass index or glucose changes, but was associated with marked improvements in all other measures.

Conclusions: OSA does not appear to induce insulin resistance in nonobese pediatric patients but seems to play a significant role in obese patients. The significant improvements in lipid profiles, C-reactive protein, and apolipoprotein B after adenotonsillectomy in the two groups suggest a pathogenic role for OSA in lipid homeostasis and systemic inflammation independent of the degree of adiposity.

Key Words: obstructive sleep apnea • inflammation • obesity • serum lipids • diabetes

Journal Neurology

APOE ε4 allele, cognitive dysfunction, and obstructive sleep apnea in children

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Abstract

Background: Obstructive sleep apnea (OSA) in children is associated with severity-dependent changes in neurocognitive functioning. However, the severity of OSA accounts for only approximately 40% of the variance in cognitive performance. Thus, genetic determinants of individual susceptibility may also contribute to the morbidity of OSA. Considering the unique susceptibility of apolipoprotein E (ApoE) knock-out mice to an experimental model of OSA, we examined whether the *APOE* ε4 allele contributes to increased neurocognitive morbidity in pediatric OSA.

Methods: Consecutive habitually snoring and nonsnoring 5- to 7-year-old children underwent overnight polysomnography, neurocognitive testing, and a blood draw the next morning.

Children were divided into OSA or no OSA, and OSA children were further subdivided into those with ≥ 2 abnormal cognitive subtest scores and those with normal cognitive scores. The presence of the *APOE* $\epsilon 4$ allele was determined from blood genomic DNA.

Results: Among all children without OSA, *APOE* $\epsilon 4$ was present in 3 of 199 children, whereas in those with OSA, *APOE* $\epsilon 4$ was found in 16 of 146 children ($p < 0.0002$). Furthermore, 16 of 74 children with OSA and cognitive scores $< 85\%$ had the *APOE* $\epsilon 4$ allele compared with 3 of 72 children with OSA with abnormal cognitive scores ($p < 0.002$).

Conclusions: *APOE* $\epsilon 4$ allele is more frequent in children with obstructive sleep apnea and particularly in those who develop neurocognitive deficits, suggesting that the *APOE* $\epsilon 4$ allele is associated with not only increased odds of having sleep-disordered breathing, but also with an increased risk for neurocognitive dysfunction.

Footnotes

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[Sleep Medicine](#)

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Rapid maxillary expansion in children with obstructive sleep apnea syndrome: 12-month follow-up[☆]

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Abstract

Objectives:

To assess the outcome of rapid maxillary expansion in the treatment of obstructive sleep apnea syndrome (OSAS) in children, we studied 16 patients (mean age 6.6 ± 2.0 ; 9 males) with dental malocclusion, a body mass index ≤ 85 percentile, and OSAS confirmed by polysomnography.

Methods:

At baseline and after the trial, all patients underwent physical examination, standard polysomnography and orthodontic assessment. The Brouillette questionnaire investigating symptoms of OSA was administered to parents before and during the trial to assess the clinical severity of their sleep-disordered breathing. Two treated patients were lost to follow-up and excluded from the final study.

Results:

In the 14 treated subjects who completed the study and follow-up, polysomnography showed a significant decrease in the apnea-hypopnea index ($p = 0.005$), hypopnea obstructive index ($p = 0.002$) and arousal index ($p = 0.001$). Questionnaire responses before and after treatment showed a significant decrease in the severity of symptoms.

Conclusion:

A rapid maxillary expander is an effective appliance for treating children with OSAS.

Keywords: Children; Obstructive sleep apnea; Rapid maxillary expander; Treatment

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Adherence to and Effectiveness of Positive Airway Pressure Therapy in Children With Obstructive Sleep Apnea

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Abstract

OBJECTIVES. Positive airway pressure therapy (PAP) is frequently used to treat children who have obstructive sleep apnea syndrome and do not respond to adenotonsillectomy. However, no studies have evaluated objectively adherence to PAP in children, and few studies have evaluated objectively the effectiveness of PAP. The objective of this study was to determine adherence and effectiveness of PAP (both continuous [CPAP] and bilevel [BPAP] pressure) in children with obstructive apnea.

METHODS. A prospective, multicenter study was performed of children who were randomly assigned in a double-blind manner to 6 months of CPAP versus BPAP. Adherence was measured objectively using the equipment's computerized output. Effectiveness was evaluated using polysomnography.

RESULTS. Twenty-nine children were studied. Approximately one third of children dropped out before 6 months. Of the 21 children for whom 6-month adherence data could be downloaded, the mean nightly use was 5.3 ± 2.5 (SD) hours. Parental assessment of PAP use considerably overestimated actual use. PAP was highly effective, with a reduction in the apnea hypopnea index from 27 ± 32 to 3 ± 5 /hour, and an improvement in arterial oxygen saturation nadir from $77 \pm 17\%$ to $89 \pm 6\%$. Results were similar for children who received CPAP versus BPAP. Children also had a subjective improvement in daytime sleepiness.

CONCLUSIONS. Both CPAP and BPAP are highly efficacious in pediatric obstructive apnea. However, treatment with PAP is associated with a high dropout rate, and even in the adherent children, nightly use is suboptimal considering the long sleep hours in children.

[Otolaryngology - Head and Neck Surgery](#)

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Skeletal expansion combined with soft-tissue reduction in the treatment of obstructive sleep apnea in children: Physiologic results

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Abstract

Twenty consecutive children, ranging in age from 6 days to 18 years, were treated with skeletal expansion, in addition to soft-tissue reduction, for medically refractory obstructive sleep apnea. The underlying diagnoses were craniofacial microsomia ($n = 6$), Down syndrome ($n = 3$), Pierre Robin syndrome ($n = 3$), cerebral palsy ($n = 3$), Nager's syndrome ($n = 1$), Treacher Collins syndrome ($n = 1$), cri du chat syndrome ($n = 1$), juvenile rheumatoid arthritis ($n = 1$), and temporomandibular joint ankylosis ($n = 1$). Fourteen children had severe medically refractory sleep apnea and were tracheostomy candidates; in the remaining six, tracheostomies were placed shortly after birth and could not be decannulated. Overnight, 12-channel polysomnography was obtained before and after surgery. The mean apnea index improved from 7.42 to 1.26, the mean respiratory disturbance index improved from 25.24 to 1.72, and the mean lowest apnea-related oxygen saturation improved from 68% to 88%. Of the 14 children with medically refractory obstructive sleep apnea, two required tracheostomies. Of the six patients with tracheostomies, five have been decannulated at the time of this writing. Skeletal expansion in conjunction with soft-tissue reduction in the pediatric population permits substantial increases in the volume of both the nasopharynx and oropharynx. Creative use of conventional osteotomies and the application of distraction osteogenesis have enabled surgeons to apply maxillofacial and craniofacial techniques in treating children with obstructive sleep apnea. (Otolaryngol Head Neck Surg 1998;119:476-85.)

[Sleep](#). 2004 Jun 15;27(4):761-6.

Rapid maxillary expansion in children with obstructive sleep apnea syndrome.

[Pirelli P](#), [Saponara M](#), [Guilleminault C](#).

Source

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Abstract

OBJECTIVE:

To evaluate the effect of rapid maxillary expansion on children with nasal breathing and obstructive sleep apnea syndrome.

METHOD:

Recruitment of children with maxillary contraction, without of adenoid hypertrophy, with a body mass index < 24 kg/m², with obstructive sleep apnea syndrome demonstrated by polysomnography, and whose parents signed informed consent. Otolaryngologic and orthognathic-odontologic evaluation with clinical evaluation, anterior rhinometry and nasal fibroscopy, panoramic radiographs, anteroposterior and laterolateral telecephalometry were performed at entry and follow-up. Intervention: Rapid maxillary expansion (ie, active phase of treatment) was performed for 10 to 20 days; maintenance of device (for consolidation) and orthodontic treatment on teeth lasted 6 to 12 months.

RESULTS:

31 children (19 boys), mean age 8.7 years, participated in the study. The mean apnea-hypopnea index was 12.2 events per hour. At the 4-month follow-up, the anterior rhinometry was normal, and all children had an apnea-hypopnea index < 1 event per hour. The mean cross-sectional expansion of the maxilla was 4.32 +/- 0.7 mm. There was a mean increase of the pyriform opening of 1.3 +/- 0.3 mm.

CONCLUSION:

Rapid maxillary expansion may be a useful approach in dealing with abnormal breathing during sleep.

___ [Sleep Med.](#) 2007 Mar;8(2):128-34. Epub 2007 Jan 18.

Rapid maxillary expansion in children with obstructive sleep apnea syndrome: 12-month follow-up.

[Villa MP](#), [Malagola C](#), [Pagani J](#), [Montesano M](#), [Rizzoli A](#), [Guilleminault C](#), [Ronchetti R](#).

Source

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Abstract

OBJECTIVES:

To assess the outcome of rapid maxillary expansion in the treatment of obstructive sleep apnea syndrome (OSAS) in children, we studied 16 patients (mean age 6.6+/-2.0; 9 males) with dental malocclusion, a body mass index < or =85 percentile, and OSAS confirmed by polysomnography.

METHODS:

At baseline and after the trial, all patients underwent physical examination, standard polysomnography and orthodontic assessment. The Brouillette questionnaire investigating symptoms of OSA was administered to parents before and during the trial to assess the clinical severity of their sleep-disordered breathing. Two treated patients were lost to follow-up and excluded from the final study.

RESULTS:

In the 14 treated subjects who completed the study and follow-up, polysomnography showed a significant decrease in the apnea-hypopnea index ($p=0.005$), hypopnea obstructive index ($p=0.002$) and arousal index ($p=0.001$). Questionnaire responses before and after treatment showed a significant decrease in the severity of symptoms.

CONCLUSION:

A rapid maxillary expander is an effective appliance for treating children with OSAS.

PERSISTENCE OF OBSTRUCTIVE SLEEP APNEA SYNDROME IN CHILDREN AFTER ADENOTONSILLECTOMY

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ANNA IVANENKO, MD, PhD, AND DAVID GOZAL, MD

Objective To investigate the relative contribution of various risk factors to the surgical outcome of adenotonsillectomy for obstructive sleep apnea syndrome in children.

Study design Children ($n = 110$; mean age, 6.4 ± 3.9 years) underwent two polysomnographic evaluations before and after adenotonsillectomy. In addition, 22 control children were studied. History for allergy and family history of sleep-disordered breathing was taken before each polysomnographic evaluation.

Results: Significant changes in sleep stage percentages and sleep fragmentation were found in the postsurgery study compared with the presurgery study; 25% of the children had apnea/hypopnea index (AHI) <1 , 46% had AHI >1 and <5 , and

29% had AHI >5 in the postsurgery study. The frequency of subjects with AHI <1 after surgery was significantly lower among obese subjects ($P < .05$). Comparison between the children who had AHI <1 after surgery and 22 control children showed

complete normalization of sleep architecture after surgery.

Conclusions Adenotonsillectomy yields improvements in respiratory abnormalities in children with obstructive sleep apnea syndrome. Complete normalization occurs in only 25% of the patients. Obesity and AHI at diagnosis are the major determinant for surgical outcome. When normalization of

Sleep VOLUME 27, ISSUE 04

Rapid Maxillary Expansion in Children with Obstructive Sleep Apnea Syndrome

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¹Department of Odontological Sciences, University Tor Vergata; ²Department of Neurology and ENT, La Sapienza University, Rome Italy; ³Stanford University Sleep Disorders Clinic, Stanford, CA, USA

Objective:

To evaluate the effect of rapid maxillary expansion on children with nasal breathing and obstructive sleep apnea syndrome.

Method:

Recruitment of children with maxillary contraction, without of adenoid hypertrophy, with a body mass index < 24 kg/m², with obstructive sleep apnea syndrome demonstrated by polysomnography, and whose parents signed informed consent. Otolaryngologic and orthognathic-odontologic evaluation with clinical evaluation, anterior rhinometry and nasal fibroscopy, panoramic radiographs, anteroposterior and laterolateral telecephalometry were performed at entry and follow-up.

Intervention:

Rapid maxillary expansion (ie, active phase of treatment) was performed for 10 to 20 days; maintenance of device (for consolidation) and orthodontic treatment on teeth lasted 6 to 12 months.

Results:

31 children (19 boys), mean age 8.7 years, participated in the study. The mean apnea-hypopnea index was 12.2 events per hour. At the 4-month follow-up, the anterior rhinometry was normal, and all children had an apnea-hypopnea index < 1 event per hour. The mean cross-sectional expansion of the maxilla was 4.32 ± 0.7 mm. There was a mean increase of the pyriform opening of 1.3 ± 0.3 mm.

Conclusion:

Rapid maxillary expansion may be a useful approach in dealing with abnormal breathing during sleep.

[PubMed](#)

Increased behavioral morbidity in school-aged children with sleep-disordered breathing. Rosen CL, Storfer-Isser A, Taylor HG, Kirchner HL, Emancipator JL, Redline S

Pediatrics. 2004;114(6):1640.

OBJECTIVE: To assess whether sleep-disordered breathing (SDB), ranging from primary snoring to obstructive sleep apnea (OSA), is associated with increased behavioral morbidity.

METHODS: A cross-sectional study was conducted of school-aged children in an urban, community-based cohort, stratified for term or preterm (<37 weeks' gestation) birth status. A total of 829 children, 8 to 11 years old (50% female, 46% black, 46% former preterm birth) were recruited from a cohort study. All children had unattended in-home overnight cardiorespiratory recordings of airflow, respiratory effort, oximetry, and heart rate for measurement of the apnea hypopnea index (number of obstructive apneas and hypopneas per hour). SDB was defined by either parent-reported habitual snoring or objectively measured OSA. Functional outcomes were assessed with 2 well-validated parent ratings of behavior problems: the Child Behavioral Checklist and the Conners Parent Rating Scale-Revised:Long.

RESULTS: Forty (5%) children were classified as having OSA (median apnea hypopnea index: 7.1 per hour; interquartile range: 3.1-10.5), 122 (15%) had primary snoring without OSA, and the remaining 667 (80%) had neither snoring nor OSA. Children with SDB had significantly higher odds of elevated problem scores in the following domains: externalizing, hyperactive, emotional lability, oppositional, aggressive, internalizing, somatic complaints, and social problems.

CONCLUSIONS: Children with relatively mild SDB, ranging from primary snoring to OSA, have a higher prevalence of problem behaviors, with the strongest, most consistent associations for externalizing, hyperactive-type behaviors.

AD

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[Sleep Breath.](#) 2011 May;15(2):179-84. Epub 2011 Mar 25.

Efficacy of rapid maxillary expansion in children with obstructive sleep apnea syndrome: 36 months of follow-up.

[Villa MP](#), [Rizzoli A](#), [Miano S](#), [Malagola C](#).

Source

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Abstract

PURPOSE:

In view of the positive outcome of orthodontic treatment using rapid maxillary expansion (RME) on sleep-disordered breathing, we generated data on RME in children with obstructive sleep

apnea (OSA) by evaluating objective and subjective data over a 36-month follow-up period, to determine whether RME is effective in the long-term treatment of OSA. We selected all patients with dental malocclusions and OSA syndrome (OSAS) confirmed by polysomnography.

METHODS:

Ten of the 14 children who completed the 12-month therapeutic trial using RME were enrolled in our follow-up study. The study was performed 24 months after the end of the RME orthodontic treatment. We enrolled all children presented with deep, retrusive or crossbite at the orthodontic evaluation. All subjects underwent an overnight polysomnography at the baseline, after 1 year of treatment and 24 months after the end of the orthodontic treatment. The children's mean age was 6.6 ± 2.1 years at entry and 9.7 ± 1.6 years at the end of follow-up.

RESULTS:

After treatment, the apnea hypopnoea index (AHI) decreased and the clinical symptoms had resolved by the end of the treatment period. Twenty-four months after the end of the treatment, no significant changes in the AHI or in other variables were observed.

CONCLUSIONS:

RME may be a useful approach in children with malocclusion and OSAS, as the effects of such treatment were found to persist 24 months after the end of treatment.

Treatment of obstructive sleep apnea syndrome by rapid maxillary expansion

Cistulli PA, Palmisano RG, Poole MD.

SLEEP. 1998 Dec 15;21(8):831-5

Centre for Sleep Disorders & Respiratory Failure, St George Hospital, NSW, Australia.

The precise role of maxillary constriction in the pathophysiology of obstructive sleep apnea (OSA) is unclear. However, it is known that subjects with maxillary constriction have increased nasal resistance and resultant mouth-breathing, features typically seen in OSA patients. Maxillary constriction is also associated with alterations in tongue posture which could result in retroglossal airway narrowing, another feature of OSA. Rapid maxillary expansion (RME) is an orthodontic treatment for maxillary constriction which increases the width of the maxilla and reduces nasal resistance. The aim of this pilot study was to investigate the effect of rapid maxillary expansion in OSA. We studied 10 young adults (8 male, 2 female, mean age 27 ± 2 [sem] years) with mild to moderate OSA (apnea/hypopnea index-AHI 19 ± 4 and minimum SaO₂ $89 \pm 1\%$), and evidence of maxillary constriction on orthodontic evaluation. All patients underwent treatment with RME, six cases requiring elective surgical assistance. Polysomnography was repeated at the completion of treatment. 9 of the 10 patients reported

improvements in snoring and hypersomnolence. There was a significant reduction in AHI (19 +/- 4 vs 7 +/- 4, $p < 0.05$) in the entire group. In seven patients, the AHI returned to normal (i.e., $= < 5$); only one patient showed no improvement. These preliminary data suggest that RME may be a useful treatment alternative for selected patients with OSA.

PEDIATRICS*

The Effect of Chronic or Intermittent Hypoxia on Cognition in Childhood: A Review of the Evidence

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Abstract

Objective. A review of the evidence concerning the effect of chronic or intermittent hypoxia on cognition in childhood was performed by using both a systematic review of the literature and critical appraisal criteria of causality. Because of the significant impact of behavioral disorders such as attention-deficit/hyperactivity disorder on certain cognitive functions as well as academic achievement, the review also included articles that addressed behavioral outcomes.

Methods. Both direct and indirect evidence were collected. A structured Medline search was conducted from the years 1966-2000 by using the OVID interface. Both English- and non-English-language citations were included. Significant articles identified by the reviewers up to 2003 were also included. To be included as direct evidence, an article needed to be an original report in a peer-reviewed journal with data on cognitive, behavioral, or academic outcomes in children up to 14 years old, with clinical conditions likely to be associated with exposure to chronic or intermittent hypoxia. Indirect evidence from other reviews and publications in closely related fields, including experimental studies in adults, was used to help formulate conclusions. Two reviewers screened abstracts and titles. Each article included as direct evidence received a structured evaluation by 2 reviewers. Adjudication of differences was performed by a group of 2 reviewers and a research consultant. After this review, tables of evidence were constructed that were used as the basis for group discussion and consensus development. Indirect evidence assigned by topic to specific reviewers was also presented as part of this process. A formal procedure was used to rank the studies by design strength. The critical appraisal criteria for causation described in *Evidence Based Pediatrics and Child Health* (Moyer V, Elliott E, Davis R, et al, eds. London, United Kingdom: BMJ Books; 2000:46–55) were used to develop consensus on causality.

Results. A total of 788 literature citations were screened. For the final analysis, 55 articles met the criteria for inclusion in the direct evidence. Of these, 43 (78.2%) reported an adverse effect. Of the 37 controlled studies, 31 (83.8%) reported an adverse effect. Adverse effects were noted at every level of arterial oxygen saturation and for exposure at every age level except for premature newborns. The studies were classified into 5 clinical categories: congenital heart disease (CHD), sleep-disordered breathing (SDB), asthma, chronic ventilatory impairment, and respiratory instability in infants. Two of these categories, CHD and SDB, which accounted for 42 (76.4%) of the included articles, fulfilled the *Evidence Based Pediatrics and Child Health* criteria for causation. The indirect evidence included 8 reviews, 1 meta-analysis, and 10 original reports covering the fields of adult anoxia, animal research, SDB in adults, natural and experimental high-altitude studies, perinatal hypoxic-ischemic encephalopathy, anemia, and carbon-monoxide poisoning. The studies of high-altitude and carbon-monoxide poisoning provided evidence for causality.

Conclusions. Adverse impacts of chronic or intermittent hypoxia on development, behavior, and academic achievement have been reported in many well-designed and controlled studies in children with CHD and SDB as well as in a variety of experimental studies in adults. This should be taken into account in any situation that may expose children to hypoxia. Because adverse effects have been noted at even mild levels of oxygen desaturation, future research should include precisely defined data on exposure to all levels of desaturation.

PEDIATRICS®

Sleep-Disordered Breathing and School Performance in Children

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Abstract

Objective. To assess the impact of sleep-associated gas exchange abnormalities (SAGEA) on school academic performance in children.

Design. Prospective study.

Setting. Urban public elementary schools.

Participants. Two hundred ninety-seven first-grade children whose school performance was in the lowest 10th percentile of their class ranking.

Methods. Children were screened for obstructive sleep apnea syndrome at home using a detailed parental questionnaire and a single night recording of pulse oximetry and transcutaneous partial pressure of carbon dioxide. If SAGEA was diagnosed, parents were encouraged to seek medical intervention for SAGEA. School grades of all participating children for the school year preceding and after the overnight study were obtained.

Results. SAGEA was identified in 54 children (18.1%). Of these, 24 underwent surgical tonsillectomy and adenoidectomy (TR), whereas in the remaining 30 children, parents elected not to seek any therapeutic intervention (NT). Overall mean grades during the second grade increased from 2.43 ± 0.17 (SEM) to 2.87 ± 0.19 in TR, although no significant changes occurred in NT (2.44 ± 0.13 to 2.46 ± 0.15). Similarly, no academic improvements occurred in children without SAGEA.

Conclusions. SAGEA is frequently present in poorly performing first-grade students in whom it adversely affects learning performance. The data suggest that a subset of children with behavioral and learning disabilities could have SAGEA and may benefit from prospective medical evaluation and treatment.

PEDIATRICS®

Sleep and Daytime Behavior in Children With Obstructive Sleep Apnea and Behavioral Sleep Disorders

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Abstract

Objective. The purpose of this study was: 1) to examine both bedtime sleep behaviors and daytime behaviors associated with daytime sleepiness in a group of children with a primary medical sleep disorder (obstructive sleep apnea syndrome [OSAS]) compared with a group of children with a primary behavioral sleep disorder (BSD) (limit setting sleep disorder or sleep onset association disorder); and 2) to investigate the impact of a comorbid BSD on sleep and daytime behavioral consequences of OSAS.

Methods. Children referred to a pediatric sleep disorders clinic during a 3-year period with a primary diagnosis of either polysomnographically-confirmed OSAS ($n = 100$) or a BSD ($n = 52$) were compared on several parent report measures assessing the following domains: symptoms of sleep disordered breathing, other sleep behaviors (primarily parasomnias), bedtime behaviors, and externalizing daytime behavior problems. The OSAS sample was then divided into a pure OSAS group ($n = 78$) and an OSAS plus a behavioral sleep diagnosis group ($n = 22$) based on the presence or absence of delayed sleep onset and/or prolonged nightwakings and compared on the parent-report symptom domains.

Results. Almost one-quarter of the OSAS group had clinically significant behavioral sleep problems, primarily bedtime resistance, in addition to OSAS. Bedtime resistance was associated with a significantly shortened sleep duration in both the BSD and OSAS-BSD groups. Although the OSAS-BSD group had less severe disease, as defined by polysomnographic variables, than the pure OSAS group, they were rated by their parents as having more daytime externalizing behavior problems associated with daytime sleepiness.

Conclusions. The results of this study suggest that evaluation for comorbid BSD should be done in all children presenting with symptoms of OSAS. The coexistence of such BSDs may contribute significantly to sleep deprivation, and thus to behavioral manifestations of daytime sleepiness in these children.

[Sleep](#). 1997 Dec;20(12):1185-92.

Symptoms of sleep disorders, inattention, and hyperactivity in children.

[Chervin RD](#), [Dillon JE](#), [Bassetti C](#), [Ganoczy DA](#), [Pituch KJ](#).

Source

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Abstract

Children with sleep disorders are often inattentive or hyperactive, and some carry a diagnosis of attention deficit/hyperactivity disorder (ADHD) until their sleep disorder is detected. However, the potential behavioral impact of undiagnosed sleep disorders is not known. We sought to determine whether children with higher levels of inattention and hyperactivity more frequently have symptoms of sleep-related breathing disorders (SRBDs) or periodic limb movement disorder (PLMD). We surveyed parents of 2-18-year-old patients at a child psychiatry clinic (n = 70) and a general pediatrics clinic (n = 73) to assess the children's behavior, snoring, complaints of restless legs at night, and daytime sleepiness. A validated pediatric sleep questionnaire provided the explanatory variables, and a scale for inattention and hyperactivity, derived from the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV), provided the dependent variable. Habitual snoring was more frequent (33%) among children who carried a diagnosis of ADHD than among the other children at the psychiatry or general pediatric clinics (11 and 9%, respectively, chi-square test, $p = 0.01$). Snoring scores, derived from six snoring- and SRBD-related question items, were associated with higher levels of inattention and hyperactivity. The complaint of restless legs and a composite score for daytime sleepiness showed some evidence, though less consistent, of an association with inattention and hyperactivity. The association of snoring with inattention and hyperactivity suggests that SRBDs and perhaps other sleep disorders could be a cause of inattention and hyperactivity in some children. If a causal effect is present, our data suggest that 81% of habitually snoring children who have ADHD--25% of all children with ADHD--could have their ADHD eliminated if their habitual snoring and any associated SRBD were effectively treated.

[Pediatrics](#). 2002 Mar;109(3):449-56.

Inattention, hyperactivity, and symptoms of sleep-disordered breathing.

[Chervin RD](#), [Archbold KH](#), [Dillon JE](#), [Panahi P](#), [Pituch KJ](#), [Dahl RE](#), [Guilleminault C](#).

Source

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Abstract

OBJECTIVE:

Inattention and hyperactivity are frequent among children with sleep-disordered breathing (SDB) and often improve when SDB is treated. However, the frequency of SDB symptoms among inattentive and hyperactive children has received little study.

DESIGN:

Cross-sectional survey.

SETTING:

Two university-affiliated but community-based general pediatrics clinics.

PATIENTS:

Patients consisted of N = 866 children (469 boys), aged 2.0 to 13.9 years (mean: 6.8 plus minus 3.2 years), with clinic appointments.

MEASURES:

A validated Pediatric Sleep Questionnaire assessed for habitual snoring (1 item), snoring severity (a 4-item subscale), sleepiness (4 items), and overall risk of SDB (16 items). Parents also completed 2 common behavioral measures, an inattention/hyperactivity scale (IHS) derived from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, and the hyperactivity index (HI, expressed as a t score) of the Conners' Parent Rating Scale.

RESULTS:

Habitual snoring was reported in 16% (95% confidence interval [CI]: 13, 19) of the participants. High HI scores (>60) were found in 13% (95% CI: 11, 16) of all participants, 22% (95% CI: 15, 29) of habitual snorers, and 12% (95% CI: 9, 14) of nonsnorers. Odds ratios between HI >60 and each of the following were: habitual snoring, 2.2 (95% CI: 1.4, 3.6); 1 additional positive symptom-item on the snoring scale, 1.3 (95% CI: 1.1, 1.5); 1 additional positive item on the sleepiness scale, 1.6 (95% CI: 1.4, 2.0); and a 1-standard deviation increase in the overall SDB score, 1.7 (95% CI: 1.4, 2.0; all odds ratios age- and sex-adjusted). Results were similar for high

IHS scores (>1.25). Stratification by age and sex showed that most of the association with snoring (but not sleepiness) derived from boys <8 years old.

CONCLUSIONS:

Inattention and hyperactivity among general pediatric patients are associated with increased daytime sleepiness and---especially in young boys---snoring and other symptoms of SDB. If sleepiness and SDB do influence daytime behavior, the current results suggest a major public health impact.

American Journal of Respiratory and Critical Care Medicine Vol 168. pp. 464-468, (2003)

Snoring, Intermittent Hypoxia and Academic Performance in Primary School Children

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Sleep-disordered breathing is associated with impaired attention and neurocognitive deficits. We assessed the association of snoring and intermittent hypoxia with poor academic performance in third grade school children (1,144 children). Snoring frequency and intermittent hypoxia were investigated using parental questionnaire and nocturnal home pulse oximetry. Intermittent hypoxia was specified as desaturation events of 90% or less pulse oximeter saturation. Poor academic performance was defined as grade 4–6 on a six-point scale (i.e., approximately the lowest quintile grades) in mathematics, science, reading, spelling, and/or handwriting in the most recent school report. Snoring "always" was significantly associated with poor academic performance in mathematics (odds ratio; 95% confidence interval: 3.6; 1.3–10.1), science (4.3; 1.3–14.6), and spelling (3.5; 1.2–10.3). Snoring "frequently" was also significantly associated with poor academic performance in mathematics (2.4; 1.3–4.7) and spelling (2.0; 1.04–3.8). A significant relationship between snoring and poor academic performance was also found in children without intermittent hypoxia, whereas intermittent hypoxia did not show an independent association with poor academic performance. Thus, habitual snoring (i.e., snoring frequently or always) was associated with poor academic performance in these primary school children.

PEDIATRICS®

Habitual Snoring, Intermittent Hypoxia, and Impaired Behavior in Primary School Children

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Abstract

Objectives. Sleep-disordered breathing is associated with impaired behavior and poor academic performance in children. We aimed to determine the extent of behavioral problems in snoring children, clarify the role of intermittent hypoxia, and test the reversibility of impaired behavior and poor academic performance.

Methods. In 1144 children, habitual snoring (HS; snoring frequently or always) and impaired behavior were assessed using parental questionnaires. Intermittent hypoxia (ie, presence of ≥ 5 arterial oxygen desaturations by $\geq 4\%$ or ≥ 1 desaturation to $\leq 90\%$) was investigated with pulse oximetry. Poor academic performance (grade 4–6 on a 6-point scale in mathematics, science, or spelling) was based on the last school report. HS, impaired behavior, and academic performance were reevaluated after 1 year. Adjusted odds ratios (ORs) were calculated using unconditional logistic regression.

Results. HS was significantly associated with hyperactive (OR: 2.4) and inattentive behavior (OR: 4.0), daytime tiredness (OR: 7.1), and sleepiness (OR: 2.6–4.8). These associations were independent of intermittent hypoxia. HS was also significantly associated with bad conduct (OR:

2.8), emotional symptoms (OR: 5.5), and peer problems (OR: 9.7). At follow-up, hyperactive and inattentive behavior but not academic success had significantly improved in children in whom HS had ceased.

Conclusions. We suggest that impaired behavior is a key feature of HS independent of intermittent hypoxia and improves when HS ceases.

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Inattention, Hyperactivity, and Symptoms of Sleep-Disordered Breathing

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Abstract

Objective. Inattention and hyperactivity are frequent among children with sleep-disordered breathing (SDB) and often improve when SDB is treated. However, the frequency of SDB symptoms among inattentive and hyperactive children has received little study.

Design. Cross-sectional survey.

Setting. Two university-affiliated but community-based general pediatrics clinics.

Patients. Patients consisted of $N = 866$ children (469 boys), aged 2.0 to 13.9 years (mean: 6.8 ± 3.2 years), with clinic appointments.

Measures. A validated Pediatric Sleep Questionnaire assessed for habitual snoring (1 item), snoring severity (a 4-item subscale), sleepiness (4 items), and overall risk of SDB (16 items). Parents also completed 2 common behavioral measures, an inattention/hyperactivity scale (IHS) derived from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, and the hyperactivity index (HI, expressed as a t score) of the Conners' Parent Rating Scale.

Results. Habitual snoring was reported in 16% (95% confidence interval [CI]: 13, 19) of the participants. High HI scores (>60) were found in 13% (95% CI: 11, 16) of all participants, 22% (95% CI: 15, 29) of habitual snorers, and 12% (95% CI: 9, 14) of nonsnorers. Odds ratios between HI >60 and each of the following were: habitual snoring, 2.2 (95% CI: 1.4, 3.6); 1 additional positive symptom-item on the snoring scale, 1.3 (95% CI: 1.1, 1.5); 1 additional positive item on the sleepiness scale, 1.6 (95% CI: 1.4, 2.0); and a 1-standard deviation increase in the overall SDB score, 1.7 (95% CI: 1.4, 2.0; all odds ratios age- and sex-adjusted). Results were similar for high IHS scores (>1.25). Stratification by age and sex showed that most of the association with snoring (but not sleepiness) derived from boys <8 years old.

Conclusions. Inattention and hyperactivity among general pediatric patients are associated with increased daytime sleepiness and—especially in young boys—snoring and other symptoms of SDB. If sleepiness and SDB do influence daytime behavior, the current results suggest a major public health impact.

Journal of Sleep Research

[Volume 13, Issue 2](#), pages 165–172, June 2004

Neurobehavioral correlates of sleep-disordered breathing in children

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Summary

The effects of sleep-disordered breathing (SDB) on neurobehavioral function were examined in two matched groups of children from the general population. Thirty-five children with polysomnographically confirmed SDB were matched for ethnicity, age, gender, maternal educational attainment, and maternal smoking, to healthy children with no evidence of SDB. Children with SDB had significantly lower mean scores on the Differential Ability Scales for General Conceptual Ability (similar to IQ) and for the Non-verbal Cluster. On the neuropsychology assessment battery (NEPSY), children with SDB scored significantly lower than the control group on the attention/executive function domain and two subtests within that domain, one measuring visual attention and the other executive function. In addition, children with SDB scored significantly lower than the controls on one subtest from the NEPSY language domain: Phonological Processing. This subtest measures phonological awareness, a skill that is critical for learning to read. No differences in behavior, as measured by the Child Behavior Checklist (CBCL) or the Conners' Parent Rating Scale, were found between the two groups. Using a novel algorithm to assess sleep pressure, we found that children with SDB were significantly sleepier than controls. Furthermore, total arousal index was negatively correlated with neurocognitive abilities, suggesting a role for sleep fragmentation in pediatric SDB-induced cognitive dysfunction.

[The Journal of Pediatrics](#)

[Volume 125, Issue 4](#), October 1994, Pages 556-562

Determinants of growth in children with the obstructive sleep apnea syndrome

Presented in part at the annual meeting of the American Thoracic Society, San Francisco, Calif., May 1993.

**Carole L. Marcus MBBCh, John L. Carroll MD, Celide B. Koerner MS, RD,
Audrey Hamer, Janita Lutz, Gerald M. Loughlin MD**

Abstract

Failure to thrive is a common complication of childhood obstructive sleep apnea syndrome (OSAS). To further evaluate its cause, we obtained 3-day dietary records, anthropometric measurements, polysomnography, and measurements of energy expenditure during sleep (SEE) in children with OSAS before and after tonsillectomy and adenoidectomy. Fourteen children were studied (mean age, 4 ± 1 [SD] years). During initial polysomnography, patients had 6 ± 3 episodes of obstructive apnea/hr, an arterial oxygen saturation nadir of $85\% \pm 8\%$, and peak end-tidal carbon dioxide tension of 52 ± 6 mm Hg. After surgery, OSAS resolved in all patients. The standard deviation score (z score) for weight increased from -0.30 ± 1.47 to 0.04 ± 1.34 ($p < 0.005$), despite unaltered caloric intake (91 ± 30 vs 90 ± 27 kcal/kg per day; not significant). The initial SEE (averaged over all sleep states) was 51 ± 6 kcal/kg per day; postoperatively, it decreased to 46 ± 7 kcal/kg per day ($p < 0.005$). Although SEE decreased during all sleep stages, the greatest

decrease occurred during rapid eye movement sleep. The patients with the highest SEE on initial study had the lowest z scores ($r = -0.62$; $p < 0.05$). We conclude that SEE decreases and weight improves after resolution of OSAS. We speculate that the poor growth seen in some children with OSAS is secondary to increased caloric expenditure caused by increased work of breathing during sleep. (J PEDIATR 1994;125:556-62)

[The Journal of Pediatrics](#)

[Volume 146, Issue 6](#), June 2005, Pages 780-786

Neuropsychological and Psychosocial Function in Children with a History of Snoring or Behavioral Sleep Problems

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Received 14 July 2004; revised 10 November 2004; Accepted 21 January 2005. Available online 22 June 2005.

Objectives

To compare neuropsychological and psychosocial function in children with a history of snoring, children with a history of behavioral sleep problems (BSP), children with both a history of snoring and BSP, and a group of control subjects.

Study design

Families awaiting consultation for “sick” visits in 5 general practice clinics completed the Sleep Disturbance Scale for Children. A subset of children were categorized into groups: Snorers ($n = 11$), BSP ($n = 13$), Snorers+BSP ($n = 9$), and controls ($n = 31$). Children underwent psychological (Wechsler Abbreviated Scale of Intelligence, Children's Memory Scale; Test of Everyday Attention and Auditory Continuous Performance Test) and psychosocial assessment (Child Behavior Checklist).

Results

With analysis of variance, it was revealed that, compared with children in the BSP and control groups, those in the Snorers+BSP and Snorers groups showed reduced intelligence and attention scores. By contrast, compared with children in the Snorers and control groups, children in the Snorers+BSP and BSP groups reported reduced social competency, increased problematic behavior, and reduced memory scores. Children in the combination of Snorers+BSP group showed more deficits than children in all other groups.

Conclusion

In children, snoring and BSP, separately and together, are associated with impaired neuropsychological and psychosocial functioning. Furthermore, snoring and BSP are related to performance in disparate ways. Snoring was associated with intelligence and attention deficits, whereas BSP was associated with memory and behavioral deficits.

Keywords: BSP, Behavioral sleep problems; SDB, Sleep disordered breathing; SDSC, Sleep Disorders Scale for Children; IQ, Intelligence; ACPT, Auditory Continuous Performance Test; TEA-Ch, Test of Everyday Attention in Children; CBCL, Child Behavior Checklist

Correlates of Respiratory Cycle-Related EEG Changes in Children with Sleep-Disordered Breathing

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Study Objectives: To explore newly-identified respiratory cycle-related electroencephalographic changes (RCREC), which may represent microarousals, as correlates of neurobehavioral outcomes in children with sleep-disordered breathing (SDB).

Design: Retrospective.

Setting: University sleep laboratory.

Participants: Ten research subjects, aged 6 to 10 years, with and without SDB.

Intervention: Polysomnography, Multiple Sleep Latency Tests, and tests of auditory attention before and after clinically-indicated tonsillectomy (n = 9) or hernia repair (n = 1, control).

Measurements: For the first 3 hours of nocturnal sleep, a computer algorithm quantified the degree to which delta, theta, and alpha electroencephalographic power varied within non-apneic respiratory cycles.

Correlations between the RCREC and standard objective measures of

SDB, sleepiness, and attention were explored.

Results: Five children had SDB (> 1 obstructive apnea per hour of sleep). Preoperative delta, theta, or alpha RCREC were statistically significant ($P < .01$) in all subjects except 1 without SDB and the 1 control. Theta RCREC correlated with rates of apneas and hypopneas ($P = .01$) and decreased after the apnea was treated. Postoperative changes in delta and theta RCREC predicted changes in Multiple Sleep Latency Test scores ($\rho = -0.84$, $P = .002$; $\rho = -0.64$, $P = .05$), whereas changes in rates of apneas and hypopneas did not ($\rho = -0.24$, $P = .50$). Postoperative changes in attention tended to correlate with changes in delta RCREC ($\rho = -0.54$, $P = .11$) more strongly than with changes in rates of apneic events ($\rho = -0.07$, $P = .84$).

Conclusions: The RCREC may reflect brief but numerous microarousals that could help to explain neurobehavioral consequences of SDB.

Citation: Chervin RD; Burns JW; Subotic NS et al. Correlates of respiratory cycle-related EEG changes in children with sleep-disordered breathing.

SLEEP 2004;27(1):116-21.

Journal of Clinical and Experimental Neuropsychology

[Volume 22](#), [Issue 5](#), 2000 pages 554-568

Behavior and Neurocognitive Performance in Children Aged 5-10 Years Who Snore Compared to Controls

10.1076/1380-3395(200010)22:5;1-9;FT554

[Sarah Blunden](#), [Kurt Lushington](#), [Declan Kennedy](#), [James Martin](#) & [Drew Dawson](#)

Abstract

Sleep disordered breathing in children is a common but largely underdiagnosed problem. It ranges in severity from primary snoring to obstructive sleep apnea syndrome (OSAS). Preliminary evidence suggests that children with severe OSAS show reduced neurocognitive performance, however, less is known about children who snore but do not have severe upper airway obstruction. Participants included 16 children referred to the Ear, Nose and Throat/Respiratory departments of a Children's Hospital for evaluation of snoring and 16 non-snoring controls aged 5-10 years. Overnight polysomnography (PSG) was carried out in 13 children who snored and 13 controls. The PSG confirmed the presence of primary snoring in seven and very mild OSAS (as evidenced by chest wall paradox) in eight children referred for snoring while controls showed a normal sleep pattern. To test for group differences in

neurocognitive functioning and behavior, children underwent one day of testing during which measures of intelligence, memory, attention, social competency, and problematic behavior were collected. Compared to controls, children who snored showed significantly impaired attention and, although within the normal range, lower memory and intelligence scores. No significant group differences were observed for social competency and problematic behavior. These findings suggest that neurocognitive performance is reduced in children who snore but are otherwise healthy and who do not have severe OSAS. They further imply that the impact of mild sleep disordered breathing on daytime functioning may be more significant than previously realized with subsequent implications for successful academic and developmental progress.

[Journal of the American Academy of Child & Adolescent Psychiatry](#)

[Volume 39, Issue 4](#), April 2000, Pages 495-501

Instability of Sleep Patterns in Children With Attention-Deficit/Hyperactivity Disorder

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ABSTRACT

Objective

To compare the stability of the sleep-wake system of children with attention-deficit/hyperactivity disorder (ADHD) and controls by objective and subjective measures.

Method

Thirty-eight school-age boys with diagnosed ADHD and 64 control school-age boys were examined using actigraphic monitoring and sleep diaries, over 5 consecutive nights.

Results

Increased instability in sleep onset, sleep duration, and true sleep were found in the ADHD group compared with the control group. Discriminant analysis revealed that children's classification (ADHD versus control) could be significantly predicted on the basis of their sleep measures.

Conclusions

The findings support the hypothesis that instability of the sleep-wake system is a characteristic of children with ADHD. Given the potential negative effects of disturbed or unstable sleep on daytime functioning, it is recommended that a thorough sleep assessment be conducted when a sleep disturbance is suspected or when symptoms associated with daytime sleepiness or decreased arousal level are present.

[The Journal of Pediatrics](#)

[Volume 145, Issue 4](#), October 2004, Pages 458-464

Sleep-disordered breathing symptoms are associated with poorer cognitive function in 5-year-old children

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Abstract

Objective

To assess the relation of sleep-disordered breathing (SDB) symptoms in children to neurocognitive function.

Study design

A cross-sectional, population-based study of 205 5-year-old children. A parent-completed questionnaire was used to ascertain SDB symptoms, defined as frequent snoring, loud or noisy breathing during sleep, or witnessed sleep apnea. Polysomnography (PSG) data were available in 85% of children. Standardized neurocognitive tests were administered by a trained psychometrist unaware of the children's SDB status. Children with ($n = 61$) and without SDB symptoms were compared using analysis of variance to adjust for demographic and respiratory health variables.

Results

Children with SDB symptoms scored significantly lower than those without SDB symptoms on tests of executive function (95.5 vs 99.9 on NEPSY Attention/Executive Core Domain, $P = .02$; 10.4 vs 11.2 on Wechsler Preschool and Primary Scale of Intelligence, Revised [WPPSI-R] Animal Pegs test, $P = .03$), memory (96.8 vs 103.0 on NEPSY Memory Domain, $P = .02$), and general intellectual ability (105.9 vs 111.7 on WPPSI-R Full Scale IQ, $P = .02$). There were no significant differences on a computerized continuous performance task. These findings persisted when children with PSG evidence of obstructive sleep apnea (OSA) were excluded from analysis.

Conclusion

Even in the absence of OSA, SDB symptoms are associated with poorer executive function and memory skills and lower general intelligence in 5-year-old children.

Abbreviations: ADHD, Attention deficit-hyperactivity disorder; AHI, Apnea-Hypopnea Index; CPRS, Conners' Parent Rating Scale, Long Form; CPT, Continuous performance task; FYFQ, Five-year follow-up questionnaire; ICPS, Infant Care Practices Study; MANOVA, Multivariate analysis of variance; OAI, Obstructive Apnea Index; OSA, Obstructive sleep apnea; PSG, Polysomnography; PSQ, Pediatric Sleep Questionnaire; SDB, Sleep-disordered breathing; WPPSI-R, Wechsler Preschool and Primary Scale of Intelligence, Revised

PEDIATRICS®

Snoring During Early Childhood and Academic Performance at Ages Thirteen to Fourteen Years

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Abstract

Objectives. Obstructive sleep apnea syndrome in young children is associated with an adverse effect on learning. However, the long-term impact of sleep-disordered breathing (SDB) during early childhood on learning remains unknown.

Methods. Questionnaires were mailed to seventh and eighth graders attending public schools whose class ranking was either in the top 25% (high performance [HP]) or bottom 25% of their class (low performance [LP]), and who were matched for age, gender, race, school, and street of

residence. Snoring frequency and loudness at 2 to 6 years of age, tonsillectomy and adenoidectomy (T&A) for snoring or recurrent infection, school grades, and parental smoking and snoring were assessed.

Results. The questionnaire response rate was 82.8%. Because of ongoing snoring, 13 responders were excluded, such that 1588 questionnaires could be analyzed (797 in LP and 791 in HP group). Frequent and loud snoring during early childhood was reported in 103 LP children (12.9%) compared with 40 HP children (5.1%; odds ratio: 2.79; confidence interval: 1.88–4.15). Furthermore, 24 LP and 7 HP children underwent T&A for snoring (odds ratio: 3.40; confidence interval: 1.47–7.84), while 21 LP and 19 HP children required surgery for recurrent tonsillitis.

Conclusions. Children with lower academic performance in middle school are more likely to have snored during early childhood and to require T&A for snoring compared with better performing schoolmates. These findings support the concept that SDB-associated neurocognitive morbidity may be only partially reversible or that a “learning debt” may develop with SDB during early childhood and hamper subsequent school performance.

Child Behavior and Quality of Life Before and After Tonsillectomy and Adenoidectomy

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Arch Otolaryngol Head Neck Surg. 2002;128:770-775.

Objective To determine the relationship between child behavior and quality of life before and after tonsillectomy and adenoidectomy by means of a standardized assessment of child behavior, the Child Behavior Checklist (CBCL), and a validated quality-of-life survey of pediatric obstructive sleep apnea, the OSA-18.

Design Before-after study.

Setting Hospital-based pediatric otolaryngology practice in a metropolitan area.

Participants Sixty-four children (mean [SD] age, 5.8 [3.1] years; 36 boys, 28 girls) who underwent tonsillectomy and adenoidectomy for treatment of sleep-disordered breathing or recurrent tonsillitis.

Intervention Parents or caretakers completed the OSA-18 and the CBCL for ages 2 to 3 years or 4 to 18 years before surgery and 3 months postoperatively.

Main Outcome Measures The OSA-18 mean survey scores and change scores, and the CBCL total problem T scores and change in total problem T scores.

Results The mean (SD) preoperative OSA-18 score was 3.9 (1.5) and change score was 2.3 (95% confidence interval, 1.9-2.7). The mean total problem score was 7.3 points lower

after surgery (95% confidence interval, 4.9-9.7), indicating a significant decrease ($P < .001$, matched t test). The preoperative CBCL total problem score was consistent with abnormal behavior for 16 children (25%), but only 5 children (8%) scored in the abnormal range postoperatively ($P = .03$, log-likelihood ratio test). The OSA-18 preoperative mean survey score had fair to good correlation with the preoperative CBCL total problem T score ($r = 0.50$, $P < .001$, Pearson correlation), and the OSA-18 change score had fair to good correlation with the change in CBCL total problem T score ($r = 0.54$, $P < .001$, Pearson correlation).

Conclusions Behavioral and emotional difficulties are found in children with sleep-disordered breathing before treatment and improve after intervention. Scores on a standardized measure of assessment of behavior demonstrate significant correlation with scores on a validated quality-of-life instrument.

Journal of the International Neuropsychological Society

- [Journal of the International Neuropsychological Society](#) (2003), 9: 1016-1026

Learning in children and sleep disordered breathing: Findings of the Tucson Children's Assessment of Sleep Apnea (TuCASA) Prospective Cohort Study

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Abstract

We examined the relationship between nocturnal respiratory disturbance and learning and compared learning in children with and without nocturnal respiratory disturbance. Subjects were 149 participants in a prospective cohort study examining sleep in children ages 6–12: The Tucson Children's Assessment of Sleep Apnea study (TuCASA). Sleep was assessed via home polysomnography. Intelligence, learning and memory, and academic achievement were assessed. Parents rated attention. Group comparisons were used to test the hypothesis that the group with

an apnea/hypopnea index (AHI) of 5 or more ($n = 77$) would have weaker performance than the group with AHI less than 5 ($n = 72$). The group with AHI of 5 or more had weaker learning and memory though differences between groups decreased when arousals were taken into account. There was a greater percentage of Stage 1 sleep in the AHI 5 or more group, and Stage 1 percentage was negatively related to learning and memory in the sample ($n = 149$). There were negative relationships between AHI and immediate recall, Full Scale IQ, Performance IQ, and math achievement. Hypoxemia was associated with lower Performance IQ. Thus, findings suggest that nocturnal respiratory disturbance is associated with decreased learning in otherwise healthy children, that sleep fragmentation adversely impacts learning and memory, and that hypoxemia adversely influences nonverbal skills. (*JINS*, 2003, 9, 1016–1026.)

Impact of Tonsillectomy and Adenoidectomy on Child Behavior

Nira A. Goldstein, MD; J. Christopher Post, MD; Richard M. Rosenfeld, MD, MPH; Thomas F. Campbell, PhD

Arch Otolaryngol Head Neck Surg. 2000;126:494-498.

Objective To measure the impact of tonsillectomy and adenoidectomy (T&A) on children's behavioral and emotional problems using a standardized assessment.

Design Prospective study.

Setting Tertiary care children's hospital.

Patients Thirty-six children, aged 2 through 18 years, with symptoms of nighttime snoring, observed apneas, and daytime mouth breathing and physical examination results demonstrating 3+ or 4+ tonsils scheduled for T&A.

Intervention Parents completed a standard survey of their children's symptoms of sleep apnea and a standardized measure of children's competencies and problems, the Child Behavior Checklist for ages 2 through 3 years or 4 through 18 years, before T&A and 3 months postoperatively.

Main Outcome Measure The Child Behavior Checklist total problem score.

Results The preoperative Child Behavior Checklist total problem score was consistent with abnormal behavior for 10 children (28%). After T&A ($n=15$), only 2 scores were abnormal, but the change was not statistically significant. In contrast, the mean total problem score was 7.5 points lower after surgery (95% confidence interval, 5.1-9.7), indicating a significant decrease ($P<.001$, matched t test).

Conclusions This pilot study demonstrates a high prevalence (28%) of abnormal behavior in children undergoing T&A for chronic upper airway obstruction. Scores on a standardized measure of behavior improve following T&A, but larger studies with increased statistical power are needed to clarify the degree of improvement and its clinical importance.

From the Division of Pediatric Otolaryngology, State University of New York Health Science Center at Brooklyn (Drs Goldstein and Rosenfeld); Department of Pediatric Otolaryngology, Allegheny General Hospital, Pittsburgh, Pa (Dr Post); and Department of Communication Science and Disorders, University of Pittsburgh, and Department of Audiology and Communication Disorders, Children's Hospital of Pittsburgh (Dr Campbell).

Cognitive Executive Dysfunction in Children with Mild Sleep-Disordered Breathing

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Abstract

In children, moderate or severe sleep-disordered breathing (SDB) may impair cognitive executive functions (EFs), including working memory, attention, and mental flexibility. The main objective of this study was to assess EFs in children with mild levels of SDB. Subjects for this descriptive study were 12 children (5 girls, 7 boys) aged 8.0 to 11.9 years ($M = 9.0 \pm 0.85$) participating in an ongoing study of the effects of adenotonsillectomy on behavior. Each subject had a nocturnal polysomnogram (PSG) and multiple sleep latency test (MSLT). Mild SDB was considered present if the child's apnea/hypopnea index (AHI) was ≥ 1 and < 10 . Between MSLT nap attempts, each child completed standardized tests of EFs. The sample showed significant impairment of sustained attention and vigilance on a computerized continuous performance test. Children with low mental flexibility scores on the Children's Category Test (CCT) spent more time in stage 1 sleep (12.2% v. 9.5%, $P = 0.028$ on PSG) and showed a marginally higher arousal index (9.7 v. 6.5, $P = 0.06$ on PSG) than children with average or above-average CCT

scores. AHI accounted for significant proportion of the variance in CCT scores when 1 outlier was removed ($N = 11$, $Rsq = 0.67$, $P = 0.002$). Mild levels of SDB and associated sleep architecture disruptions may be associated with impairment of EFs in children.

Cognition, sleep and respiration in at-risk children treated for obstructive sleep apnoea

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Abstract

Sleep-disordered breathing in children has been associated with cognitive impairment. The purpose of this study was to examine the impact of tonsillectomy and adenoidectomy (T&A) on sleep, respiration and cognitive function in children of pre-school age with obstructive sleep apnoea (OSA) from a low-income community population.

Altogether, 19 children attending state-funded pre-school programmes underwent overnight polysomnography and cognitive assessment before and following surgical treatment for OSA; 19 matched controls were also assessed.

Following T&A, OSA subjects' delta sleep increased, rapid eye movement sleep decreased, and respiratory and arousal indices improved. There were no significant differences in OSA subjects' post-operative sleep or respiratory measures compared to controls. Prior to T&A, cognitive scores were significantly lower in OSA subjects *versus* controls; following T&A, OSA subjects' scores improved compared to pre-operative scores and did not differ from those of matched controls.

Following tonsillectomy and adenoidectomy, at-risk pre-schoolers recruited directly from the community showed normalised sleep and respiratory patterns and improved cognitive scores. These findings, in this uniquely vulnerable population, which is unlikely to seek evaluation and treatment for obstructive sleep apnoea, underscore the potential value of outreach screening

programmes for sleep-disordered breathing, particularly among low-income groups of pre-school age.

[International Journal of Pediatric Otorhinolaryngology](#)

[Volume 70, Issue 3](#), March 2006, Pages 395-406

Behavior, neurocognition and quality-of-life in children with sleep-disordered breathing

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Summary

Objectives

To summarize current evidence that sleep-disordered breathing in children is associated with behavioral, neurocognitive and quality-of-life problems and to suggest new lines of investigation for future research on sleep-disordered breathing and behavior.

Methods

A comprehensive review of the medical literature between January 1990 and December 2004 was performed using the National Library of Medicine's PUBMED database.

Results

Analysis revealed 33 articles that satisfied the inclusion and exclusion criteria. The total study population in these articles was 22,255 children. Sample sizes per study ranged from 12 to 5728 children. The age range was 2–18 years (mean 6.8 ± 2.8). The majority of studies examined behavior, neurocognition or quality-of-life as a single outcome measure. Behavioral problems included reduced attention, hyperactivity, increased aggression, irritability, emotional and peer problems, and somatic complaints. The following neurocognitive skills were affected: memory; immediate recall; visual-spatial functions; attention and vigilance; mental flexibility; and intelligence. The quality-of-life of children with sleep-disordered breathing was similar that of children with asthma or rheumatoid arthritis. Improvements in behavior, neurocognition and

quality-of-life scores for children with sleep-disordered breathing were seen after adenotonsillectomy.

Conclusions

There is compelling evidence that sleep-disordered breathing in children is associated with behavioral and neurocognitive problems and leads to reduced quality-of-life. In addition to improvements in sleep, adenotonsillectomy is associated with improvements in behavior, neurocognition and quality-of-life in these children. However, the lack of uniform criteria for the diagnosis of sleep-disordered breathing in children and variation in methods used to assess the outcome of surgical therapy limit our current knowledge and should be addressed by future research. The high prevalence of sleep-disordered breathing in children should make this research a public health priority.

Keywords: Pediatric sleep apnea; Adenotonsillectomy; Polysomnography; Behavior; Cognition; Quality-of-life

Child Behavior and Quality of Life in Pediatric Obstructive Sleep Apnea

Khoa D. Tran, MD; Cuong D. Nguyen, BA; Jeremy Weedon, PhD; Nira A. Goldstein, MD

Arch Otolaryngol Head Neck Surg. 2005;131:52-57.

Objective To assess behavior and quality of life in children with obstructive sleep apnea (OSA) undergoing tonsillectomy and adenoidectomy compared with control children.

Design Prospective controlled study.

Setting Hospital-based pediatric otolaryngology practice.

Participants Forty-two children (25 boys and 17 girls; mean [SD] age, 5.8 [2.5] years) with OSA confirmed by positive findings on polysomnography undergoing tonsillectomy and adenoidectomy and 41 control children (29 boys and 12 girls; mean [SD] age, 7.3 [3.8] years) with no history of snoring undergoing unrelated elective surgery.

Interventions Parents completed the standardized Child Behavior Checklist and a validated pediatric OSA quality-of-life survey before and 3 months after surgery.

Main Outcome Measures Child Behavior Checklist T scores and score classifications and quality-of-life survey mean scores.

Results Change in mean total problem T score was significantly greater in the OSA group (from 51.6 at baseline to 48.3 at follow-up) than in controls (from 45.5 at baseline to 46.7 at follow-up) ($P = .03$). The improvement in total T score classification (normal vs borderline

or abnormal) was significant for children with OSA compared with control children ($P = .009$). Children with OSA had significant improvements in the quality-of-life survey mean total score and all individual domain scores compared with controls ($P < .001$).

Conclusions Behavioral and emotional difficulties are found in children with documented OSA compared with control children, and they improve after treatment. Large improvements in disease-specific quality of life are also found. Scores on a standardized measure of behavior assessment demonstrated significant correlation with scores on a validated quality-of-life instrument.

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Daytime Sleepiness and Hyperactivity in Children With Suspected Sleep-Disordered Breathing

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Abstract

Objectives. Excessive daytime sleepiness (EDS) is seen less frequently as a presenting complaint in children with sleep-disordered breathing than in adults. Instead, symptoms of hyperactivity are often described. We hypothesized that children with suspected sleep-disordered breathing (S-SDB) were both sleepier and more hyperactive than control subjects. Furthermore, we hypothesized that overnight polysomnographic parameters correlated with sleepiness and hyperactivity.

Methods. A cross-sectional study was conducted at a university-affiliated hospital and a community-based pediatric clinic. A total of 108 patients with S-SDB (mean [standard deviation] age: 7 ± 4 years) and 72 control subjects (8 ± 4 years) were recruited. A modified Epworth Sleepiness Scale (ESS) and the Conners Abbreviated Symptom Questionnaire were administered. Polysomnography was performed in patients with S-SDB.

Results. Patients with S-SDB had a higher ESS (8.1 ± 4.9 vs 5.3 ± 3.9) and a higher Conners score (12.8 ± 7.6 vs 9.0 ± 6.2) than control subjects. On the basis of adult criteria, 28% of patients had EDS. There was no difference in the ESS and Conners scores of patients with primary snoring and patients with obstructive sleep apnea. The ESS had weak correlations with polysomnographic parameters.

Conclusions. Although the ESS score of children with S-SDB was within the normal range for adults, these children were sleepier and more hyperactive than control subjects. However, these data should be confirmed by a population-based study.

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Nocturnal Arterial Oxygen Saturation and Academic Performance in a Community Sample of Children

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Abstract

Objective. Hypoxemia, often assessed via pulse oximetry, is associated with neurocognitive deficits in children. The best way to qualify hypoxemia, or which level of hypoxemia already affects cognition, is unknown.

Methods. We assessed the association of pulse oximetry-derived variables that qualify hypoxemia with impaired academic performance in mathematics in a population-based cross-section of 995 primary school children who underwent overnight home recordings of motion-resistant new-generation pulse oximeter saturation (SpO₂). Impaired academic performance in

mathematics was based on the last school report and defined as grade 4 to 6 on a 6-point scale (ie, approximately the lowest quintile grades).

Results. Of 10 variables under study, only the nadir of the SpO_2 values was significantly associated with impaired performance. Categories of this variable representing mild (ie, 91%–93% SpO_2 ; odds ratio: 1.65; 95% confidence interval: 1.06–2.56) and moderate hypoxemia (ie, $\leq 90\%$ SpO_2 ; odds ratio: 2.28; 95% confidence interval: 1.30–4.01) both were associated with impaired performance in mathematics.

Conclusions. We suggest using the nadir of the SpO_2 values in an overnight study to qualify hypoxemia in future studies. This variable may predict neurocognitive deficits in school children. Mild hypoxemia, as yet widely considered benign, may already affect cognition in childhood.

[Sleep Medicine](#)

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Prevalence of recurrent otitis media in habitually snoring school-aged children

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Abstract

Introduction

The pathophysiology of obstructive sleep apnea (OSA) and recurrent otitis media (ROM) is intimately associated with the presence of adenotonsillar hypertrophy in children. However, it remains unclear whether habitually snoring children have a higher prevalence of ROM and whether they require tympanostomy tube placement more frequently.

Methods

Questionnaires collected from parental surveys of 5- to 7-year-old children attending the public schools in Louisville, KY were retrospectively reviewed for the presence of habitual snoring (HS), ROM, and the need for tympanostomy tube insertion.

Results

There were 16,321 surveys with complete datasets (51.2% boys; 18.6% African American (AA) with a mean age of 6.2 ± 0.7 years). Of these children, 1844 (11.3%) were HS (53% boys; 25.9% AA); and, of these, 827 HS had also a positive history of ROM (44.8%) with a slight predominance in males (55%). In addition, 636 of these children underwent placement of tympanostomy tubes (i.e., 34.4% of all HS and 76.9% of ROM). Among the 14,477 non-snoring children (NS), ROM was reported in 4247 NS children (29.3%; $p < 0.000001$; odds ratio [OR]: 1.95; confidence interval [CI]: 1.77–2.16) of which 57.6% were boys, and 1969 NS with ROM underwent tympanostomy tube placement (i.e., 46.3% of those with ROM and 13.6% of all non-snoring children). Thus, the risk for tympanostomy tube placement was also greater among HS compared to NS children ($p < 0.00001$; OR: 2.19; CI: 1.98–2.43).

Conclusions

Habitual snoring is associated with a significant increase in the prevalence of recurrent otitis media and the need for tympanostomy tube placement. Further studies aiming to assess the prevalence of obstructive sleep apnea among children with ROM are needed.

[Sleep Medicine Reviews](#)

[Volume 10, Issue 2](#), April 2006, Pages 109-118

The contribution of intermittent hypoxia, sleep debt and sleep disruption to daytime performance deficits in children: Consideration of respiratory and non-respiratory sleep disorders

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Summary

In children, the most abundant available information regarding the effects of paediatric sleep disturbance on daytime function has been obtained by studying children with sleep disordered breathing (SDB). The purported underlying pathophysiological mechanisms responsible for these deficits include hypoxia secondary to obstructive apneas/hypopneas and/or disrupted sleep

architecture from frequent arousals during sleep. This review will present evidence that, while hypoxia is likely to play a role for many children with SDB, sleep disruption is an important and often overlooked factor that can contribute to daytime deficits in children with SDB. Indeed, sleep deprivation and disruption appear to have a potent impact on the daytime functioning of the much larger number of children with non-respiratory sleep disorders. It is concluded that sleep deprivation, sleep disruption, and intermittent hypoxia independently may be sufficient to cause daytime effects in vulnerable children, and the combination of two or more of these factors can result in particularly impaired daytime functioning. These conclusions have significant implications for research and clinical practice.

Keywords: Children; Sleep disorders; Sleep disordered breathing; Behavioural disturbance; School performance; Emotional disturbance; Cognitive deficits

Abbreviations: ADHD, attention deficit hyperactivity disorder; AHI, apnea hypopnea index; BEARS, Bedtime, Excessive Daytime Sleepiness, Awakenings, Regularity, Snoring; O

Childhood Obstructive Sleep Apnea Associates with Neuropsychological Deficits and Neuronal Brain Injury

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Background

Childhood obstructive sleep apnea (OSA) is associated with neuropsychological deficits of memory, learning, and executive function. There is no evidence of neuronal brain injury in children with OSA. We hypothesized that childhood OSA is associated with neuropsychological performance dysfunction, and with neuronal metabolite alterations in the brain, indicative of neuronal injury in areas corresponding to neuropsychological function.

Methods and Findings

We conducted a cross-sectional study of 31 children (19 with OSA and 12 healthy controls, aged 6–16 y) group-matched by age, ethnicity, gender, and socioeconomic status. Participants underwent polysomnography and neuropsychological assessments. Proton magnetic resonance spectroscopic imaging was performed on a subset of children with OSA and on matched controls. Neuropsychological test scores and mean neuronal metabolite ratios of target brain areas were compared.

Relative to controls, children with severe OSA had significant deficits in IQ and executive functions (verbal working memory and verbal fluency). Children with OSA demonstrated decreases of the mean neuronal metabolite ratio N-acetyl aspartate/choline in the left hippocampus (controls: 1.29, standard deviation [SD] 0.21; OSA: 0.91, SD 0.05; $p = 0.001$) and right frontal cortex (controls: 2.2, SD 0.4; OSA: 1.6, SD 0.4; $p = 0.03$).

Conclusions

Childhood OSA is associated with deficits of IQ and executive function and also with possible neuronal injury in the hippocampus and frontal cortex. We speculate that untreated childhood OSA could permanently alter a developing child's cognitive potential.

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SUBJECTIVE SLEEPINESS AND POLYSOMNOGRAPHIC CORRELATES IN CHILDREN SCHEDULED FOR ADENOTONSILLECTOMY VS. OTHER SURGICAL CARE

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Abstract

Study Objectives: To compare a validated subjective measure of childhood sleepiness to an objective determination, assess the frequency of problematic sleepiness among children with suspected sleep-disordered breathing (SDB), and examine what standard or investigational polysomnographic measures of SDB predict subjective sleepiness.

Design: Prospective, cross-sectional

Setting: University-based sleep disorders laboratory

Participants: Washtenaw County Adenotonsillectomy Cohort

Intervention: Polysomnography followed by Multiple Sleep Latency Tests in 103 children 5-12 years old: 77 were scheduled for clinically-indicated adenotonsillectomy, usually for suspected SDB, and 26 for unrelated surgical care. Parents completed the previously-validated, 4-item Pediatric Sleep Questionnaire–Sleepiness Subscale (PSQ-SS).

Results: Thirty-three (43%) of the adenotonsillectomy children had high PSQ-SS scores, in comparison to only 3 (12%) of the controls ($p=0.004$). The PSQ-SS scores correlated inversely with mean sleep latencies on the Multiple Sleep Latency Tests ($\rho=-0.23$, $p=0.006$). The obstructive apnea index, apnea/hypopnea index, and respiratory disturbance index (which included respiratory event-related arousals identified by esophageal pressure monitoring) each correlated similarly with PSQ-SS scores, as did investigational quantification of esophageal pressures and respiratory cycle-related EEG changes (each $\rho\approx 0.30$, $p<0.02$). A stepwise regression identified sigma-frequency respiratory cycle-related EEG changes as the strongest independent predictor of subjective sleepiness among all subjects, and particularly those without obstructive sleep apnea.

Conclusions: Sleepiness is a frequent problem among children with suspected SDB. Subjective sleepiness (PSQ-SS) reflects Multiple Sleep Latency Test results to a limited extent, as in adults. Standard polysomnographic measures of SDB predict subjective sleepiness, but respiratory cycle-related EEG changes may offer additional clinical utility.

PEDIATRICS*

Increased Cerebral Blood Flow Velocity in Children With Mild Sleep-Disordered Breathing: A Possible Association With Abnormal Neuropsychological Function

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Abstract

OBJECTIVE. Sleep-disordered breathing describes a spectrum of upper airway obstruction in sleep from simple primary snoring, estimated to affect 10% of preschool children, to the syndrome of obstructive sleep apnea. Emerging evidence has challenged previous assumptions that primary snoring is benign. A recent report identified reduced attention and higher levels of social problems and anxiety/depressive symptoms in snoring children compared with controls. Uncertainty persists regarding clinical thresholds for medical or surgical intervention in sleep-disordered breathing, underlining the need to better understand the pathophysiology of this condition. Adults with sleep-disordered breathing have an increased risk of cerebrovascular disease independent of atherosclerotic risk factors. There has been little focus on cerebrovascular function in children with sleep-disordered breathing, although this would seem an important line of investigation, because studies have identified abnormalities of the systemic vasculature. Raised cerebral blood flow velocities on transcranial Doppler, compatible with raised blood flow and/or vascular narrowing, are associated with neuropsychological deficits in children with

sickle cell disease, a condition in which sleep-disordered breathing is common. We hypothesized that there would be cerebral blood flow velocity differences in sleep-disordered breathing children without sickle cell disease that might contribute to the association with neuropsychological deficits.

DESIGN. Thirty-one snoring children aged 3 to 7 years were recruited from adenotonsillectomy waiting lists, and 17 control children were identified through a local Sunday school or as siblings of cases. Children with craniofacial abnormalities, neuromuscular disorders, moderate or severe learning disabilities, chronic respiratory/cardiac conditions, or allergic rhinitis were excluded. Severity of sleep-disordered breathing in snoring children was categorized by attended polysomnography. Weight, height, and head circumference were measured in all of the children. BMI and occipitofrontal circumference z scores were computed. Resting systolic and diastolic blood pressure were obtained. Both sleep-disordered breathing children and the age- and BMI-similar controls were assessed using the Behavior Rating Inventory of Executive Function (BRIEF), Neuropsychological Test Battery for Children (NEPSY) visual attention and visuomotor integration, and IQ assessment (Wechsler Preschool and Primary Scale of Intelligence Version III). Transcranial Doppler was performed using a TL2-64b 2-MHz pulsed Doppler device between 2 pm and 7 pm in all of the patients and the majority of controls while awake. Time-averaged mean of the maximal cerebral blood flow velocities was measured in the left and right middle cerebral artery and the higher used for analysis.

RESULTS. Twenty-one snoring children had an apnea/hypopnea index <5 , consistent with mild sleep-disordered breathing below the conventional threshold for surgical intervention. Compared with 17 nonsnoring controls, these children had significantly raised middle cerebral artery blood flow velocities. There was no correlation between cerebral blood flow velocities and BMI or systolic or diastolic blood pressure indices. Exploratory analyses did not reveal any significant associations with apnea/hypopnea index, apnea index, hypopnea index, mean pulse oxygen saturation, lowest pulse oxygen saturation, accumulated time at pulse oxygen saturation $<90\%$, or respiratory arousals when examined in separate bivariate correlations or in aggregate when entered simultaneously. Similarly, there was no significant association between cerebral blood flow velocities and parental estimation of child's exposure to sleep-disordered breathing. However, it is important to note that whereas the sleep-disordered breathing group did not exhibit significant hypoxia at the time of study, it was unclear to what extent this may have been a feature of their sleep-disordered breathing in the past. IQ measures were in the average range and comparable between groups. Measures of processing speed and visual attention were significantly lower in sleep-disordered breathing children compared with controls, although within the average range. There were similar group differences in parental-reported executive function behavior. Although there were no direct correlations, adjusting for cerebral blood flow velocities eliminated significant group differences between processing speed and visual attention and decreased the significance of differences in Behavior Rating Inventory of Executive Function scores, suggesting that cerebral hemodynamic factors contribute to the relationship between mild sleep-disordered breathing and these outcome measures.

CONCLUSIONS. Cerebral blood flow velocities measured by noninvasive transcranial Doppler provide evidence for increased cerebral blood flow and/or vascular narrowing in childhood sleep-disordered breathing; the relationship with neuropsychological deficits requires further

exploration. A number of physiologic changes might alter cerebral blood flow and/or vessel diameter and, therefore, affect cerebral blood flow velocities. We were able to explore potential confounding influences of obesity and hypertension, neither of which explained our findings. Second, although cerebral blood flow velocities increase with increasing partial pressure of carbon dioxide and hypoxia, it is unlikely that the observed differences could be accounted for by arterial blood gas tensions, because all of the children in the study were healthy, with no cardiorespiratory disease, other than sleep-disordered breathing in the snoring group. Although arterial partial pressure of oxygen and partial pressure of carbon dioxide were not monitored during cerebral blood flow velocity measurement, assessment was undertaken during the afternoon/early evening when the child was awake, and all of the sleep-disordered breathing children had normal resting oxyhemoglobin saturation at the outset of their subsequent sleep studies that day. Finally, there is an inverse linear relationship between cerebral blood flow and hematocrit in adults, and it is known that iron-deficient erythropoiesis is associated with chronic infection, such as recurrent tonsillitis, a clinical feature of many of the snoring children in the study. Preoperative full blood counts were not performed routinely in these children, and, therefore, it was not possible to exclude anemia as a cause of increased cerebral blood flow velocity in the sleep-disordered breathing group. However, hemoglobin levels were obtained in 4 children, 2 of whom had borderline low levels (10.9 and 10.2 g/dL). Although there was no apparent relationship with cerebral blood flow velocity in these children (cerebral blood flow velocity values of 131 and 130 cm/second compared with 130 and 137 cm/second in the 2 children with normal hemoglobin levels), this requires verification. It is of particular interest that our data suggest a relationship among snoring, increased cerebral blood flow velocities and indices of cognition (processing speed and visual attention) and perhaps behavioral (Behavior Rating Inventory of Executive Function) function. This finding is preliminary: a causal relationship is not established, and the physiologic mechanisms underlying such a relationship are not clear. Prospective studies that quantify cumulative exposure to the physiologic consequences of sleep-disordered breathing, such as hypoxia, would be informative.



Inflammatory Mediators in Exhaled Breath Condensate of Children With Obstructive Sleep Apnea Syndrome*

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Abstract

Background: Upper airway inflammation is now recognized in adults with obstructive sleep apnea (OSA) syndrome. However, the role played by eicosanoids such as leukotrienes and prostaglandins is unclear.

Objective: To investigate whether eicosanoids are measurable in exhaled breath condensate (EBC), and to determine whether differences in these inflammatory mediators emerge among children with and without sleep-disordered breathing (SDB).

Methods: EBC was collected from 50 consecutive snoring children undergoing overnight polysomnography for suspected SDB, and from 12 nonsnoring control subjects. Prostaglandin E₂ (PGE₂), leukotriene B₄ (LTB₄), and cysteinyl leukotrienes (cys-LTs: leukotriene C₄ [LTC₄]/leukotriene D₄ [LTD₄]/leukotriene E₄ [LTE₄]) EBC levels were analyzed using enzyme-linked immunosorbent assay.

Results: LTB₄ levels were elevated in children with an apnea-hypopnea index (AHI) > 5/h (SDB; 97.6 ± 6.3 pg/mL) compared to children with an AHI < 5/h (mild SDB; 66.4 ± 19.1 pg/mL; p < 0.01) and control subjects (27.8 ± 3.7 pg/mL; p < 0.01). Similarly, cys-LT (LTC₄/LTD₄/LTE₄) concentrations were also increased in SDB (45.1 ± 10.6 pg/mL in SDB vs 27.6 ± 8.3 pg/mL in mild SDB, and 15.7 ± 7.6 pg/mL in control subjects; p < 0.01). In contrast, PGE₂ concentrations were similar among the three groups.

Conclusions: Inflammatory mediators such as leukotrienes and prostaglandins can be readily quantified in EBC collected from the upper airway of children. Disease severity-dependent increases in leukotriene concentrations (LTB₄ and LTC₄/LTD₄/LTE₄) emerge among children and may serve as a noninvasive tool in the clinical assessment of these children.

[Sleep Medicine](#)

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Plasma IGF-1 levels and cognitive dysfunction in children with obstructive sleep apnea

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Abstract

Background

Pediatric OSA is associated with substantial morbidity in cognitive function. However, for any given OSA severity level, altered cognitive performance may or may not be present. Since IGF-1 is neuroprotective, we hypothesized that higher systemic IGF-1 levels may identify children at lower susceptibility for cognitive morbidity.

Methods

Consecutive habitually snoring and non-snoring children ages 5–7 years were recruited from the community, and underwent overnight polysomnography, and neurocognitive testing and a blood draw the next morning. Snoring children were divided into OSA or no OSA, and OSA children were further subdivided into those with ≥ 2 abnormal cognitive subtests and into those with normal cognitive scores. Plasma levels of IGF-1 were also measured using ELISA.

Results

Among snoring children without OSA, circulating IGF-1 was 910 ± 110 pg/mL compared with 1070 ± 240 pg/mL in those with OSA ($p < 0.01$). However, IGF-1 was 540 ± 70 pg/mL in children with OSA and cognitive deficits, compared to 1370 ± 170 μ g/L in children with OSA and normal cognitive scores ($p < 0.001$).

Conclusions

IGF-1 levels are higher in children with OSA, particularly in those who do not manifest neurocognitive deficits, suggesting that the magnitude of the IGF-1 response elicited by OSA may play a significant protective role against the neurocognitive dysfunction associated with OSA.

[Otolaryngology - Head and Neck Surgery](#)

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Quality of Life after Adenotonsillectomy for SDB in Children

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Objective

To evaluate the relationship between quality of life and the relative severity of sleep-disordered breathing (SDB) and to compare changes in quality of life after adenotonsillectomy in children with similar demographics but with either obstructive sleep apnea syndrome (OSAS) or with milder forms of SDB.

Study design and setting

All study participants underwent polysomnography to document the severity of SDB. The effectiveness of adenotonsillectomy for the relief of SDB was evaluated by using the OSA-18 quality of life survey (OSA-18). Preoperative and postoperative OSA-18 scores for each group of children (OSAS and mild SDB) were compared by using a repeated measures ANOVA. Changes between the 2 groups were compared by using an analysis of covariance with the preoperative score as a covariate.

Results

The study population included 61 children, 43 with OSAS and 18 with mild SDB. The demographics in the 2 groups were similar. The mean apnea-hypopnea index for children with OSAS was 21 (range, 5-46), and for children with mild SDB, it was 3 (range 0-4.9). The total OSA-18 score and the scores for all domains showed significant improvement after surgery for both groups of children ($P < .001$). A comparison of mean difference in total and domain scores for the 2 groups of children was not significant.

Conclusions and significance

Preoperative values for the OSA-18 total and domain scores are high in children with either OSAS or mild SDB. Both groups of children show a dramatic improvement in quality of life after adenotonsillectomy and the degree of improvement is similar. Fortunately, surgical therapy with adenotonsillectomy is associated with marked improvement in quality of life for children with either OSAS or mild SDB.

Snoring in primary school children and domestic environment:

A Perth school based study

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Abstract

Background: The home is the predominant environment for exposure to many environmental irritants such as air pollutants and allergens. Exposure to common indoor irritants including volatile

organic compounds, formaldehyde and nitrogen dioxide, may increase the risk of snoring for children. The aim of this study was to investigate domestic environmental factors associated with snoring in children.

Methods: A school-based respiratory survey was administered during March and April of 2002. Nine hundred and ninety six children from four primary schools within the Perth metropolitan area

were recruited for the study. A sub-group of 88 children aged 4–6 years were further selected from this sample for domestic air pollutant assessment.

Results: The prevalences of infrequent snoring and habitual snoring in primary school children were 24.9% and 15.2% respectively. Passive smoking was found to be a significant risk factor for

habitual snoring (odds ratio (OR) = 1.77; 95% confidence interval (CI): 1.20–2.61), while having pets

at home appeared to be protective against habitual snoring (OR = 0.58; 95% CI: 0.37–0.92).

Domestic pollutant assessments showed that the prevalence of snoring was significantly associated

with exposure to nitrogen dioxide during winter. Relative to the low exposure category (<30 µg/m³), the adjusted ORs of snoring by children with medium (30 – 60 µg/m³) and high exposures (>

60 µg/m³) to NO₂ were 2.5 (95% CI: 0.7–8.7) and 4.5 (95% CI: 1.4–14.3) respectively. The corresponding linear dose-response trend was also significant (P = 0.011).

Conclusion: Snoring is common in primary school children. Domestic environments may play a significant role in the increased prevalence of snoring. Exposure to nitrogen dioxide in domestic environment is associated with snoring in children.

Background

Snoring occurs when there is an obstruction to the free flow of air through the airways at the back of the mouth and nose. The prevalence of habitual snoring in children has been reported to vary between 3.2 and 11%. Infrequent snoring is present in 17–27% of all children [1-3].

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Respiratory Research 2004, **5**:19 doi:10.1186/1465-9921-5-19

Abstract

Background: The home is the predominant environment for exposure to many environmental irritants such as air pollutants and allergens. Exposure to common indoor irritants including volatile

organic compounds, formaldehyde and nitrogen dioxide, may increase the risk of snoring for children. The aim of this study was to investigate domestic environmental factors associated with snoring in children.

Methods: A school-based respiratory survey was administered during March and April of 2002. Nine hundred and ninety six children from four primary schools within the Perth metropolitan area were recruited for the study. A sub-group of 88 children aged 4–6 years were further selected from this sample for domestic air pollutant assessment.

Results: The prevalences of infrequent snoring and habitual snoring in primary school children were 24.9% and 15.2% respectively. Passive smoking was found to be a significant risk factor for habitual snoring (odds ratio (OR) = 1.77; 95% confidence interval (CI): 1.20–2.61), while having pets at home appeared to be protective against habitual snoring (OR = 0.58; 95% CI: 0.37–0.92). Domestic pollutant assessments showed that the prevalence of snoring was significantly associated with exposure to nitrogen dioxide during winter. Relative to the low exposure category (<30 µg/m³), the adjusted ORs of snoring by children with medium (30 – 60 µg/m³) and high exposures (> 60 µg/m³) to NO₂ were 2.5 (95% CI: 0.7–8.7) and 4.5 (95% CI: 1.4–14.3) respectively. The corresponding linear dose-response trend was also significant (P = 0.011).

Conclusion: Snoring is common in primary school children. Domestic environments may play a significant role in the increased prevalence of snoring. Exposure to nitrogen dioxide in domestic environment is associated with snoring in children.

[The Journal of Pediatrics](#)

[Volume 155, Issue 3](#), September 2009, Pages 362-368.e1

Original Article

Blood Pressure is Elevated in Children with Primary Snoring

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Objectives

To compare ambulatory blood pressure (ABP) in nonoverweight, prepubertal children with and without primary snoring (PS), and to investigate whether PS is a part of the dose-response relationship between sleep-disordered breathing (SDB) and BP in children.

Study design

This was a cross-sectional community-based study involving 190 children age 6 to 13 years. Each participant underwent an overnight sleep study and ABP monitoring after completing a validated sleep symptoms questionnaire. Individual systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial BP were calculated for wake and sleep periods. Subjects were hypertensive if mean SBP or DBP was > 95th percentile (relative to sex and height) of reference.

Results

A total of 56 nonsnoring controls, 46 children with PS, 62 children with an apnea-hypopnea index (AHI) of 1 to 3, and 26 children with an AHI > 3 were identified. The daytime and nighttime BP increased across the severity spectrum of SDB. The dose-response trends for the proportion of subjects with nighttime systolic and diastolic hypertension also were significant. Nighttime DBP was significantly higher in the children with PS compared with controls after adjusting for age, sex, and body mass index.

Conclusions

PS was demonstrated to be an aspect of the dose-response relationship between SDB and BP in children and should not be considered completely benign.

Keywords: ABP, Ambulatory blood pressure; AHI, Apnea-hypopnea index; BMI, Body mass index; BP, Blood pressure; DBP, Diastolic blood pressure; IQR, Interquartile range; MAP, Mean arterial pressure; ODI, Oxygen desaturation index; OSA, Obstructive sleep apnea; PS, Primary snoring; PSG, Polysomnography; SBP, Systolic blood pressure; SD, Standard deviation; SDB, Sleep-disordered breathing; SpO₂, Oxyhemoglobin saturation

Snoring and Sleep-Disordered Breathing in Young Children: Subjective and Objective Correlates

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Study Objectives: We sought to assess the predictive validity of parental report of snoring and other behaviors by comparing such reports with objective findings from overnight polysomnography for the evaluation of sleep-disordered breathing in 2 nonclinical samples, namely, at-risk preschoolers and an older group reflective of the general community. Predictive validity of snoring alone and a score based on multiple child

behaviors were compared to outcome at different levels of severity of sleep-disordered breathing.

Design: Retrospective observational study.

Setting: Questionnaires were distributed through school programs; polysomnography was performed at Kosair Children's Hospital in Louisville, Kentucky.

Participants: One hundred twenty-two preschoolers and 172 5- to 7-year-olds, and their parents, participated in both subjective-report and objective-recording portions of the study.

Measurements and Results: Compared to the presence of snoring on polysomnography, parental report of frequent snoring was highly sensitive and specific for both age groups. At all but the lowest level of severity of sleep-disordered breathing, predictive ability was higher for both groups when a parental-report score based on multiple measures of child behavior was applied, compared to parental report of snoring alone. The profiles of these predictive child behaviors differed between the 2 groups, as did their sensitivity and specificity, at their high ranges of parental report.

Conclusions: Scores derived from parental-report questionnaires of children's snoring and other sleep and wake behaviors can be used as surrogate predictors of snoring or sleep-disordered breathing in children. However, design and interpretation should consider age, risk status, and the purpose of the screening assessment.

Citation: Montgomery-Downs HE; O'Brien LM; Holbrook CR; Gozal D. Snoring and sleep-disordered breathing in young children: subjective and

objective correlates. *SLEEP* 2004;27(1):87-94.

[Sleep](#). 2005 Jul;28(7):885-90.

Snoring predicts hyperactivity four years later.

[Chervin RD](#), [Ruzicka DL](#), [Archbold KH](#), [Dillon JE](#).

Source

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Abstract

STUDY OBJECTIVES:

Cross-sectional studies implicate snoring and sleep-disordered breathing as potential contributors to hyperactive behavior in some children. However, no prospective cohort study has demonstrated that symptoms of sleep-disordered breathing precede development of hyperactivity.

PARTICIPANTS:

Parents of 229 children aged 2 to 13 years, recruited at 2 general pediatrics clinics, completed initial and 4-year follow-up surveys.

MEASUREMENTS:

Surveys included a validated Pediatric Sleep Questionnaire about snoring, sleepiness, and overall risk of sleep-disordered breathing, and the hyperactivity index (expressed as a T-score) within the Conners' Parent Rating Scale.

RESULTS:

Thirty children (13%) were rated as hyperactive (hyperactivity index > 60) at follow-up. After adjustment for hyperactivity at baseline and stimulant use at follow-up, hyperactivity at follow-up was predicted by baseline habitual snoring (odds ratio = 4.4, 95% confidence interval [1.3, 14.7]) or loud snoring (4.5, [1.2, 17.5]) and by top-quartile composite scores for snoring (5.3, [1.7, 16.8]), sleepiness (3.0, [1.0, 9.4]), or sleep-disordered breathing (4.0, [1.4, 11.6]).

CONCLUSIONS:

This 4-year prospective cohort study shows that snoring and other symptoms of sleep-disordered breathing are strong risk factors for future emergence or exacerbation of hyperactive behavior. These findings support the hypothesis that untreated childhood sleep-disordered breathing contributes to development of hyperactivity.

[Sleep Medicine](#)

[Volume 7, Issue 1](#), January 2006, Pages 43-48

Original article

Sleep disturbances and teacher ratings of school achievement and temperament in children

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Abstract

Background

The current study examined the relationships between academic achievement, sleep, temperament and demographic-historical data in school-age children.

Methods

Teachers were asked to fill out the teacher temperament questionnaire and a form for school achievement, while mothers filled out a demographic-historical form and the sleep disturbance scale for children (SDSC), a 26-item questionnaire that consisted of six factors: difficulty in initiating and maintaining sleep (DIMS), sleep breathing disorders (SBD), arousal disorders (DA), sleep–wake transition disorders (SWTD), disorders of excessive somnolence (DOES), sleep hyperhydrosis (SHY).

From a sample of 380 school children, 264 (70%) were suitable for the analyses (141 M and 123 F aged 8–11 years, mean 9.6 years). A school achievement index (SAI) was derived, summing up four items (reading ability, reading comprehension, mathematics, executive ability) of the teacher form for school achievement.

Results

SAI mean for the total sample was 11.1 (SD=2.8). A significant gender difference was found: females have higher SAI than males. The analysis of the demographic-historical form showed that only two factors appeared to affect SAI score: enuresis and the low educational level of the mother. The pattern of correlations showed that (a) the SAI was negatively related to the SDSC total score, in particular to DIMS and DOES sub-factors, and (b) the SAI was significantly and positively correlated with the temperamental traits of task-orientation and personal–social flexibility. A multiple stepwise regression analysis showed that the temperamental traits task-orientation and personal–social flexibility are the most predictive factors for SAI while the mother's educational level and the SDSC total score, although they contributed significantly to the prediction of SAI, accounted for only a small portion of variance.

Conclusions

Temperament and sleep are important factors influencing school achievement, and their assessment could help to identify children at risk regarding school achievement.

Sleep Problems in Children With Attention-Deficit/Hyperactivity Disorder

Prevalence and the Effect on the Child and Family

Valerie Sung, MBBS; Harriet Hiscock, MD, FRACP, MBBS; Emma Sciberras, BA; Daryl Efron, MD, FRACP, MBBS

Arch Pediatr Adolesc Med. 2008;162(4):336-342.

Objectives To determine the prevalence of sleep problems in children with attention-deficit/hyperactivity disorder (ADHD) and their associations with child quality of life (QOL), daily functioning, and school attendance; caregiver mental health and work attendance; and family functioning.

Design Cross-sectional survey.

Setting Pediatric hospital outpatient clinic, private pediatricians' offices, and ADHD support groups in Victoria, Australia.

Participants Schoolchildren with ADHD.

Main Exposure Attention-deficit/hyperactivity disorder.

Outcome Measures Primary measure was caregivers' reports of their children's sleep problems (none, mild, or moderate or severe). Secondary outcomes were (1) child QOL (Pediatric Quality of Life Inventory), daily functioning (Daily Parent Rating of Evening and Morning Behavior scale), and school attendance, (2) caregiver mental health (Depression Anxiety Stress Scale) and work attendance, and (3) family functioning (Child Health Questionnaire subscales). Caregivers also reported on how their pediatrician treated their children's sleep problems.

Results Two hundred thirty-nine of 330 (74%) eligible families completed the survey. Child sleep problems were common (mild, 28.5%; moderate or severe, 44.8%). Moderate or severe sleep problems were associated with poorer child psychosocial QOL, child daily functioning, caregiver mental health, and family functioning. After adjusting for confounders, all associations held except for family impacts. Compared with children without sleep problems, those with sleep problems were more likely to miss or be late for school, and their caregivers were more likely to be late to work. Forty-five percent of caregivers reported that their pediatricians had asked about their children's sleep and, of these, 60% reported receiving treatment advice.

Conclusions Sleep problems in children with ADHD are common and associated with poorer child, caregiver, and family outcomes. Future research needs to determine whether management of sleep problems can reduce adverse outcomes.

Effect of Weight, Sleep Duration, and Comorbid Sleep Disorders on Behavioral Outcomes in Children With Sleep-Disordered Breathing

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Arch Pediatr Adolesc Med. 2008;162(4):313-321.

Objective To assess the relative contribution of potential risk factors for adverse neurobehavioral outcomes in children referred for evaluation of sleep-disordered breathing (SDB), including weight, mean sleep duration, and comorbid sleep disorders.

Design Medical record review.

Setting Academic pediatric medical center.

Participants Clinical sample of 235 children aged 3 to 18 years undergoing overnight polysomnography for symptoms of SDB.

Outcome Measures History of behavioral, emotional, and academic problems and Child Behavior Checklist (CBCL) scores.

Results More than half (56%) of the sample was overweight or at risk for overweight, more than one-third (36%) was classified as being short sleepers, and almost half (49%) had at least 1 additional sleep diagnosis. Forty-seven percent had a history of behavioral problems and 23% had a reported diagnosis of attention-deficit/hyperactivity disorder. There were no significant differences in CBCL scores based on any measure of SDB disease severity. Increased weight was associated with increased internalizing CBCL scores in a dose-dependent fashion ($P = .003$), while short sleepers were more likely to have elevated externalizing scores ($P < .001$). Overall, the strongest predictor of adverse behavioral outcomes was the presence of at least 1 additional sleep diagnosis ($P < .001$).

Conclusions The relationship between SDB and parent-reported behavioral outcomes in children is complex. In addition to SDB-related impairments, clinicians should consider the relative contributions of being overweight, insufficient sleep, and comorbid sleep disorders when assessing behavior in these children.

PEDIATRICS®

Chronic Snoring and Sleep in Children: A Demonstration of Sleep Disruption

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Abstract

OBJECTIVE. Chronic snoring that does not adhere to the criteria for a diagnosis of obstructive sleep apnea syndrome may be associated with learning and behavioral problems. We investigated the sleep structure of chronic snorers who had an apnea-hypopnea index of <1 event per hour and analyzed the cyclic alternating pattern.

METHODS. Fifteen successively seen chronic snorers (9.8 ± 4 years) with an apnea-hypopnea index of <1 and 15 aged-matched control subjects (10.3 ± 5 years) underwent an investigation of their sleep with the determination of non-apneic-hypopneic breathing abnormalities polysomnographic scoring using current criteria and analysis of the cyclic alternating pattern.

RESULTS. Chronic snorers have evidence of flow limitations and tachypnea during sleep even if they do not present with apneas, hypopneas, and decrease in oxygen saturations. They also present with abnormal cyclic alternating pattern rates and changes in phase A of cyclic alternating pattern compared with control subjects.

CONCLUSIONS. An apnea-hypopnea index value cannot be the sole determinant in evaluating sleep-disordered breathing in children. Children who have chronic snoring and do not respond to the criteria for obstructive sleep apnea syndrome can present with an abnormal sleep electroencephalogram as evidenced by a significant increase in cyclic alternating pattern rates, with a predominance of abnormalities in slow wave sleep.

The Laryngoscope

[Volume 117, Issue 9](#), pages 1685–1688, September 2007

Behavioral Changes in Children With Mild Sleep-Disordered Breathing or Obstructive Sleep Apnea After Adenotonsillectomy[†]

1. Ron B. Mitchell MD^{1,*},
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DOI: 10.1097/MLG.0b013e318093edd7

Abstract

Objective: To compare changes in behavior after adenotonsillectomy in children with either mild sleep-disordered breathing (SDB) or obstructive sleep apnea (OSA).

Study Design: Prospective cohort study.

Methods: Children at the University of New Mexico Children's Hospital, Albuquerque with mild SDB or OSA were included in the study. All children underwent preoperative polysomnography before adenotonsillectomy. Mild SDB was defined as an apnea-hypopnea index (AHI) less than 5 or an apnea index (AI) less than 1. OSA was defined as an AHI 5 or greater or an AI 1 or greater. Pre- and postoperative scores from the Behavioral Assessment System for Children (BASC) survey were compared using repeated measures analysis of variance.

Results: The mean preoperative AHI for children with mild SDB ($n = 17$) was 3.1 (range, 1.7–4.7), and for children with OSA ($n = 23$) it was 25.3 (range, 10.0–48.0). The mean preoperative BASC scores for children with mild SDB were not significantly different from the scores for children with OSA. The demographics in the two groups of children were similar. The behavior symptom index, a global measure of behavior, showed significant improvement after surgery for both groups of children ($P < .01$). Children also showed significant improvement after adenotonsillectomy in the BASC scales of atypicality, depression, hyperactivity, and somatization. Mean changes in BASC scores after adenotonsillectomy were not significantly different in the two groups of children.

Conclusions: Behavioral problems are prevalent in children with either mild SDB or OSA, and both groups of children show significant improvements in behavior after adenotonsillectomy.

Pediatric Pulmonology

[Volume 38, Issue 3](#), pages 210–216, September 2004

Snoring and atopic disease: A strong association[‡]

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DOI: 10.1002/ppul.20075

Abstract

The prevalence and factors associated with snoring and habitual snoring in Asian children are largely unknown. Our objectives were to evaluate the prevalence and factors associated with snoring and habitual snoring in preschool and primary school children in Singapore. A self-response questionnaire on snoring was administered to parents of children aged 4–7 years in randomly selected preschools and primary schools in Singapore. The overall response rate was 91.3% ($n = 11,114$). Snoring and habitual snoring were reported in 28.1% and in 6.0% of the

children, respectively. On multivariate logistic regression analysis, snoring was significantly associated with male gender, race, atopy (asthma, allergic rhinitis, or atopic dermatitis), maternal atopy (allergic rhinitis or atopic dermatitis), maternal smoking, and breastfeeding. Habitual snoring was significantly associated with obesity (odds ratio (OR), 3.75; 95% confidence interval (CI), 1.67–8.42), allergic rhinitis (OR, 2.90; 95% CI, 2.06–4.08), atopic dermatitis (OR, 1.80; 95% CI, 1.28–2.54), maternal smoking (OR, 2.22; 95% CI, 1.09–4.53), and breastfeeding (OR, 1.49; 95% CI, 1.11–1.98). Atopy was the strongest risk factor for habitual snoring, and the effect was cumulative. The odds ratio of a child with all three atopic diseases (asthma, allergic rhinitis, and atopic dermatitis) to have habitual snoring was 7.45 (95% CI, 3.48–15.97). In conclusion, snoring and habitual snoring are common in Asian children. Atopy is strongly associated with snoring and habitual snoring. We suggest that children who are significantly atopic receive additional attention during screening for snoring, habitual snoring, and other features of obstructive sleep apnea syndrome. © 2004 Wiley-Liss, Inc.

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Are sleep problems under-recognised in general practice?

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Abstract

Aims: To evaluate the frequency of sleep problems in Australian children aged 4.5–16.5 years, and to determine whether the frequency of sleep problems on questionnaire predicts the reporting of sleep problems at consultation.

Methods: Parents of 361 children (aged 4.5–16.5 years) attending their general practitioner for “sick” visits were asked to assess their child’s sleep over the previous six months using the Sleep Disturbance Scale for Children, from which six sleep “disorder” factors and a total sleep problem score were obtained.

Results: The percentage of children with a total sleep problem score indicative of clinical significance (T score >70 or >95th centile) was 24.6% (89/361). Despite this high frequency, parents only addressed sleep problems in 4.1% (13/317) of cases and reported that GPs discussed sleep problems in 7.9% (25/317) of cases. Of the 79 children who reported total sleep problem T scores in the clinical range, only 13.9% (11/79) discussed sleep with their general practitioner within the previous 12 months. Regression analyses revealed an age related decrease in problems with sleep-wake transition and sleep related obstructive breathing; sleep hyperhydrosis, initiating and maintaining sleep, and excessive daytime sleepiness did not significantly decrease with age. No significant gender differences were observed.

Conclusions: Results suggest that chronic sleep problems in Australian children are significantly under-reported by parents during general practice consultations despite a relatively high frequency across all age groups. Given the impact on children and families, there is a need for increased awareness of children’s sleep problems in the community and for these to be more actively addressed at consultation.

[Sleep Medicine Reviews](#)

[Volume 10, Issue 2](#), April 2006, Pages 97-107

CLINICAL REVIEW

Neuropsychological morbidity linked to childhood sleep-disordered breathing

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Summary

Understanding the long-term neuropsychological consequences of sleep disorders in children poses a significant challenge to researchers. Since children are in a state of rapidly changing cognition and neurobehavioral function, impacts on development may have profound consequences. Recent studies now demonstrate that mild sleep apnea and snoring, once considered within the spectrum of normal sleep patterns, are associated with deficits of neuropsychological function. Preliminary data suggest that some of these cognitive deficits may be reversible following treatment of mild sleep apnea in children; however, factors such as age at treatment, duration of sleep disordered breathing, pre-morbid intellectual level, socioeconomic status, or the effectiveness of treatment may adversely affect long-term outcome. Furthermore, it is imperative that researchers determine whether the developing brain exhibits critical periods of plasticity during which episodes of sleep-disordered breathing might cause long-term or permanent neuropsychological effects

Journal of the International Neuropsychological Society

- [Journal of the International Neuropsychological Society](#) (2004), 10: 962-975

Neuropsychological effects of pediatric obstructive sleep apnea

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Abstract

Obstructive sleep apnea (OSA) is a fairly common nocturnal breathing disorder, affecting 2–4% of individuals. Although OSA is associated with medical morbidity, its most functionally disruptive effects in adults appear to be neuropsychological in nature. Research on the neuropsychological effects of pediatric OSA has been limited. This study compared the neuropsychological functioning of school-aged children with OSA to that of healthy children. The primary goal was to clarify the presence and pattern of neuropsychological morbidity associated with pediatric OSA. Sleep was assessed with parent-report questionnaires and laboratory sleep studies. Neuropsychological functioning was assessed by formal tests and parent- and teacher-report questionnaires. Data indicated OSA-related cognitive and behavioral impairment that was particularly marked on measures of behavior regulation and some aspects of attention and executive functioning. Minimal effects were observed on measures of intelligence, verbal memory, or processing speed. Exploratory analyses failed to indicate any clear relationship between neuropsychological functioning and objective indexes of hypoxia or sleep

disruption, though the sample was small. These data add to a growing literature which suggests that significant neuropsychological deficits are associated with pediatric OSA. Findings suggest a pattern of neuropsychological morbidity that is similar but not identical to that seen in adult OSA. (*JINS*, 2004, 10, 962–975.)

Journal of the International Neuropsychological Society

- [Journal of the International Neuropsychological Society](#) (2008), 14: 571-581

Neuropsychological and behavioral functioning in children with and without obstructive sleep apnea referred for tonsillectomy

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Abstract

Adenotonsillectomy (AT) is among the most common pediatric surgical procedures and is performed as often for obstructive sleep apnea (OSA) as for recurrent tonsillitis. This study compared behavioral, cognitive, and sleep measures in 27 healthy control children recruited from a university hospital-based pediatric general surgery clinic with 40 children who had OSA (AT/OSA+) and 27 children who did not have OSA (AT/OSA-) scheduled for AT. Parental ratings of behavior, sleep problems, and snoring, along with specific cognitive measures (i.e., short-term attention, visuospatial problem solving, memory, arithmetic) reflected greater difficulties for AT children compared with controls. Differences between the AT/OSA- and control groups were larger and more consistent across test measures than were those between the AT/OSA+ and control groups. The fact that worse outcomes were not clearly demonstrated for the AT/OSA+ group compared with the other groups was not expected based on existing literature. This counterintuitive finding may reflect a combination of factors, including age, daytime sleepiness, features of sleep-disordered breathing too subtle to show on standard

polysomnography, and academic or environmental factors not collected in this study. These results underscore the importance of applying more sophisticated methodologies to better understand the salient pathophysiology of childhood sleep-disordered breathing. (*JINS*, 2008, 14, 571–581.)

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PMCID: PMC2817912

Sleep Disturbance, Daytime Sleepiness, and Neurocognitive Performance in Children with Juvenile Idiopathic Arthritis

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Abstract

Study Objectives:

To compare daytime sleepiness and neurobehavioral performance in children with active and inactive juvenile idiopathic arthritis (JIA), and explore relations among measures of sleep disturbance, daytime sleepiness, and neurobehavioral performance.

Design:

Cross-sectional, comparison.

Setting:

A university-based research sleep laboratory.

Participants:

Seventy (70) children 6-11 years of age with active or inactive JIA.

Measurements and Results:

Self-reported daytime sleepiness, multiple sleep latency tests (MSLTs), and computerized neurobehavioral performance test scores were obtained after 2 nights of polysomnography. Children with active disease (mean physician global rating score = 2.9 ± 1.9 SD) showed shorter mean MSLT latency (15 ± 6.0 min) than those with inactive disease (16.5 ± 5.5 min, $P < 0.03$). Scores on neurobehavioral performance tests showed no group differences. However, number of wake bouts predicted sustained visual attention (rapid visual processing, $P < 0.05$) and apnea hypopnea index (AHI) predicted reaction time ($P < 0.0001$), after controlling for age, IQ, medication, and disease status.

Conclusion:

Indices of sleep disturbance were associated with validated tests of neurobehavioral performance in JIA, regardless of disease activity. Additional research is needed about the extent of sleep disturbances in relation to neurocognitive performance in JIA and compared to healthy children.

Citation:

Ward TM; Archbold K; Lentz M; Ringold S; Wallace CA; Landis CA. Sleep disturbance, daytime sleepiness, and neurocognitive performance in children with juvenile idiopathic arthritis. *SLEEP* 2010;33(2):252-259.

Sleep. 2009 October 1; 32(10): 1325–1332.

PMCID: PMC2753810

Sleep Stage Dynamics Differ Between Children With and Without Obstructive Sleep Apnea

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Abstract

Study Objectives:

Analysis of sleep dynamics—distributions of contiguous sleep and sleep stage durations—reveal exponential distributions and potential clinical utility in adults. We sought to examine these polysomnographic variables for the first time in children, and in the context of childhood sleep disordered breathing (SDB).

Design and Setting:

Analysis of polysomnographic data available from the Washtenaw County Adenotonsillectomy Cohort.

Participants:

Selected subjects were 48 children aged 5–12 years with SDB (pediatric apnea/hypopnea index ≥ 1.5) who were scheduled for adenotonsillectomy and 20 control subjects of similar ages without SDB. Subjects were studied at enrollment and again one year later in almost all cases.

Results:

Durations of sleep and specific sleep stage bouts generally followed exponential distributions. At baseline, the number of sleep stage changes, proportion of total sleep time occupied by stage 1 sleep, proportion stage 2 sleep, mean stage 2 duration, and mean stage REM duration each distinguished subjects with and without SDB ($P < 0.05$), but only mean stage 2 duration did so independently after accounting for the other variables ($P = 0.03$). At one-year follow-up, changes in total sleep time, mean stage 2 duration, and mean stage REM duration distinguished SDB from control subjects, but again only changes in mean stage 2 duration did so independently ($P = 0.01$).

Conclusions:

Durations of uninterrupted sleep and specific sleep stages appear to follow exponential distributions in children with or without SDB. Parameters that describe these distributions—particularly mean duration of stage 2 sleep periods—may provide useful additions to standard sleep stage analyses.

Neuromuscular cause of OSA:

Neuromechanical control of upper airway patency during sleep

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Obstructive sleep apnea is caused by pharyngeal occlusion due to alterations in upper airway mechanical properties and/or disturbances in neuromuscular control. The objective of the study was to determine the relative contribution of mechanical loads and dynamic neuromuscular responses to pharyngeal collapse during sleep. Sixteen obstructive sleep apnea patients and sixteen normal subjects were matched on age, sex, and body mass index. Pharyngeal collapsibility, defined by the critical pressure, was measured during sleep. The critical pressure was partitioned between its passive mechanical properties (passive critical pressure) and active dynamic responses to upper airway obstruction (active critical pressure). Compared with normal subjects, sleep apnea patients demonstrated elevated mechanical loads as demonstrated by higher passive critical pressures [-0.05 (SD 2.4) vs. -4.5 cmH₂O (SD 3.0), $P = 0.0003$]. Dynamic

responses were depressed in sleep apnea patients, as suggested by failure to lower their active critical pressures [−1.6 (SD 3.5) vs. −11.1 cmH₂O (SD 5.3), $P < 0.0001$] in response to upper airway obstruction. Moreover, elevated mechanical loads placed some normal individuals at risk for sleep apnea. In this subset, dynamic responses to upper airway obstruction compensated for mechanical loads and maintained airway patency by lowering the active critical pressure. The present study suggests that increased mechanical loads and blunted neuromuscular responses are both required for the development of obstructive sleep apnea.

CHEST

Upper Airway Collapsibility During Sleep in Upper Airway Resistance Syndrome*

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Abstract

Study objectives: To compare upper airway collapsibility during sleep between patients with upper airway resistance syndrome (UARS), normal subjects, and patients with obstructive sleep apnea/hypopnea syndrome (OSA/H).

Design: A descriptive study of a series of clinical patients and a cohort of normal control subjects.

Setting: Two academic sleep-disorders centers.

Patients or participants: One hundred six adult patients with sleep-disordered breathing evaluated at the SUNY Sleep Disorders Center–Medicine and 12 adult subjects without habitual

snoring or daytime sleepiness and with an apnea/hypopnea index (AHI) < 5/h evaluated at the Johns Hopkins Pediatric Sleep Disorders Center.

Interventions: All subjects underwent full-night polysomnography and a determination of pharyngeal critical pressure (Pcrit). All patients had a determination of therapeutic level of nasal continuous positive airway pressure (Ptherapeutic).

Measurements and results: The mean $\pm$ SD Pcrit of the 12 normal subjects was -15.4 ± 6.1 cm H₂O; the mean Pcrit of the 22 UARS patients was -4.0 ± 2.1 cm H₂O; the mean Pcrit of the 37 patients with mild-to-moderate OSA/H (AHI ≥ 10 /h and < 40/h) was -1.6 ± 2.6 cm H₂O; and the mean Pcrit of the 47 patients with moderate-to-severe OSA/H (AHI ≥ 40 /h) was 2.4 ± 2.8 cm H₂O. The Pcrit of each group differed from that of all other groups ($p < 0.01$). The mean Ptherapeutic of patients with UARS was 6.9 ± 1.7 cm H₂O; the mean Ptherapeutic of patients with mild-to moderate OSA/H was 7.9 ± 1.9 cm H₂O ($p = 0.08$ compared with the Ptherapeutic of UARS patients); and the mean Ptherapeutic of patients with moderate-to severe OSA/H was 10.5 ± 2.4 cm H₂O ($p < 0.0001$ compared to each of the other patient groups).

Conclusion: UARS is a syndrome of increased upper airway collapsibility during sleep. The upper airway collapsibility during sleep of patients with UARS is intermediate between that of normal subjects and that of patients with mild-to moderate OSA/H.

[Journal of Biomechanics](#)

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Computational fluid dynamics modeling of the upper airway of children with obstructive sleep apnea syndrome in steady flow

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Abstract

Computational fluid dynamic (CFD) analysis was used to model the effect of airway geometry on internal pressure in the upper airway of three children with obstructive sleep apnea syndrome (OSAS), and three controls. Model geometry was reconstructed from magnetic resonance images obtained during quiet tidal breathing, meshed with an unstructured grid, and solved at normative peak resting flow. The unsteady Reynolds-averaged Navier–Stokes equations were solved with steady flow boundary conditions in inspiration and expiration, using a two-equation low-Reynolds number turbulence model. Model results were validated using an in-vitro scale model, unsteady flow simulation, and reported nasal resistance measurements in children.

Pharynx pressure drop strongly correlated to airway area restriction. Inspiratory pressure drop was primarily proportional to the square of flow, consistent with pressure losses due to convective acceleration caused by area restriction. On inspiration, in OSAS pressure drop occurred primarily between the choanae and the region where the adenoids overlap the tonsils (overlap region) due to airway narrowing, rather than in the nasal passages; in controls the majority of pressure drop was in the nasal passages. On expiration, in OSAS the majority of pressure drop occurred between the oropharynx (posterior to the tongue) and overlap region, and local minimum pressure in the overlap region was near atmospheric due to pressure recovery in the anterior nasopharynx. The results suggest that pharyngeal airway shape in children with OSAS significantly affects internal pressure distribution compared to nasal resistance. The model may also help explain regional dynamic airway narrowing during expiration.

[Experimental Neurology](#)

[Volume 62, Issue 1](#), October 1978, Pages 48-67

Obstructive sleep apnea: Electromyographic and fiberoptic studies

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Received 11 October 1977; revised 19 June 1978; Available online 28 January 2004.

Abstract

Seventeen predominantly obstructive sleep apnea patients and four normal controls (all adult males) underwent one or both investigative protocols: (A) A fiberoptic endoscope was introduced intranasally into the pharynx and subjects were monitored continuously and filmed intermittently during wakefulness and sleep. (B) Muscles selected because of their anatomical importance in maintaining the oropharynx during the respiratory cycle were electromyographically implanted intraorally or, in tracheostomy patients, at time of surgery, and subjects were polygraphically monitored during wakefulness and sleep. In both protocols, standard electroencephalogram, chin electromyogram (EMG), electrooculogram (EOG), and respiration were monitored simultaneously. During fiberoptic studies obstructive apnea during sleep first appeared as a partial or total invagination of the posterolateral pharyngeal walls, while the laryngeal inlet remained patent. EMG recordings showed normal firing patterns in patients during unobstructed sleep. During sleep-induced obstructive apnea, however, a significant decrease or complete disappearance of EMG activity was observed in the palatoglossus, palatopharyngeus, genioglossus, superior and middle constrictors of the pharynx, and stylopharyngeus. The obstruction involves absence, during inspiration, of the activity in the pharyngeal dilators needed to counteract the loads abruptly imposed by intrathoracic negative pressure changes.

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Upper Airway Structure and Body Fat Composition in Obese Children with Obstructive Sleep Apnea Syndrome

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Rationale: Mechanisms leading to obstructive sleep apnea syndrome (OSAS) in obese children are not well understood.

Objectives: The aim of the study was to determine anatomical risk factors associated with OSAS in obese children as compared with obese control subjects without OSAS.

Methods: Magnetic resonance imaging was used to determine the size of upper airway structure, and body fat composition. Paired analysis was used to compare between groups. Mixed effects regression models and conditional multiple logistic regression models were used to determine whether body mass index (BMI) Z-score was an effect modifier of each anatomic characteristic as it relates to OSAS.

Measurements and Main Results: We studied 22 obese subjects with OSAS (12.5 ± 2.8 yr; BMI Z-score, 2.4 ± 0.4) and 22 obese control subjects (12.3 ± 2.9 yr; BMI Z-score, 2.3 ± 0.3). As compared with control subjects, subjects with OSAS had a smaller oropharynx ($P < 0.05$) and larger adenoid ($P < 0.01$), tonsils ($P < 0.05$), and retropharyngeal nodes ($P < 0.05$). The size of lymphoid tissues correlated with severity of OSAS whereas BMI Z-score did not have a modifier effect on these tissues. Subjects with OSAS demonstrated increased size of parapharyngeal fat pads ($P < 0.05$) and abdominal visceral fat ($P < 0.05$). The size of these tissues did not correlate with severity of OSAS and BMI Z-score did not have a modifier effect on these tissues.

Conclusions: Upper airway lymphoid hypertrophy is significant in obese children with OSAS. The lack of correlation of lymphoid tissue size with obesity suggests that this hypertrophy is caused by other mechanisms. Although the parapharyngeal fat pads and abdominal visceral fat are larger in obese children with OSAS we could not find a direct association with severity of OSAS or with obesity.



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Obstructive sleep apnoea is associated with impaired pictorial memory task acquisition and retention in children

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Abstract

The aim of our study was to evaluate whether obstructive sleep apnoea (OSA) is associated with impaired acquisition and recall of a pictorial-based memory tasks in children.

54 children with OSA and 17 controls matched for age, sex and ethnicity underwent a sleep study (overnight polysomnogram). Before the sleep study subjects completed a 15-min pictorial memory task acquisition consisting of four trials, followed by a free-recall period to assess retention after 10 min and the following morning upon awakening.

Children with OSA had a higher obstructive apnoea/hypopnoea index (6.3 ± 1.5 events·h⁻¹ TST) than controls (0.6 ± 0.1 events·h⁻¹ TST) ($p < 0.0001$). Mean learning scores in controls over the four consecutive trials were incrementally better than in children with OSA for the four-trial set ($p < 0.0001$). Both immediate ($p < 0.0001$) and overnight recall performances were worse among OSA children ($p < 0.0001$), who also exhibited declines in recall performance that was absent in controls ($p < 0.001$).

Differences in pictorial task acquisition trajectories suggest that children with OSA require more time and an increased number of learning opportunities to reach immediate and long-term recall performances that are reduced compared with controls. Thus, both acquisition and retention of newly learned material are compromised. These findings confirm and expand on the presence of known cognitive deficits in children with OSA.

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Palatine tonsil size and its correlation with subjective tonsil size in patients with sleep-disordered breathing.

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Source

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Abstract

OBJECTIVE:

To investigate the correlation of subjective tonsil size with real palatine tonsil size and to compare the differences of each parameter according to subjective tonsil size and between children and adults.

STUDY DESIGN:

Prospective evaluation of subjective tonsil size (0-4+) and real palatine tonsil size, including tonsil height (TH), tonsil width (TW), tonsil thickness (TT), total tonsil volume (TTV), and embedded tonsil volume (ETV) within the tonsillar fossa.

SETTING:

Tertiary-care rhinologic clinic.

SUBJECTS AND METHODS:

We measured TH, TW, TT, TTV, and ETV in 277 children and 63 adults with sleep-disordered breathing (SDB).

RESULTS:

In both children and adults, subjective tonsil size was significantly correlated with TTV, TH, TW, and TT (correlation coefficients 0.199-0.427 for children and 0.462-0.551 for adults). In children, TTV increased in proportion to subjective tonsil size, but about 45 percent and 34 percent of tonsils markedly deviated from the mean value of their TTV in size 2 and 3 groups, respectively. In adults, TTV of subjective tonsil size 3 and 4 groups was significantly larger than that of size 1 and 2 groups.

CONCLUSIONS:

Real palatine tonsil size correlated with subjective tonsil size in both children and adults with SDB. Although there is a statistical correlation in children between TTV and subjective tonsil size, there is significant discordance in size 2 and 3 groups, thus greatly limiting the value of subjective tonsil size assessment in the majority of children. However, adult subjective tonsil size may reflect real palatine tonsil size and may help predict it preoperatively.

CHEST

Obesity and Persisting Sleep Apnea After Adenotonsillectomy in Greek Children

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Abstract

Background:

The relative importance of obesity and adenotonsillar hypertrophy in the pathogenesis of obstructive sleep-disordered breathing (SDB) in childhood is unclear. Adenotonsillectomy (AT) for SDB is not always curative, and obese children are at increased risk for residual disease postoperatively.

Objective:

The aim of this investigation was to assess the efficacy of AT as treatment for SDB in obese and nonobese children.

Methods:

Children with adenoidal and/or tonsillar hypertrophy who underwent AT for the treatment of SDB underwent polysomnography preoperatively and postoperatively. A body mass index (BMI) z score of > 1.645 was used to define obesity. The achievement of a postoperative obstructive apnea-hypopnea index (OAHI) of less than one episode per hour (*ie*, the cure of SDB) was the primary outcome measure.

Results:

Twenty-two obese children (mean $\pm$ SD] age, 5.8 ± 1.8 years; mean BMI z score, 2.6 ± 0.8 ; mean OAH, 9.5 ± 9.7 episodes per hour) and 48 nonobese children (mean age, 6.9 ± 2.6 years; mean BMI z score, 0.09 ± 1.1 ; OAH, 6 ± 5.4 episodes per hour) were recruited. After surgery, obese and nonobese subjects did not differ in the efficacy of AT (postoperative OAH of less than one episode per hour, 22.7% vs 25% of subjects, respectively; $p > 0.05$). The presence of obesity, adenoidal or tonsillar hypertrophy, gender, and postoperative BMI change were not significant predictors of SDB cure.

Conclusions:

Obesity does not necessarily predict an unfavorable outcome of AT as treatment for SDB

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Increased Upper Airway Collapsibility in Children with Obstructive Sleep Apnea during Wakefulness

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Upper airway collapsibility (UAC) is increased in children with sleep-disordered breathing (SDB), but during wakefulness, active neural processes preserve upper airway patency, such that measurement of upper airway dynamics using acoustic pharyngometry may contribute to diagnostic accuracy in snoring children. Upper airway cross-sectional area obtained from acoustic pharyngometry measurements was assessed in 247 children referred for evaluation of suspected SDB and control subjects, before and after application of cetacaine 1% spray to the pharyngeal introitus under visual inspection. UAC was determined from the percentage change in cross-sectional area after topical anesthesia. UAC measurements were reproducible 1 week apart in both control subjects and patients with SDB ($p < 0.005$). A UAC less than or equal to -30% exhibited high sensitivity and specificity in identification of all children with obstructive apnea-hypopnea index greater than 5/hour total sleep time in a prospective initial sample of 54 children and in a subsequent *post hoc* sample of 94 snoring children. Thus, upper airway dynamic testing during wakefulness in response to a topical airway anesthetic may provide a useful clinical adjunct to the evaluation of snoring children, with more accurate identification of those children with SDB.

Otolaryngology- Head and Neck Surgery

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Head and Neck Surgery Foundation, Inc

Clinical Practice Guideline

Polysomnography for Sleep-Disordered Breathing Prior to Tonsillectomy in Children

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Abstract

Objective. This guideline provides otolaryngologists with evidence-based recommendations for using polysomnography in assessing children, aged 2 to 18 years, with sleep-disordered breathing and are candidates for tonsillectomy, with or without adenoidectomy. Polysomnography is the electrographic recording of simultaneous physiologic variables during sleep and is currently considered the gold standard for objectively assessing sleep disorders.

Purpose. There is no current consensus or guideline on when children 2 to 18 years of age, who are candidates for tonsillectomy, are recommended to have polysomnography. The primary purpose of this guideline is to improve referral patterns for polysomnography among these patients. In creating this guideline, the American Academy of Otolaryngology—Head and Neck Surgery Foundation selected a panel representing the fields of anesthesiology, pulmonology medicine, otolaryngology–head and neck surgery, pediatrics, and sleep medicine.

Results. The committee made the following recommendations: (1) before determining the need for tonsillectomy, the clinician should refer children with sleep-disordered breathing for polysomnography if they exhibit certain complex medical conditions such as obesity, Down syndrome, craniofacial abnormalities, neuromuscular disorders, sickle cell disease, or mucopolysaccharidoses. (2) The clinician should advocate for polysomnography prior to tonsillectomy for sleep-disordered breathing in children without any of the comorbidities listed in statement 1 for whom the need for surgery is uncertain or when there is discordance between tonsillar size on physical examination and the reported severity of sleep-disordered breathing. (3) Clinicians should communicate polysomnography results to the anesthesiologist prior to the induction of anesthesia for tonsillectomy in a child with sleep-disordered breathing. (4) Clinicians should admit children with obstructive sleep apnea documented on polysomnography for inpatient, overnight monitoring after tonsillectomy if they are younger than age 3 or have severe obstructive sleep apnea (apnea-hypopnea index of 10 or more obstructive events/hour, oxygen saturation nadir less than 80%, or both). (5) In children for whom polysomnography is indicated to assess sleep-disordered breathing prior to tonsillectomy, clinicians should obtain laboratory-based polysomnography, when available.

Comparison of Static Mechanical Properties of the Passive Pharynx between Normal Children and Children with Sleep-disordered Breathing

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Collapsibility of the active pharynx, where active contraction of the upper airway muscles is evident, was previously reported to be higher in children with obstructive sleep apnea (OSA) than in those with primary snoring during sleep. Contribution of neuromuscular and anatomic factors to the increased collapsibility, however, was not estimated. We therefore evaluated collapsibility of the passive pharynx, in which upper airway muscle activities were eliminated. Our aim in the present study was to test the hypothesis that children with sleep-disordered breathing (SDB) have a structurally narrowed and a more collapsible pharynx compared with normal children. The static pressure/area relationship of the passive pharynx was endoscopically quantified in 14 children with SDB and in 13 normal children under general anesthesia with complete paralysis. The majority of children with SDB primarily closed their airways at levels of enlarged adenoids and tonsils with positive closing pressure (P_{close}) (3.5 ± 4.3 cm H₂O), whereas half of the normal children closed their airways at the soft palate edges and the other half at the tongue bases with subatmospheric P_{close} (-7.4 ± 4.9 cm H₂O). Cross-sectional area of the narrowest segment was significantly smaller in SDB children than in normal children. Interestingly, collapsibility of the retropalatal and retroglottal segments significantly increased in SDB children, compared with the normal subjects. We conclude that anatomic factors play a significant role in the pathogenesis of pediatric OSA and that predisposing structural abnormalities of the entire pharynx are likely to contribute to manifestation of OSA in addition to enlarged adenoids and tonsils.

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The Effects of Common Airway Maneuvers on Airway Pressure and Flow in Children Undergoing Adenoidectomies

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Abstract

Obstruction of the upper airway occurs frequently in anesthetized, spontaneously breathing children, especially in those with adenoidal hyperplasia. To improve airway patency, maneuvers such as chin lift (CL), jaw thrust (JT), and continuous positive airway pressure (CPAP) are often used. In this study, we examined the comparative efficacy of these maneuvers in children scheduled to undergo adenoidectomy. Sixteen children aged 2–9 yr were anesthetized with sevoflurane. During spontaneous breathing, the flows and pressures in the mask (P_{ma}), oropharynx (P_{op}), and esophagus (P_{es}) were measured simultaneously, and maximal pressure differences during inspiration (ΔP) were calculated. After baseline recording, CL and JT maneuvers were performed in random order without and with CPAP (5 cm H₂O). The observed $\Delta P_{ma} - P_{es}$ of 12.3 ± 3.4 cm H₂O at baseline decreased with all airway maneuvers ($P < 0.05$). This resulted from decreases of $\Delta P_{ma} - P_{op}$ ($P < 0.05$) and $\Delta P_{op} - P_{es}$ ($P < 0.05$) in all interventions except CL, in which $\Delta P_{ma} - P_{op}$ remained similar. In contrast, significant improvements of minute ventilation and maximal inspiratory peak flow ($P > 0.05$) were observed only with JT (with and without CPAP). We conclude that CL may improve airway patency and ventilation, whereas JT with or without CPAP was the most effective maneuver to overcome airway obstruction in children with adenoidal hyperplasia.

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Changes in Upper Airway Size during Tidal Breathing in Children with Obstructive Sleep Apnea Syndrome

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We performed respiratory-gated magnetic resonance imaging to evaluate airway dynamics during tidal breathing in 10 children with obstructive sleep apnea syndrome (OSAS; age, 4.3 ± 2.3 years) and 10 matched control subjects (age, 5.0 ± 2.0 years). We hypothesized that respiratory cycle fluctuations in upper airway cross-sectional area would be larger in children with OSAS. **Methods:** Studies were performed under sedation. Respiratory gating was performed automatically at 10, 30, 50, 70, and 90% of inspiratory and expiratory volume. Airway cross-sectional area was measured at four ascending oropharyngeal levels at each increment of the respiratory cycle. **Results:** We noted the following in subjects with OSAS compared with control subjects: (1) a smaller upper airway cross-sectional area, particularly during inspiration; (2) airway narrowing occurred during inspiration without evidence of complete airway collapse; (3) airway dilatation occurred during expiration, particularly early in the phase; and (4) magnitude of cross-sectional areas fluctuations during tidal breathing noted in OSAS at levels 1 through 4 were 317, 422, 785, and 922%, compared with 19, 15, 17, and 24% in control subjects ($p < 0.001$, $p < 0.005$, $p < 0.001$, and $p < 0.001$, respectively). **Conclusions:** Fluctuations in airway area during tidal breathing are significantly greater in subjects with OSAS compared with control subjects. Resistive pressure loading is a probable explanation, although increased airway compliance may be a contributing factor.

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Upper Airway Size Analysis by Magnetic Resonance Imaging of Children with Obstructive Sleep Apnea Syndrome

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Detailed analysis of the upper airway has not been performed in children with obstructive sleep apnea. We used magnetic resonance imaging and automatic segmentation to delineate the upper airway in 20 children with obstructive sleep apnea and in 20 control subjects (age, 3.7 ± 1.4 versus 3.9 ± 1.7 years, respectively). We measured mean and minimal cross-sectional area, length, and volume of: (1) the total airway; (2) regions along the adenoid, tonsils, and where

adenoid and tonsils overlap; and (3) 10 segments at 10% increments along the airway. The mean cross-sectional area of the total airway of the obstructive sleep apnea group was significantly smaller in comparison with the control group, 28.1 ± 12.6 versus $47.1 \pm 18.2 \text{ mm}^2$, respectively ($p < 0.0005$). Minimal cross-sectional area and airway volume were smaller in this group, 4.6 ± 3.3 versus $15.7 \pm 12.7 \text{ mm}^2$ ($p < 0.0005$), and $1,129 \pm 515$ versus $1,794 \pm 846 \text{ mm}^3$ ($p < 0.005$), respectively. Regional analysis suggested that the upper airway in children with obstructive sleep apnea is most restricted where adenoid and tonsils overlap. Segmental analysis demonstrated that the upper airway is restricted throughout the initial two-thirds of its length and that the narrowing is not in a discrete region adjacent to either the adenoid or tonsils, but rather in a continuous fashion along both.

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Sleep and Behavior Problems in School-Aged Children

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Abstract

Objectives. The primary purposes of the present study were to survey the prevalence of sleep problems in school-aged children and to examine these associations with parental perception of sleep problems, medical history, and childhood psychopathology.

Methods. Sleep and medical history questionnaires and the Child Behavior Checklist were administered to the parents of 472 children between ages 4 and 12 years receiving routine pediatric care from urban, rural, and suburban pediatric practices.

Results. Although sleep problems were reported for 10.8% of the sample during the past 6 months, less than one half of the parents who identified sleep problems reported that they had discussed sleep with their child's pediatrician. The best predictor of current sleep problems was a

history of sleep problems before age 2 years. Sleep problems such as snoring, tiredness during the day, and taking excessive time to fall asleep were very common, occurring at least 1 night per week in over 20% of the total sample. Factor analysis of the sleep problems questionnaire resulted in 5 sleep problem factors that accounted for 58.7% of the variance. Specific sleep problem factors include: parasomnias, enuresis/gags, tiredness, noisy sleep, and insomnia. Sleep problem factor scores were differentially associated with medical history variables and measures of childhood psychopathology. Children rated highly on parasomnias were more likely to have frequent falls and to display pica. Parasomnias and noisy sleep were inversely associated with socioeconomic status (SES). Children from lower SES families were rated higher on these factors than children from higher SES families. Enuresis/gags was the only sleep problem factor associated with age. Younger children scored higher on this factor. Duration of naps was highly correlated with age and with bed times during the week and weekends. As expected, younger children were more likely to nap for longer periods and to have earlier bed times. In addition, higher tiredness factor scores were associated with napping and with later bed times during the week and weekend. Boys were much more likely than were girls to have higher scores on enuresis/gags, and higher enuresis/gags scores were associated with an increased prevalence of trauma and falls. Bed times were not associated with any other sleep problem factor score. Children rated highly on tiredness were more likely to have a history of hospitalizations. Tiredness factor scores were strongly associated with the sleep practice of sharing a bed but not with sharing a room. Sharing a room was not associated with any sleep problem factor score. High scores on noisy sleep were associated with allergies, falls frequently, and with sharing a bed. Children with high scores on the insomnias were also more likely to display an increased prevalence of allergies.

Conclusions. Parental perception of global sleep problems was surprisingly common in school-aged children receiving routine pediatric care. Parental reports of their children's sleep problems may be a red flag for specific sleep problems and psychiatric, social, or medical problems. Sleep problems should be queried about during pediatric visits for school-aged children

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Sleepless in America: Inadequate Sleep and Relationships to Health and Well-being of Our Nation's Children

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Abstract

OBJECTIVE. Our goal was to identify characteristics associated with inadequate sleep for a national random sample of elementary school-aged children (6–11 years) and adolescents (12–17 years).

METHODS. Data from 68418 participants in the 2003 National Survey of Children's Health were analyzed by using weighted bivariate and multivariate regression models. The dependent variable was report of not getting enough sleep for a child of his or her age ≥ 1 night of the past week. Independent variables included demographic characteristics, child health, school and other activities, and family life.

RESULTS. Parents of elementary school-aged children with inadequate sleep were more likely to report that their child was having problems at school or had a father with fair or poor health. Parents of adolescents with inadequate sleep were more likely to report that their child had an atopic condition, frequent or severe headaches, a parent with less-than-excellent emotional health, or experienced frequent parental anger. Inadequate sleep in both age groups was associated with parental report that their child usually or always displayed depressive symptomatology, family disagreements involved heated arguing, or parental concern that the child was not always safe at home, at school, or in their neighborhood.

CONCLUSIONS. Approximately 15 million American children are affected by inadequate sleep. Primary care providers should routinely identify and address inadequate sleep and its associated health, school, and family factors.

[Sleep Medicine Reviews](#)

[Volume 7, Issue 6](#), 2003, Pages 491-506

Understanding adolescent's sleep patterns and school performance: a critical appraisal

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Abstract

The present paper reviews and critiques studies assessing the relation between sleep patterns, sleep quality, and school of performance of adolescents attending middle school, high school, and/or college. The majority of studies relied on self-report, yet the researchers approached the question with different designs and measures. Specifically, studies looked at (1) sleep/wake patterns and usual grades, (2) school start time and phase preference in relation to sleep habits and quality and academic performance, and (3) sleep patterns and classroom performance (e.g., examination grades). **The findings strongly indicate that self-reported shortened total sleep time, erratic sleep/wake schedules, late bed and rise times, and poor sleep quality are negatively associated with academic performance for adolescents from middle school through the college years.** Limitations of the current published studies are also discussed in detail in this review.

[J Dev Behav Pediatr](#). 1999 Jun;20(3):164-9.

Sleep and behavior problems among preschoolers.

[Lavigne JV](#), [Arend R](#), [Rosenbaum D](#), [Smith A](#), [Weissbluth M](#), [Binns HJ](#), [Christoffel KK](#).

Source

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Abstract

This study described the relationship between amount of sleep and behavior problems among preschoolers. Participants were 510 children aged 2 to 5 years who were enrolled through 68 private pediatric practices. Parents reported on the amount of sleep their child obtained at night and in 24-hour periods. With demographic variables controlled, regression models were used to determine whether sleep was associated with behavior problems. The relationship between less sleep at night and the presence of a DSM-III-R psychiatric diagnosis was significant (odds ratio = 1.23, $p = .026$). Less night sleep ($p < .0001$) and less sleep in a 24-hour period ($p < .004$) were associated with increased total behavior problems on the Child Behavior Checklist; less night sleep ($p < .0002$) and less 24-hour sleep ($p < .004$) were also associated with more externalizing problems on that measure. Further research is needed to ascertain whether sleep is playing a causal role in the increase of behavior problems.

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Sleep and Neurobehavioral Characteristics of 5- to 7-Year-Old Children With Parentally Reported Symptoms of Attention-Deficit/Hyperactivity Disorder

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Abstract

Objectives. This study examined the hypothesis that domains of neurobehavioral function would be selectively affected by sleep-disordered breathing (SDB). Therefore, we assessed potential relationships between objectively measured sleep disturbances and neurobehavioral function in children with reported symptoms of attention-deficit/hyperactivity disorder (ADHD) and also determined the incidence of snoring and other sleep problems in 5- to 7-year-old children in the local community and potential relationships to parental snoring and passive smoking.

Methods. Parents of 5- to 7-year-old children in public schools were surveyed about their child's sleeping habits using a validated questionnaire. The questionnaire also asked whether they believed their child to be hyperactive or have ADHD. Children with reported symptoms of ADHD and control children were randomly selected and invited to the Sleep Medicine Center for an overnight polysomnographic assessment and a battery of neurocognitive tests.

Results. The questionnaire response rate was 47.6% ($n = 5728$). Frequent and loud snoring was reported for 673 children (11.7%). Similarly, 418 (7.3%) children were reported to have hyperactivity/ADHD, 313 (76.5%) of which were boys. Eighty-three children with parentally reported symptoms of ADHD were invited for full evaluation at the Sleep Medicine Center together with 34 control children. After assessment with the Conners' Parent Rating Scale, 44

children were designated as having “significant” symptoms of ADHD, 27 as “mild,” and 39 designated as “none” (controls). Overnight polysomnography indicated that obstructive sleep apnea was present in 5% of those with significant ADHD symptoms, 26% of those with mild symptoms, and 5% of those with no symptoms. In the cohort, no sleep variable accounted for more than a negligible proportion of the variance in domains of neurobehavioral function.

Conclusions. An unusually high prevalence of snoring was identified among a group of children designated as showing mild symptoms of ADHD based on the Conners’ ADHD index identified from a community sample. However, whereas SDB is not more likely to occur among children with significant ADHD symptoms, it is significantly highly prevalent among children with mild hyperactive behaviors. Sleep studies further revealed that rapid eye movement disturbances are more likely to occur in children with significant symptoms, and they seem to impose significant but mild effects on daytime neurobehavioral functioning. We conclude that in children with significant symptoms of ADHD, the prevalence of SDB is not different from that of the general pediatric population and that rapid eye movement sleep in these children is disturbed and may contribute to the severity of their behavioral manifestations. Furthermore, SDB can lead to mild ADHD-like behaviors that can be readily misperceived and potentially delay the diagnosis and appropriate treatment.

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Increased Behavioral Morbidity in School-Aged Children With Sleep-Disordered Breathing

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Abstract

Objective. To assess whether sleep-disordered breathing (SDB), ranging from primary snoring to obstructive sleep apnea (OSA), is associated with increased behavioral morbidity.

Methods. A cross-sectional study was conducted of school-aged children in an urban, community-based cohort, stratified for term or preterm (<37 weeks' gestation) birth status. A total of 829 children, 8 to 11 years old (50% female, 46% black, 46% former preterm birth) were recruited from a cohort study. All children had unattended in-home overnight cardiorespiratory recordings of airflow, respiratory effort, oximetry, and heart rate for measurement of the apnea hypopnea index (number of obstructive apneas and hypopneas per hour). SDB was defined by either parent-reported habitual snoring or objectively measured OSA. Functional outcomes were assessed with 2 well-validated parent ratings of behavior problems: the Child Behavioral Checklist and the Conners Parent Rating Scale–Revised:Long.

Results. Forty (5%) children were classified as having OSA (median apnea hypopnea index: 7.1 per hour; interquartile range: 3.1–10.5), 122 (15%) had primary snoring without OSA, and the remaining 667 (80%) had neither snoring nor OSA. Children with SDB had significantly higher odds of elevated problem scores in the following domains: externalizing, hyperactive, emotional lability, oppositional, aggressive, internalizing, somatic complaints, and social problems.

Conclusions. Children with relatively mild SDB, ranging from primary snoring to OSA, have a higher prevalence of problem behaviors, with the strongest, most consistent associations for externalizing, hyperactive-type behaviors.

[Child Dev.](#) 2002 Mar-Apr;73(2):405-17.

Sleep, neurobehavioral functioning, and behavior problems in school-age children.

[Sadeh A](#), [Gruber R](#), [Raviv A](#).

Source

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Abstract

The aim of this study was to examine the associations between sleep and neurobehavioral functioning (NBF) in school-age children. These variables were assessed for 135 unreferred, healthy school children (69 boys and 66 girls), from second-, fourth-, and sixth-grade classes. Objective assessment methods were used on the participants in their regular home settings. Sleep was monitored using actigraphy for 5 consecutive nights; and NBF was assessed using a computerized neurobehavioral evaluation system, administered twice, at different times of the day. Significant correlations between sleep-quality measures and NBF measures were found, particularly in the younger age group. Children with fragmented sleep were characterized by lower performance on NBF measures, particularly those associated with more complex tasks such as a continuous performance test and a symbol-digit substitution test. These children also had higher rates of behavior problems as reported by their parents on the Child Behavior

Checklist. These results highlight the association between sleep quality, NBF, and behavior regulation in child development; and raise important questions about the origins of these associations and their developmental and clinical significance.

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Sleep-related disorders in neurologic disease during childhood

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Abstract

Sleep disorders commonly are associated with neurologic disorders in childhood. This review discusses primary sleep disorders that affect children with primary neurologic diseases. Primary sleep disorders are discussed as they relate to the primary neurologic disease. In addition, sleep disorders secondary to neurologic disorders commonly seen in the practice of pediatric neurology are reviewed. A useful sleep history to improve diagnostic and therapeutic interventions is outlined.

Pediatric Research:

August 2003 - Volume 54 - Issue 2 - pp 237-243

[Sleep Disturbances in Children with Attention Deficit Hyperactivity Disorder](#)

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DISCUSSION

This study illustrates that prepubertal children with ADHD display significant alterations in REM sleep patterns and, furthermore, children with ADHD referred to a sleep clinic are more likely to have an elevated PLMa compared with ADHD children from the general community. Our findings further suggest that REM% and PLMa together account for nearly half of the variance observed between index and control groups.

The current study is, to our knowledge, the largest to date to compare subjective and objective reports of sleep problems in children with ADHD and controls and, furthermore, it is unique in that we had the opportunity to investigate a referred population as well as a community population of children with ADHD. Our subjective findings are in agreement with previous studies [\(1-8\)](#), and show that parents of ADHD children report significantly more problems with sleep, which include increased bedtime resistance [\(7, 8\)](#), difficulty initiating sleep [\(1, 5, 7, 8\)](#), nighttime awakenings [\(1, 7\)](#), sleep-related anxiety [\(3, 7\)](#), enuresis [\(5\)](#), and excessive daytime sleepiness [\(7\)](#). In fact, a comprehensive review of the literature [\(4\)](#) revealed that parents of children with ADHD were five times as likely to report that their children have sleep problems compared with parents of healthy children.

Despite such high frequency of sleep-related complaints, objective assessments of the sleep of children with ADHD have shown inconsistent findings [\(20-23\)](#). However, small sample sizes and inconsistent criteria make comparisons of these studies difficult. The disparity between subjective and objective findings is consistent with that found in the present study and reported by Corkum *et al.* [\(8\)](#), who compared 25 children with ADHD with 25 age-matched controls (mean age, 9 y) using parent- and child-reports of sleep quality and 7-d actigraphic recordings. Parents of children diagnosed with ADHD reported significantly more problems with sleep onset, morning awakenings, restless sleep, and bedtime resistance than children in the control group. However, when both actigraphy recordings and the children's report of their own sleep were analyzed, the only variable that was significantly different between the two groups was bedtime resistance. Corkum and colleagues hypothesized that the significant difficulties that parents of children with ADHD report with their children's sleep may be related to the difficult and often oppositional behaviors manifesting as bedtime resistance rather than represent primary sleep disorders in ADHD. In addition, the objective-subjective incongruences could also be related to differences introduced by retrospective and prospective collection of sleep measures.

Clinically, parents of children with ADHD complain of hyperactive and oppositional behaviors that occur throughout the day and into the evening. The extension of these behaviors to bedtime is the most likely explanation for the higher probability that parents of children with ADHD will report that their children have bedtime resistance and sleep-onset delay. Thus, children with ADHD may be displaying oppositional behaviors that prevent them from following rules and engaging in appropriate bedtime behaviors, and therefore reflect more sleep limit-setting issues rather than represent sleep disorders *per se*.

In contrast with other studies [\(16-19, 25, 26\)](#) we did not find an increase in PLMI in our ADHD children. However, the clinic sample tended to show a greater proportion of children with PLMI ≥ 5 , although this did not reach statistical significance. Interestingly, significantly more of the ADHDcl group demonstrated arousals associated with the PLM. Sampling bias is the most likely explanation for these findings. Thus, children presenting to clinics are more likely to have more

severe sleep problems than those children not in need of specialty care services. The samples of children with ADHD recruited by Picchietti and colleagues [\(17-19\)](#) appear similar to those children enrolled in the ADHDcl group of the present study inasmuch as they presented to a clinic setting for treatment of behavioral and sleep difficulties associated with their ADHD. We postulate that the children in our ADHDcom sample are most likely to reflect the vast majority of children with ADHD who are functioning without the assistance of specialized sleep, psychiatry, or neurology clinics. This further poses the question of whether those children attending the clinical setting are actually a subgroup of children with ADHD who are also more likely to have a nighttime disorder (*i.e.* PLMD). In other words, ADHD children referred to a tertiary specialty clinic may represent a subgroup of ADHD children who are at risk for PLMD, which in turn may exacerbate daytime behavior.

An alternative possibility may be that children presenting to sleep disorders centers are more likely to exhibit PLMD, whether or not they are diagnosed with ADHD. Chervin and Hedger [\(35\)](#) found that 26% of children presenting to their sleep disorders center who underwent PSG had PLMI ≥ 5 and found no association between PLMD and inattention/hyperactivity in children. Conversely, Picchietti and Walters [\(18\)](#) discovered that 91% of children with PLMD in their clinic had a diagnosis of ADHD. The disparity in these findings is therefore difficult to reconcile, and further indicates the need for additional research on the prevalence and significance of PLMD in children with ADHD.

The association between sleep architecture abnormalities and ADHD remains unclear. A review of the published studies that used polysomnography for objective sleep assessment yields inconsistent results in regards to REM sleep characteristics, latency to sleep onset, and total sleep duration in children with ADHD [\(4\)](#). Our present findings indicate that preadolescent children with ADHD have significantly increased REM sleep latency with reduction in percentage of REM sleep compared with controls. These findings appear to be consistent with some of the previously reported data on REM sleep characteristics in ADHD children that revealed prolonged latency to the first REM sleep period and reduced amount of REM sleep [\(20, 23\)](#).

In one of the most recent studies, 30 preadolescent medication-free children with ADHD were compared with 19 age-matched controls using PSG with video monitoring [\(36\)](#). In this latter study, the mean REM sleep latency reported in the ADHD sample (157.8 min) was remarkably similar to the mean REM sleep latencies of the clinical ADHD group (161.1 min) and that of the community ADHD sample (159.0 min) in the present study. However, our control group of children exhibited much shorter REM sleep latency of 121.3 min compared with the 143.2 min reported by Konofal *et al.* [\(36\)](#). Because sleep characteristics are greatly influenced by age, the narrow age range and large sample sizes of both our controls ($n = 49$) and ADHD subjects ($n = 100$) permitted us to uncover statistically significant differences in objective sleep measures, while eliminating many of the biases that may have affected previous studies.

One of the obvious limitations of our study was that PSG was conducted for only one night. First-night effect is one of the factors that may affect REM sleep latency, and the increased REM sleep latency among ADHD children could essentially underlie the fact that ADHD children are more sensitive to changes in the environment. However, when the sleep EEG dynamics were

followed in ADHD children for four consecutive nights, there was a tendency to maintain prolonged REM sleep latency across all the nights ⁽²⁰⁾.

Medications and psychiatric co-morbidities could affect REM sleep as well as sleep continuity measures. Even though there is no clear evidence for stimulant medication directly affecting REM sleep, a later onset to the first REM sleep period in patients treated with psychostimulants has been reported ^(37,38). In a recent study, however, we found that stimulant medication had little effect on both subjective and objective sleep characteristics ⁽³⁹⁾ in preadolescent children. Psychiatric co-morbidities such as anxiety, depression, and behavioral disorders may have a significant impact on sleep disturbances reported by parents ⁽⁴⁰⁾. In this present study, we excluded children with co-morbid diagnoses and those treated with antidepressant and antipsychotic medications to avoid introduction of bias to the study.

Several methodological issues in the current study deserve further comment. First, none of the children included into the study was rigorously assessed using structured diagnostic interviews and rating scales to establish diagnosis of ADHD and determine whether additional psychiatric co-morbidities were present. However, we attempted to gain a more objective measure of hyperactivity by requiring that all of the ADHDcl had a professional diagnosis and assessing all of the ADHDcom group with a validated rating scale, such that selection of both ADHD children and controls was not based strictly on parental reports. A second limitation is that the sleep/wake schedules of our cohort were not controlled by actigraphic recordings before the PSG, and effects of partial sleep loss and inconsistent sleep schedules cannot be excluded as potential modifiers of sleep characteristics. A third limitation was, as mentioned above, the use of single-night PSG for assessment of sleep characteristics without having children acclimated to sleeping in an unfamiliar environment, therefore making it difficult to evaluate the role of adaptation processes, which may differ in ADHD children and normal controls. Finally, although we have recently developed normative data in children's sleep propensity ⁽⁴¹⁾, we did not assess for objective measures of daytime sleepiness, thereby restricting our ability to interpret increased parental reports of excessive daytime sleepiness ⁽⁴²⁾ in clinical samples of ADHD compared with ADHDcom and controls.

CONCLUSION

Consistent with previous findings, we show that parental reports demonstrate an increased frequency of sleep problems among children with ADHD. We have further confirmed and expanded on the reduction in the proportion of REM sleep and prolongation of REM sleep latency in children with ADHD. However, increased PLMD with associated arousals was present only in the clinical sample of ADHD children, suggesting that this condition should not be extrapolated to all children with ADHD and could represent a unique subset of ADHD children with nocturnal motor hyperactivity.

Adequate sleep among adolescents is positively associated with health status and health-related behaviors

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Abstract

Background

Amount of sleep is an important indicator of health and well-being in children and adolescents. Adequate sleep (AS: adequate sleep is defined as 6–8 hours per night regularly) is a critical factor in adolescent health and health-related behaviors. The present study was based on a health promotion project previously conducted on adolescents in Tao-Yuan County, Taiwan. The aim was to examine the relationship between AS during schooldays and excessive body weight, frequency of visiting doctors and health-related behaviors among Taiwanese adolescents.

Methods

A cross-sectional study design, categorical and multivariate data analyses were used. The hypotheses investigated were: high frequency of AS is positively associated with lack of obesity and less frequent visits to doctors; and high frequency AS is positively associated with health-related behavior.

Results

A total of 656 boys (53.2%) and girls (46.8%), ranging in age from 13–18 years were studied between January and June 2004. Three hundred and fifty seven subjects (54%) reported that they slept less than the suggested 6–8 hours on schooldays. A significant negative association was found between low sleep and of the following health-related behaviors: (1) life appreciation; (2) taking responsibility for health; (3) adopting healthy diet; (4) effective stress management; (5) regular exercise; and (6) total AHP score. High frequency AS was associated with low frequencies of obesity after potential confounding factors were controlled. Junior high school adolescents reported significantly higher frequencies of AS than high school participants.

Gender, family structure, home location and frequency of television watching or computer use were not significantly associated with AS.

Conclusion

These findings support the proposition that AS is associated with good health status and high-frequency adoption of health-related behavior. Furthermore, these findings suggest that inadequate sleep may be a screening indicator for an unhealthy lifestyle and poor health status. The results might be useful for future research into the development of intervention strategies to assist adolescents who are not receiving enough hours of sleep.

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Influence of Gender and Age on Upper-Airway Length During Development

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Abstract

OBJECTIVE. Obstructive sleep apnea has a strong male predominance in adults but not in children. The collapsible portion of the upper airway is longer in adult men than in women (a property that may increase vulnerability to collapse during sleep). We sought to test the hypothesis that in prepubertal children, pharyngeal airway length is equal between genders, but after puberty boys have a longer upper airway than girls, thus potentially contributing to this change in apnea propensity.

METHODS. Sixty-nine healthy boys and girls who had undergone computed tomography scans of their neck for other reasons were selected from the computed tomography archives of Rambam and Carmel hospitals. The airway length was measured in the midsagittal plane and

defined as the length between the lower part of the posterior hard palate and the upper limit of the hyoid bone. Airway length and normalized airway length/body height were compared between the genders in prepubertal (4- to 10-year-old) and postpubertal (14- to 19-year-old) children.

RESULTS. In prepubertal children, airway length was similar between boys and girls (43.2 ± 5.9 vs 46.8 ± 7.7 mm, respectively). When normalized to body height, airway length/body height was significantly shorter in prepubertal boys than in girls (0.35 ± 0.03 vs 0.38 ± 0.04 mm/cm). In contrast, postpubertal boys had longer upper airways (66.5 ± 9.2 vs 52.2 ± 7.0 mm) and normalized airway length/body height (0.38 ± 0.05 vs 0.33 ± 0.05 mm/cm) than girls.

CONCLUSIONS. Although boys have equal or shorter airway length compared with girls among prepubertal children, after puberty, airway length and airway length normalized for body height are significantly greater in boys than in girls. These data suggest that important anatomic changes at puberty occur in a gender-specific manner, which may be important in explaining the male predisposition to pharyngeal collapse in adults.

Upper Airway Collapsibility During REM Sleep in Children with the Obstructive Sleep Apnea Syndrome

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Abstract

Study Objectives:

In children, most obstructive events occur during rapid eye movement (REM) sleep. We hypothesized that children with the obstructive sleep apnea syndrome (OSAS), in contrast to age-matched control subjects, would not maintain airflow in the face of an upper airway inspiratory pressure drop during REM sleep.

Design:

During slow wave sleep (SWS) and REM sleep, we measured airflow, inspiratory time, inspiratory time/total respiratory cycle time, respiratory rate, tidal volume, and minute ventilation at a holding pressure at which flow limitation occurred and at 5 cm H₂O below the holding pressure in children with OSAS and in control subjects.

Setting:

Sleep laboratory.

Participants:

Fourteen children with OSAS and 23 normal control subjects.

Results:

In both sleep states, control subjects were able to maintain airflow, whereas subjects with OSAS preserved airflow in SWS but had a significant decrease in airflow during REM sleep (change in airflow of 18.58 ± 12.41 mL/s for control subjects vs -44.33 ± 14.09 mL/s for children with OSAS, $P = 0.002$). Although tidal volume decreased, patients with OSAS were able to maintain minute ventilation by increasing the respiratory rate and also had an increase in inspiratory time and inspiratory time per total respiratory cycle time

Conclusion:

Children with OSAS do not maintain airflow in the face of upper-airway inspiratory-pressure drops during REM sleep, indicating a more collapsible upper airway, compared with that of control subjects during REM sleep. However, compensatory mechanisms exist to maintain minute ventilation. Local reflexes, central control mechanisms, or both reflexes and control mechanisms need to be further explored to better understand the pathophysiology of this abnormality and the compensation mechanism.

Citation:

Huang J; Karamessinis LR; Pepe ME; Glinka SM; Samuel JM; Gallagher PR; Marcus CL. Upper airway collapsibility during REM sleep in children with the obstructive sleep apnea syndrome. *SLEEP* 2009;32(9):1173-1181.

Sleep. 2010 July 1; 33(7): 968–972.

Upper Airway Sensory Function in Children with Obstructive Sleep Apnea Syndrome

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Abstract

Study Objectives:

Children with the obstructive sleep apnea syndrome (OSAS) have impaired responses to hypercapnia, subatmospheric pressure, and inspiratory resistive loading during sleep. This may be due, in part, to an impairment in the afferent limb of the upper airway sensory pathway. Therefore, we hypothesized that children with OSAS had diminished upper airway sensation compared to controls.

Design:

Case-control

Setting:

Academic hospital

Participants:

Subjects with OSAS aged 6–16 years, and age- and BMI-matched controls.

Interventions:

Two-point discrimination (TPD) was measured during wakefulness with modified calipers in the anterior tongue, right interior cheek, and hard palate.

Results:

Thirteen children with OSAS and 9 controls were tested. The age (mean $\pm$ SD) for OSAS and controls was 11 ± 4 vs. 13 ± 2 years (NS); OSAS BMI Z score 2.4 ± 0.5 , controls 2.2 ± 0.5 (NS); OSAS apnea hypopnea index 31 ± 48 , controls 0.4 ± 0.5 events/hour ($P < 0.001$). Children with OSAS had impaired TPD in the anterior tongue (median [range]) = 9 [3–14] mm, controls 3 [1–7], $P = 0.002$) and hard palate (OSAS 6 [3–9] mm, controls 3 [1–4], $P < 0.001$). TPD in the cheek was similar between the groups ($P = 0.12$).

Conclusion:

TPD in the anterior tongue and hard palate was impaired in children with OSAS during wakefulness. We speculate that this impairment might be due to a primary sensory function abnormality or secondary to nerve damage and/or hypoxemia caused by OSAS. Further studies after treatment of OSAS are needed.

Citation:

Adenotonsillectomy improves slow-wave activity in children with obstructive sleep apnoea

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Abstract

The aim of the present study was to estimate slow-wave activity (SWA), a marker of sleep homeostasis, in children with obstructive sleep apnoea (OSA) before and after adenotonsillectomy (AT) compared with untreated OSA children (comparison group).

14 children with OSA (mean±sd age 6.4±2.5 yrs; apnoea–hypopnoea index (AHI) 10.0±10.3 events·h⁻¹) who underwent AT were consecutively recruited to the study. The comparison group comprised six retrospectively recruited children (age 5.4±2.2 yrs; AHI 9.4±7.6 events·h⁻¹) with OSA that did not undergo treatment. Electroencephalogram (derivation C3/A2) was analysed using spectral and waveform analysis to determine SWA energy and slow-wave slope. The same procedure was repeated 5.4 and 19 months later for the AT and comparison groups, respectively.

AT improved respiration without a change in duration of sleep stages. Following AT, >50% elevation of SWA during the first two sleep cycles ($p<0.01$) and a more physiological decay of SWA across the night ($p<0.0001$) were noted. The slow-wave slope increased by >30% following AT ($p<0.03$). No significant changes were found in SWA in the comparison group.

Sleep homeostasis is considerably impaired in pre-pubescent children with OSA. AT restores more physiological sleep homeostasis in children with OSA. SWA analysis may provide a useful addition to standard sleep-stage analyses in children with OSA.

Pathophysiology of upper airway obstruction: a developmental perspective.

(PMID:15453561)

- [Abstract](#)
- [Citations](#) 
- [BioEntities](#) 
- [Related Articles](#) 

[Arens R, Marcus CL](#)

Division of Pulmonary Medicine and Sleep Disorders Center, The Children's Hospital of Philadelphia, University of Pennsylvania School of Medicine, Philadelphia 19104, USA.

[Sleep](#) [2004, 27(5):997-1019]

Type: Journal Article, Review, Research Support, U.S. Gov't, P.H.S.

Abstract

The obstructive sleep apnea syndrome (OSAS) occurs in patients of all ages, from the premature infant to the elderly. Much remains unknown about the pathophysiology of the syndrome. However, research suggests that OSAS in all age groups is due to a combination of both anatomic airway narrowing and abnormal upper airway neuromotor tone. The anatomic predisposing factors for OSAS differ over the lifespan. However, a smaller upper airway is noted in all age groups and probably predisposes to airway collapse during sleep. Despite the known anatomic factors, such as craniofacial anomalies, obesity, and adenotonsillar hypertrophy, that contribute to OSAS throughout life, a clear anatomic factor cannot always be identified. This suggests that alterations in upper airway neuromotor tone also play an important role in the etiology of OSAS. Infants and children are less likely than adults to arouse in response to upper airway obstruction and do not compensate for prolonged increases in inspiratory resistive load. The overall ventilatory drive is probably normal in patients of all ages with OSAS. However, upper airway neuromotor tone and reflexes during sleep vary with age and are increased in normal infants and children compared to adults, perhaps as a compensatory response for their relatively narrow airway. This compensatory response appears to be blunted in children with OSAS. Further research is needed to fully understand the complexities of upper airway structure and function during both normal development and disease.



Adenotonsillectomy for upper airway obstruction carries increased risk in children with a history of prematurity

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Pediatric Pulmonology

[Volume 13, Issue 4](#), pages 222–226, August 1992

Keywords:

- Perioperative complications;
- abnormal facial development

Abstract

To define better the clinical presentation and perioperative outcome in children undergoing adenotonsillectomy (T&A) for relief of upper airway obstruction (UAO), we reviewed the hospital records of 60 consecutive, otherwise normal children aged 12 years or younger. Seven patients with trisomy 21, neurologic impairments, or preoperative cor pulmonale were excluded. Intraoperative and postoperative complications were experienced by 15 (34%) and 13 (25%), respectively, of the 53 children with preoperative UAO. The most severe complications comprised pulmonary edema and prolonged postoperative oxyhemoglobin desaturation. Multivariate logistic regression analysis found a history of prematurity and/or low birth weight to be the most significant risk factors related to the occurrence of complications. Twenty-eight % of the study population had a history of prematurity and they had approximately 85% of the perioperative complications seen in children with UAO undergoing T&A. Other significant risk factors included adenoidal facies and evidence of respiratory distress at the time of surgery. It appears that T&A poses significant risk for children with UAO who were born prematurely and have evidence of abnormal facial development or respiratory distress preoperatively. © 1992 Wiley-Liss, Inc.

[International Journal of Pediatric Otorhinolaryngology](#)

[Volume 70, Issue 10](#), October 2006, Pages 1675-1682

The effect of adenotonsillectomy on children suffering from obstructive sleep apnea syndrome (OSAS): The Negev perspective

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Summary

Objective

To present the Negev perspective in recent decades as to the effect of adenotonsillectomy regarding clinical and polysomnographic features, cardiopulmonary morbidity, growth, neurocognitive function, health care services utilization, and enuresis by reviewing current related literature.

Methods

All relevant published data by the Soroka University Medical Center and related community medical services were reviewed and compared to MEDLINE linked literature regarding aspects of childhood obstructive sleep apnea published through November 2005.

Results

Published data support a significant effect of adenotonsillectomy on the associated co morbidities: adenotonsillectomy resulted in the reduction of pulmonary hypertension, improved growth as a result of an increase in growth hormone secretion, improvement of neurocognitive function to the normal range, reduction in nocturnal enuresis, as well as reducing general morbidities, as reflected by the reduction in health care utilization. However, there are still uncertainties relating to major aspects. There is no specific definition for OSAS grading, or for generating a guideline for surgical treatment and refinement of the indications of T&A.

Conclusions

Adenotonsillectomy has a beneficial effect on children with OSAS, however, further research is required before recommendations for the treatment of OSAS in children can be formulated.

Childhood obesity and obstructive sleep apnea syndrome

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- Submitted 29 June 2009.
- accepted in final form 26 October 2009.

Abstract

The increasing prevalence of obesity in children seems to be associated with an increased prevalence of obstructive sleep apnea syndrome (OSAS) in children. Possible pathophysiological mechanisms contributing to this association include the following: adenotonsillar hypertrophy due to increased somatic growth, increased critical airway closing pressure, altered chest wall mechanics, and abnormalities of ventilatory control. However, the details of these mechanisms and their interactions have not been elucidated. In addition, obesity and OSAS are both associated with metabolic syndrome, which is a constellation of features such as hypertension, insulin resistance, dyslipidemia, abdominal obesity, and prothrombotic and proinflammatory states. There is some evidence that OSAS may contribute to the progression of metabolic syndrome with a potential for significant morbidity. The treatment of OSAS in obese children has not been standardized. Adenotonsillectomy is considered the primary intervention followed by continuous positive airway pressure treatment if OSAS persists. Other methods such as oral appliances, surgery, positional therapy, and weight loss may be beneficial for individual subjects. The present review discusses these issues and suggests an approach to the management of obese children with snoring and possible OSAS.

Journal of Applied Physiology

Childhood obesity and obstructive sleep apnea syndrome

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Abstract

The increasing prevalence of obesity in children seems to be associated with an increased prevalence of obstructive sleep apnea syndrome (OSAS) in children. Possible pathophysiological mechanisms contributing to this association include the following: adenotonsillar hypertrophy due to increased somatic growth, increased critical airway closing pressure, altered chest wall mechanics, and abnormalities of ventilatory control. However, the details of these mechanisms and their interactions have not been elucidated. In addition, obesity and OSAS are both associated with metabolic syndrome, which is a constellation of features such as hypertension, insulin resistance, dyslipidemia, abdominal obesity, and prothrombotic and proinflammatory states. There is some evidence that OSAS may contribute to the progression of metabolic syndrome with a potential for significant morbidity. The treatment of OSAS in obese children has not been standardized. Adenotonsillectomy is considered the primary intervention followed by continuous positive airway pressure treatment if OSAS persists. Other methods such as oral appliances, surgery, positional therapy, and weight loss may be beneficial for individual subjects. The present review discusses these issues and suggests an approach to the management of obese children with snoring and possible OSAS.

[Sleep and Breathing](#)

[Volume 11, Number 4](#), 209-216, DOI: 10.1007/s11325-007-0104-3

Use of a sibilant phoneme registration protocol to prevent upper airway collapse in patients with TMD

[Gurdev Dave Singh](#) and [Steven Olmos](#)

Abstract

Patients with temporomandibular dysfunction (TMD) require antero-posterior (AP) correction of mandibular position inter alia. Determination of the limit of the AP correction using a sibilant phoneme registration (SPR) protocol is essential in not increasing muscular tonus. The aim of this study is to investigate the effect of a SPR protocol on the upper airway. Using acoustic pharyngometry data, mean airways of 46 adults undergoing treatment for TMD were reconstructed in 3-D and analyzed using finite element analysis and principal components analysis. When the mean baseline functional residual capacity (FRC) airway was compared to the mean collapsed residual volume (RV) airway, a 25% reduction in the 3-D upper airway was demonstrable ($p < 0.01$). When the mean baseline FRC airway was compared to the mean airway with SPR (FRC-SPR), a 12% increase was found at the oropharyngeal junction of the 3-D airway, but this finding failed to reach statistical difference. Similarly, when the mean

FRC–SPR airway was compared to the mean RV–SPR airway, the amount of collapse was reduced to 16% but again no statistical difference was found. In contrast, when the mean RV airway was compared to the mean RV–SPR airway, a 15–18% increase was found ($p < 0.05$). It is concluded that the use of a SPR protocol may be useful in improving upper airway RV in patients, during treatment for TMD.

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Obesity and Excessive Daytime Sleepiness in Prepubertal Children With Obstructive Sleep Apnea

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Abstract

INTRODUCTION. The epidemic of childhood obesity has prompted remarkable changes in the relative proportions of symptomatic overweight or obese children being referred for evaluation of habitual snoring. However, it remains unclear whether obesity modifies the relative frequency of daytime symptoms such as excessive daytime sleepiness.

METHODS. Fifty consecutive, nonobese, habitually snoring, otherwise-healthy children (age range: 6–9 years) and 50 age-, gender-, and ethnicity-matched obese children (BMI z score: >1.67) underwent an overnight polysomnographic evaluation, followed by a multiple sleep latency test the following day.

RESULTS. The mean obstructive apnea/hypopnea index values for the 2 groups were similar (nonobese: 12.0 ± 1.7 episodes per hour of total sleep time; obese: 10.9 ± 1.5 episodes per hour of total sleep time). However, the mean sleep latency for obese children was significantly shorter (12.9 ± 0.9 minutes) than that for nonobese children (17.9 ± 0.7 minutes). Furthermore, 21 obese children had mean sleep latencies of ≤ 12.0 minutes, compared with only 5 nonobese children. Although significant associations emerged between mean sleep latency, obstructive apnea/hypopnea index, proportion of total sleep time with oxygen saturation of $<95\%$, and respiratory arousal index for the whole cohort, the slopes and intersects of the linear correlation of mean sleep latency with any of these polygraphic measures were consistently greater in the obese cohort.

CONCLUSIONS. The likelihood of excessive daytime sleepiness for obese children is greater than that for nonobese children at any given level of obstructive sleep apnea severity and is strikingly reminiscent of excessive daytime sleepiness patterns in adults with obstructive sleep apnea.

CHEST

Urine Concentrations of Cysteinyl Leukotrienes in Children With Obstructive Sleep-Disordered Breathing

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Abstract

Background: Adenotonsillar tissue of children with obstructive sleep-disordered breathing (SDB) has increased content of cysteinyl leukotrienes (CysLTs) and expression of CysLTs receptors. Furthermore, CysLTs concentrations in the nasal exhaled breath condensate of children with sleep apnea are elevated.

Objective: To investigate the relationship between urine levels of CysLTs and severity of SDB in children.

Methods: Morning urine concentrations of CysLTs were measured in children with symptoms of SDB and in control subjects with recurrent tonsillitis and without snoring who underwent polysomnography and were expressed in pg/mL per mg/dL of urine creatinine.

Results: Nineteen children with moderate-to-severe SDB (mean [$\pm$ SD] age, 5.4 ± 1.6 years; obstructive apnea-hypopnea index [OAHI]: 14.4 ± 9.6 episodes/h), 29 subjects with mild SDB (5.1 ± 1.5 years; OAHI: 2.9 ± 0.8 episodes/h), 26 children with primary snoring (PS) [7 ± 2.6 years; OAHI: 1.1 ± 0.3 episodes/h], and 18 control subjects (6.4 ± 2.5 years; OAHI: 0.7 ± 0.3 episodes/h) were studied. Children with moderate-to-severe SDB had higher log-transformed urine CysLTs levels than those with mild SDB, PS, or control subjects (2.39 ± 0.51 vs 2.06 ± 0.26 vs 2.11 ± 0.25 vs 1.86 ± 0.28 ; $p < 0.05$). Log-transformed CysLTs concentration, tonsillar size, and body mass index z score were significant predictors of log-transformed OAHI ($p < 0.01$).

Conclusions: Urine excretion of CysLTs is related to SDB severity in children. This finding indicates that 5-lipoxygenase pathway products participate in the pathogenesis of obstructive sleep apnea in childhood or alternatively that SDB promotes CysLTs biosynthesis.

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Infant-Feeding Methods and Childhood Sleep-Disordered Breathing

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Abstract

OBJECTIVE. Childhood sleep-disordered breathing has an adverse impact on cognitive development, behavior, quality of life, and use of health care resources. Early viral infections and other immune-mediated responses may contribute to development of the chronic inflammation of the upper airway and hypertrophic upper airway lymphadenoid tissues underlying childhood sleep-disordered breathing. Breastfeeding provides immunologic protection against such early

exposures. Therefore, we sought to explore whether sleep-disordered breathing severity would differ for children who were breastfed as infants.

METHODS. The parents or guardians of 196 habitually snoring children (mean $\pm$ SD: 6.7 $\pm$ 2.9 years old) who were undergoing overnight polysomnography at Kosair Children's Hospital Sleep Medicine and Apnea Center completed a retrospective survey on the method(s) used to feed the child as an infant.

RESULTS. Among habitually snoring children, those who were fed breast milk for at least 2 months had significantly reduced sleep-disordered breathing severity on every measure assessed, including apnea-hypopnea index, oxyhemoglobin desaturation nadir, and respiratory arousal index. Breastfeeding for longer than 5 months did not contribute additional benefits.

CONCLUSIONS. Our findings support the notion that breastfeeding may provide long-term protection against the severity of childhood sleep-disordered breathing. Future research should explore mechanism(s) whereby infant-feeding methods may affect the pathophysiology of development of childhood sleep-disordered breathing.

Otolaryngology -- Head and Neck Surgery

Palatine Tonsil Size and its Correlation with Subjective Tonsil Size in Patients with Sleep-Disordered Breathing

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Abstract

OBJECTIVE: To investigate the correlation of subjective tonsil size with real palatine tonsil size and to compare the differences of each parameter according to subjective tonsil size and between children and adults.

STUDY DESIGN: Prospective evaluation of subjective tonsil size (0–4+) and real palatine tonsil size, including tonsil height (TH), tonsil width (TW), tonsil thickness (TT), total tonsil volume (TTV), and embedded tonsil volume (ETV) within the tonsillar fossa.

SETTING: Tertiary-care rhinologic clinic.

SUBJECTS AND METHODS: We measured TH, TW, TT, TTV, and ETV in 277 children and 63 adults with sleep-disordered breathing (SDB).

RESULTS: In both children and adults, subjective tonsil size was significantly correlated with TTV, TH, TW, and TT (correlation coefficients 0.199–0.427 for children and 0.462–0.551 for adults). In children, TTV increased in proportion to subjective tonsil size, but about 45 percent and 34 percent of tonsils markedly deviated from the mean value of their TTV in size 2 and 3 groups, respectively. In adults, TTV of subjective tonsil size 3 and 4 groups was significantly larger than that of size 1 and 2 groups.

CONCLUSIONS: Real palatine tonsil size correlated with subjective tonsil size in both children and adults with SDB. Although there is a statistical correlation in children between TTV and subjective tonsil size, there is significant discordance in size 2 and 3 groups, thus greatly limiting the value of subjective tonsil size assessment in the majority of children. However, adult subjective tonsil size may reflect real palatine tonsil size and may help predict it preoperatively.

[Sleep and Breathing](#)

[Volume 4, Number 2](#), 67-77, DOI: 10.1007/BF03045026

Neuropsychological and behavioral correlates of obstructive sleep apnea syndrome in children: A preliminary study

[Judith Owens](#), [Anthony Spirito](#), [Ann Marcotte](#), [Melissa McGuinn](#) and [Leslie Berkelhammer](#)

Abstract

Study Objectives: The purpose of this pilot study was to evaluate a group of children with mild to moderate Obstructive Sleep Apnea Syndrome (OSAS) for baseline neurocognitive deficits and behavioral dysfunction. A subset of the sample were also reassessed, using the same test battery, after treatment with adenotonsillectomy. **Design:** Baseline and post-treatment neuropsychological and behavioral assessment. **Setting:** Pediatric sleep disorders clinic at a children's teaching hospital. **Patients:** 18 children (12 males, 6 females, mean age 7.3 years $\pm$ 2.0) meeting polysomnographic criteria for OSAS underwent baseline assessment; 8 children (6 males, 2 females, mean age 8.4 years $\pm$ 2.6) also completed the post-treatment assessment phase. **Measurements:** An age appropriate neuropsychological battery including measures of global cognitive functioning, language, executive functioning and attention, memory, visual perception/visual motor skills and motor skills; two parent rating scales of behavior. **Results:** Modest

impairments, largely in executive functioning/attention and motor skills, were found at baseline. Parents endorsed a variety of behavioral problems, especially somatic complaints and problems with learning. There appeared to be relatively little association between impairment and disease severity, although there was a trend for the children with less severe disease, who were also older, to have relatively more behavioral problems. Post treatment, there were modest improvements in executive functioning/attention and motor skills, as well as in parent-reported internalizing and externalizing behaviors. **Conclusions:** The preliminary results with a small sample suggest mild deficits in executive functions and motor skills in children with mild to moderate OSAS, with modest improvements in the same neuropsychological domains post-treatment. A variety of parent-reported behavioral problems were found at baseline, again with modest improvement post-adenotonsillectomy.

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The Practice of Pediatric Sleep Medicine: Results of a Community Survey

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Abstract

Objective. To assess knowledge, screening, evaluation, treatment practices, and attitudes regarding sleep disorders in children and adolescents in a large sample of community-based and academic pediatricians.

Design. Cross-sectional survey.

Participants. Six hundred twenty-six pediatricians in Rhode Island, Massachusetts, and Connecticut.

Instrument. The Pediatric Sleep Survey, a 42-item questionnaire assessing general and specific sleep knowledge categories; clinical screening, diagnostic, and treatment practices for common pediatric sleep disorders; and practitioner attitudes regarding the impact of sleep disorders in the clinical setting and as a public health issue.

Results. On the knowledge section, the mean Total Knowledge score for the respondents was 18.1 ± 3.5 out of 30 items, with 23.5% of the sample responding correctly on half or less of the

items. Pediatricians scored highest on items relating to developmental and behavioral aspects of sleep and parasomnias, whereas the mean percentage of correct responses was <50% for items relating to sleep disordered breathing, excessive daytime sleepiness, and sleep movement disorders. Although only 16.5% and 18.2% of the sample reported not screening routinely for sleep disorders in infants and toddlers, this percentage rose to 43.9% in adolescents. Furthermore, only 38.3% regularly question the adolescents themselves about their sleep. Only about one quarter of the respondents screen toddlers and school-aged children for snoring. In evaluating and treating pediatric sleep problems, 53.2% of the sample never or rarely order overnight sleep studies to assess for obstructive sleep apnea and few use alternative treatment strategies, such as continuous positive airway pressure. A quarter of the sample at least occasionally recommends diphenhydramine and almost half suggests a psychological evaluation for children with night terrors. Finally, the percent of pediatricians rating the impact on children of sleep problems in a variety of domains as important or very important ranged from 49.7% (nonintentional injuries) to 92.6% (academic performance). However, only 46% of the sample felt confident or very confident about their own ability to screen for sleep problems, whereas 34.2% and 25.3% similarly rated their ability to evaluate and treat sleep problems in children.

Conclusions. The results of this survey suggest that there are still significant gaps among practicing pediatricians both in basic knowledge about pediatric sleep disorders, and in the translation of that knowledge into clinical practice. Despite their acknowledgment of the importance of sleep problems, many pediatricians fail to screen adequately for them, especially in older children and adolescents. Additional educational efforts regarding pediatric sleep issues are warranted, and should be targeted at the medical school, postgraduate training, and continuing medical education levels.

[Sleep Medicine Reviews](#)

[Volume 10, Issue 6](#), December 2006, Pages 399-405

CLINICAL REVIEW

Sleep and sleep disorders in adults with attention deficit/hyperactivity disorder

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Summary

Attention deficit/hyperactivity disorder (ADHD) is a frequent disorder that often persists in adulthood. Persistent ADHD is known to be a serious risk factor for other disorders in adulthood, and adults with ADHD often report on sleep disorders. Despite this, only few studies have investigated the subjective and objective quality of sleep in adults suffering from ADHD.

Previous studies have revealed seriously impaired subjective sleep quality and increased nocturnal motor activity in spite of essentially normal standard polysomnographic parameters in this patient group. However, primary sleep disorders such as sleep apnea syndrome or restless legs syndrome (RLS) may be misdiagnosed as ADHD. Moreover, ADHD and primary sleep disorders may occur as comorbidities. In particular, RLS was suggested to be highly associated with ADHD, indicating a probable common central nervous dopaminergic dysfunction. To date, larger studies with adequate sample sizes that compare sleep in adult patients with ADHD, healthy control groups and patients with other primary sleep disorders are still lacking.

Keywords: Attention deficit hyperactivity disorder; Adults; Sleep; Polysomnography; Subjective sleep quality

Abbreviations: ADD, Attention deficit disorder; ADHD, Attention deficit/hyperactivity disorder; ADHDRS, Attention deficit/hyperactivity disorder rating scale; ASP, antisocial personality disorder; BMI, body mass index; CPAP, continuous positive airway pressure; ESS, Epworth Sleepiness Scale; HC, healthy control; MSLT, multiple sleep latency test; OSA, obstructive sleep apnea; PSG, polysomnography; Pts, patients; SDB, sleep disordered breathing; SSS, Stanford sleepiness scale; WURS, Wender Utah Rating Scale

[Sleep Medicine](#)

[Volume 9, Issue 4](#), May 2008, Pages 418-424

Risk for sleep-disordered breathing and executive function in preschoolers

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Abstract

Background

Pediatric sleep-disordered breathing is known to negatively impact cognitive development. While a theoretical basis has been proposed for the developmental effect of pediatric sleep-disordered breathing on executive function specifically, this had not been directly examined among preschool-age children. This population may be particularly vulnerable if school-readiness is compromised. The purpose of the current study was to use a multi-dimensional approach to assessing executive function among preschool-age children at risk for sleep-disordered breathing.

Methods

Thirty-nine preschool children were administered executive function tasks assessing the dimensions of inhibition, working memory, and planning as part of a larger study. A parent or guardian completed a validated questionnaire concerning the child's snoring and other behaviors indicating risk for sleep-disordered breathing.

Results

After controlling for age in a series of regressions, higher parent-reported risk for sleep-disordered breathing was associated with substantially lower performance on each executive function dimension. In comparing the group means of children at high and low risk for sleep-disordered breathing, the single snoring frequency item also showed that children who snored frequently or almost always had lower performance on each executive function dimension.

Conclusions

The results suggest that sleep-disordered breathing may be associated with impaired executive function in preschoolers, with its strongest impact on the inhibition dimension, further emphasizing the importance of early intervention for sleep-disordered breathing in this early age group.

Keywords: Pediatric; Obstructive sleep apnea; Sleep-disordered breathing; Cognition; Executive function; Preschool; Development

Periodic Leg Movements and Sleep-Disordered Breathing in Children

1. Sabine Scholle,
2. Hans-Christoph Scholle,
3. And Gerhard Zwacka

Somnologie

[Volume 5, Issue 4](#), pages 153–158, December 2001

Summary*Objective* Children with OSAS (obstructive sleep apnea syndrome) have a restless sleep. Furthermore they show a changed daytime behavior comparable with attention deficit hyperactivity disorder (ADHD). We investigated the prevalence of periodic leg movements in sleep in OSAS patients to answer the question whether OSAS can be misinterpreted by

insufficient diagnostics for example actigraphy alone. *Methods* 25 children who had no OSAS (controls) (age 3.1 to 14.3 years, median 7.3 years) were examined polysomnographically. 25 age-matched patients with clinically confirmed OSAS and an apnea/hypopnea index (AHI) ≥ 5 /h were investigated polysomnographically in one night before treatment (diagnostic night – baseline) and in one night with therapy. In the 3 groups the number of all leg movements (LM) and periodic leg movements (PLM) were counted in the time in bed as well as in the total sleep time (LMS/PLMS). Furthermore the number of LM and PLM was calculated in wakefulness, NREM and REM. The ratio of PLM to LM was calculated. Additionally we calculated, how frequently LMS and PLMS were accompanied by EEG-arousals. *Results* 92 % of OSAS patients had an enhanced PLMS-Index > 5 /h TST. OSAS patients without therapy had a significantly enhanced number of LMS (LMS: 19.2/h TST [qr = 12.3]) and PLMS (11.8/h TST [qr = 10.6]) in comparison to controls (LMS: 8.9/h TST [qr = 2.4], PLMS: 2.3/h TST [qr = 2.1]) and treated OSAS patients (LMS: 9.9/h TST [qr = 4.7], PLMS: 3.7/h TST [qr = 3.6]). Under therapy there was a significant diminution of LM and PLM in NREM and REM but not during wakefulness. Without therapy two thirds of all LMS were PLMS (66.3 % [qr = 16.4]) while in treated patients the total LMS included one third PLMS (39.6 % [qr = 32.9]) comparable with controls (28.4 % [qr = 15.9]). 90.1 % [qr = 18.9] of all PLMS in controls were accompanied by EEG-arousals but 61.0 % [qr = 23.9] in OSAS patients and 71.4 % [qr = 36.7] in treated OSAS patients. *Conclusions* OSAS patients in childhood have a PLMD by definition (PLMS > 5 per hour TST, changed daytime behavior [2]) resolving by the therapy of sleep disturbed breathing. Because of the overlap of the symptoms sleep-disordered breathing should be considered in the differential diagnosis of children with PLMD, RLS (restless legs syndrome) and ADHD (attention deficit hyperactivity disorder). Different pathogenesis needs an appropriate therapeutic strategy.

[Neuromuscular Disorders](#)

[Volume 16, Issues 9-10](#), October 2006, Pages 564-570

Sleep disorders in childhood-onset myotonic dystrophy type 1

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Received 24 February 2006; revised 9 June 2006; Accepted 21 June 2006. Available online 23 August 2006.

Abstract

Slowness, fatigue, and learning difficulties are common in young patients with myotonic dystrophy type 1. These features may indicate poor sleep quality. The aim of this study was to search for sleep disorders in this population. This prospective study used questionnaires, genetic testing, night-time polysomnography and multiple sleep latency tests to evaluate objective daytime sleepiness. Twenty-one patients were included. Mean age was 15.0 ± 3.0 . Age of onset of myotonic disorders was after birth and before 10 years old. Age of diagnosis was 12.0 ± 2.9 . Fatigue was reported by 76% of patients, while somnolence was present in 52%. Sleep was disturbed by numerous microarousals (mean 16.6 ± 7.3 /h of sleep) caused by abnormal respiratory events (6/21 patients) and/or periodic limb movements (8/21 patients). In young patients with DM1, complaints of fatigue and/or somnolence should lead to a polysomnography to look for sleep apnea syndrome and/or periodic limb movement, which were present in two-thirds of our population.

[Sleep Medicine](#)

[Volume 2, Issue 5](#), September 2001, Pages 407-416

Nasal bilevel positive airway pressure therapy in children with a sleep-related breathing disorder and attention-deficit hyperactivity disorder: effects on electrophysiological measures of brain function

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Abstract

Objective: To examine the effect of nasal bilevel positive airway pressure (BiPAP) treatment for concurrent sleep-related breathing disorders (SRBDs) and attention-deficit hyperactivity disorder (ADHD) on electrophysiological measures of spontaneous brain activity and auditory stimulus processing.

Methods: Nineteen children diagnosed with both SRBD and ADHD participated. Electroencephalogram (EEG) activity was recorded during a resting period and an auditory oddball task before beginning BiPAP treatment, after 6 months on treatment, and after a subsequent 1 week non-treatment period. Treatment effects on EEG and event-related potentials (ERPs) to target stimuli were examined via topographic analysis.

Results: Thirteen of the initial 19 children completed 6 months of BiPAP therapy, with six lost mainly due to compliance problems. Children on BiPAP therapy showed a significant decrease

in slow-wave (delta and theta) and an increase in fast wave (beta) EEG activity. The P3 component of the ERP showed treatment effects in amplitude and latency.

Conclusions: The electrophysiological data suggest that SRBDs may contribute to ADHD symptomatology. Treatment of SRBD with BiPAP therapy in children with concurrent ADHD can lead to significant changes, in the direction of normalization, of the typical electrophysiological features of ADHD.

Keywords: Nasal bilevel positive airway pressure; Sleep related breathing disorder; Attention-deficit hyperactivity disorder; Electroencephalogram, Event related potential; P3

Nature and Science of Sleep Dovepress

Neurocognitive performance and behavior before and after treatment for sleep-disordered breathing in children

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Abstract: Neurocognitive and behavioral problems are increasingly reported in children with sleep-disordered breathing (SDB). The impact of treatment for SDB on neurocognition and behavior is, therefore, an issue of increasing importance. To date, there has been little consideration given to the quality of studies when reviewing associated neurocognitive and behavioral problems in children with SDB, and furthermore, there has been little systematic review of treatment outcomes. The aim of this review was to provide an up-to-date and critical review of the current literature. Findings indicate a specific pattern of neurocognitive problems in children with SDB; however, the pattern of behavioral problems is less clear. Very few studies were found to provide a rigorous investigation of posttreatment neurocognitive and behavior outcomes. Despite this, relatively consistent improvements in global intelligence, attention, and visual spatial ability are shown; however, persistent deficits in other domains are also evident. For behavior, problems of hyperactivity, aggression or conduct problems, and somatic complaints improve following treatment. In contrast, symptoms of anxiety and social problems less consistently improve. These findings should aid in the development of more targeted investigations and well-designed studies exploring both the causative mechanisms and the treatment response for neurocognitive and behavior problems in children with SDB.

Keywords: adenotonsillectomy, neurocognition, sleep-disordered breathing, children, behavior



Journal for Oto-Rhino-Laryngology, Head and Neck Surgery

[Vol. 69, No. 6, 2007](#)

Outcomes and Quality of Life following Adenotonsillectomy for Sleep-Disordered Breathing in Children

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Abstract

Purpose: To summarize current knowledge of the outcome of adenotonsillectomy (T&A) for the treatment of sleep-disordered breathing (SDB) in children. *Results:* The success rate of T&A for SDB as measured on the basis of objective criteria using polysomnography ranges from 79 to 92%. Dramatic improvements in quality of life after T&A for SDB have been shown in a number of studies and these improvements are maintained up to 2 years after surgery. Significant improvements that are maintained in the long term are also seen in behavioral and neurocognitive parameters following T&A for SDB. Not surprisingly, total health care costs are reduced by one third following T&A mostly because of a reduction in upper respiratory tract infections. *Conclusions:* T&A is associated with improvements in polysomnography, behavior and quality of life in children with SDB. Improved health in these children leads to a reduction in health care utilization.

[Child and Adolescent Psychiatric Clinics of North America](#)

[Volume 18, Issue 4](#), October 2009, Pages 813-823

Pediatric Sleep Disorders

The Neurocognitive Effects of Sleep Disruption in Children and Adolescents

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Abstract

Sleep problems in children and adolescents are common, and sleep disruption is associated with a wide range of behavioral, cognitive, and mood impairments, including hyperactivity, reduced school grades, and depression. Insufficient or fragmented sleep may induce sleepiness, which is associated with problematic behavior, impaired learning, and/or negative mood. Furthermore, treatment of sleep disruption, by improving sleep hygiene or treating specific sleep disorders, is often associated with improvements in daytime performance, suggesting a common mechanism for the behavioral manifestations. This article reviews the daytime manifestations of sleep disruption.

[Otolaryngologic Clinics of North America](#)

[Volume 40, Issue 4](#), August 2007, Pages 855-875

Sleep Disorders

Surgery for Pediatric Sleep Apnea

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Abstract

Sleep-related breathing disorders (SRBD) in children are caused by a diverse group of anatomic and physiologic pathologies. These disorders share a common clinical presentation as stertor or sonorous breathing, occasionally accompanied by apneic events of variable duration. Successful management depends on accurate identification of the site of obstruction and the severity of obstruction. Intervention, both surgical and nonsurgical, is tailored to the disorder. In children with SRBD, such intervention may alter behavior and cognition, improve sleep and feeding, or even save a life.

[Acta Otorrinolaringol Esp.](#) 2009 Sep-Oct;60(5):325-31. Epub 2009 Aug 13.

[Neurocognitive and behavioural abnormalities in paediatric sleep-related breathing disorders].

[Article in Spanish]

[Esteller Moré E](#), [Barceló Mongil M](#), [Segarra Isern F](#), [Piñeiro Aguín Z](#), [Pujol Olmo A](#), [Soler EM](#), [Ademà Alcover JM](#).

Source

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Abstract

INTRODUCTION:

Behavioural and neurocognitive abnormalities in children may be a consequence of sleep-related breathing disorders. The effectiveness of assessments based on questioning parents is dubious and objective assessment tools are therefore required.

AIM:

To ascertain the impact of these abnormalities in children with sleep-related breathing disorders and compare the reliability of questioning parents in relation to validated psychological tests.

METHOD:

A prospective study was performed on 20 children with sleep-related breathing disorders and 20 healthy control children between 3 and 12 years of age. Both groups were subjected to a battery of validated psychological tests. The results of both groups were compared with each other and with the response to clinical questionnaires given to parents in the problem group.

RESULTS:

More than 75% of the cases in the problem group presented abnormalities with regard to attention, anxiety, memory and spatial structuring. The percentage involvement in all concepts was higher in the problem group. Comparisons of attention (40% of children affected in the control group and 80% in the problem group), memory (50% and 84.2%), and spatial structuring (45% and 75%) were statistically significant. More abnormality was observed in the parameters assessed with psychological tests than the equivalent concept obtained from interviewing the parents. Comparison of abnormal concentration assessed from the questionnaires (40% of children affected) with attention during the psychological test (80%), memory (15% and 84.21%), and delayed language development (10%) compared to spatial structuring (75%) was statistically significant.

CONCLUSIONS:

A high prevalence of behavioural and neurocognitive abnormalities was observed in children with sleep-related breathing disorders compared to a control group of healthy children. The use of objective assessment such as psychological tests revealed more abnormalities than were expressed by parents in response to clinical interviews.

[Archivos de Bronconeumología \(\(English Edition\)\)](#)

[Volume 43, Issue 12](#), 2007, Pages 655-661

Sleep Apnea-Hypopnea Syndrome in a Pediatric Population: Differences Between Children With Tonsillar Hypertrophy and Those With Concomitant Disease

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OBJECTIVE

Our aim was to compare clinical and polysomnographic variables in pediatric patients with sleep apnea-hypopnea syndrome (SAHS) secondary to tonsillar hypertrophy with those in patients with concomitant disease.

PATIENTS AND METHODS

We studied 42 children with SAHS (mean [SD] age, 8 [4] years; body mass index [BMI], 19.6 [5.2] kg/m²; neck circumference, 29 [4] cm; and BMI percentile, 67 [36]), 26 of whom were otherwise healthy (group A) and 16 of whom had concomitant disease (group B).

RESULTS

A comparison of groups A and B showed no significant differences in age (7.7 [3.9] years vs 8.4 [3.9] years; P =not significant [NS]); sex, BMI (17.6 [4] kg/m² vs 20.4 [6] kg/m²; P =NS), neck circumference (29.3 [4.7] cm vs 30.7 [3.5] cm; P =NS), or BMI percentile (61 [37] vs 76 [34]; P =NS). Tonsillar hypertrophy was more frequent in group A (P =.02) and craniofacial abnormalities (P =.008), macroglossia (P =.04), and dolichocephalia (P =.04) were more frequent in group B. No significant differences were observed in neurophysiologic variables or in the respiratory disturbance index, although group A presented higher oxygen saturation levels (97 [1.7] vs 95 [2]; P <.007), lower oxygen desaturation index scores (7 [7] vs 15 [10]; P =.007), and a

lower cumulative percentage of time with oxygen saturation lower than 90% (2.2 [4] vs 16.4 [4]; $P=.01$). Twenty-three patients (88.5%) in group A underwent tonsillectomies compared to 7 (44%) patients in group B ($P=.003$). Seven patients (44%) in group B were treated with continuous positive airway pressure (CPAP) and 2 patients were treated with bilevel positive airway pressure (BiPAP), compared to 1 patient (3.8%) treated with CPAP in group A ($P=.003$). Three children in group B underwent maxillary surgery. The evolution of clinical and polygraphic variables was more favorable in group A ($P=.04$).

CONCLUSIONS

Children with SAHS suffer from repeated infections, delayed weight gain, hyperactivity, and neuropsychiatric manifestations. Obesity (associated with concomitant disease) and sleepiness are uncommon. Although most patients require surgery, as many as a third require treatment with CPAP or BiPAP. Furthermore, children with SAHS and concomitant disease show no specific clinical characteristics, although they tend to be more obese, have more craniofacial abnormalities, and greater nocturnal hypoventilation.

[Arq Neuropsiquiatr.](#) 2007 Jun;65(2A):228-33.

Sleep disturbances in 50 children with attention-deficit hyperactivity disorder.

[Neves SN](#), [Reimão R](#).

Source

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Abstract

OBJECTIVE:

This study assesses the relationship between sleep disturbances (SD) and attention-deficit and hyperactivity disorder (ADHD) to characterize clinical features and associated problems.

METHOD:

The medical records of 50 children and adolescents ranging in age from 4 to 17 years with ADHD without the diagnosis of mental retardation or pervasive developmental disorders were reviewed.

RESULTS:

Significant relationships were found between SD and drug therapy ($p < 0.01$), co-morbidity ($p < 0.01$) and greater adherence to treatment prescribed for ADHD disorders ($p < 0.05$).

CONCLUSION:

The results of this study suggest that SD are an important problem in children with ADHD and may be linked to increased symptoms.

Executive functioning in the presence of sleep disordered breathing

by Amy M Sutton

Volume: 69, Issue: 1-B, Pages: 701

Abstract

The purpose of the study was to investigate whether sleep-disordered breathing (SDB) impairs executive functioning in children. Additionally, the study sought to identify the executive functions at risk in SDB and the contribution of daytime sleepiness. SDB represents a spectrum of upper airway conditions that can be mild, such as snoring, or severe, such as obstructive sleep apnea (OSA). Children with these problems may present with excessive sleepiness, failure to thrive, and a variety of cognitive and behavioral dysfunctions including impaired executive functioning. Beebe and Gozal (2002) developed a theoretical model to explain the impact of sleepiness and hypoxia on executive functioning. This model provided a framework to examine links between the medical disorder and the neuropsychological consequences. Twenty-seven children with suspected SDB were tested with polysomnography (PSG) and a neuropsychological battery. Parents completed subjective measures of cognitive function and sleep symptoms. The children were ages 8 to 18 and had no congenital or acquired brain damage. They were matched for age and gender with 21 healthy controls. The executive function protocol included subtests from the Delis-Kaplan Executive Function System (D-KEFS), the digit span subtest from the Wechsler Intelligence Scale for Children (WISC-IV), the Tower of London-II-Drexel University (TOL-II), the Behavioral Rating Inventory of Executive Functioning (BRIEF), and the Conners? Continuous Performance Test (CPT-II). Statistical analysis was performed using 2 statistical software packages, SAS and NCSS. Regression analysis was used to evaluate all variables. Due to significant group differences in socio-economic status (SES), SES was included as a covariate, along with IQ. No group differences in IQ were found. Significantly less robust executive function in children with SDB was identified in the domains of cognitive flexibility and impulsivity. Additionally, poorer executive planning and overall inattentiveness was also associated with SDB. Level of significance was set at 0.05 and trends ($0.05 < p < 0.10$) were acknowledged. Other areas of executive function, including working memory, behavioral and emotional inhibition, and processing speed were not associated with SDB. Moreover, academic functioning was significantly lower in children with SDB, although the differences can be shared equally with SDB, SES and IQ. (PsycINFO Database Record (c) 2010 APA, all rights reserved).

Neurocognitive assessment and sleep analysis in children with sleep-disordered breathing

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Abstract

Objective

To assess possible correlations between intelligence quotient (IQ) and attention deficit hyperactive disorder (ADHD) rating scale values and sleep (including cyclic alternating patterns analysis) and respiratory parameters in children with sleep-disordered breathing (SDB).

Methods

Thirteen children who satisfied the criteria for primary snoring and 31 children for obstructive sleep apnea syndrome (OSAS) underwent polysomnography in a standard laboratory setting and a neurocognitive assessment. Sixty normal controls recruited from two schools underwent the neurocognitive assessment.

Results

The IQ estimates of controls were higher and the ADHD rating scale scores lower than those of children with SDB. Children with OSAS had a higher REM sleep latency and arousal index as well as a lower N3 and A mean duration than children who snored. In our sample of children with SDB, the percentage of wakefulness after sleep onset, of N1, of A2, of arousal and A2 index correlated positively with global intelligence. Total and hyperactivity scores correlated positively with the A2 index. Regression analysis mostly confirmed the correlations between neurocognitive measures and sleep parameters and further demonstrated a negative correlation between the hyperactivity rating score and oxygen saturation during the night.

Conclusions

Our results support the hypothesis that arousal is a defensive mechanism that may preserve cognitive function by counteracting the respiratory events, at the expense of sleep maintenance and NREM sleep instability.

DSM-IV DIAGNOSES AND OBSTRUCTIVE SLEEP APNEA IN CHILDREN BEFORE AND 1 YEAR AFTER ADENOTONSILLECTOMY

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Drs. Dillon and Champine are with the Division of Child and Adolescent Psychiatry, University of Michigan Medical School; Dr. Blunden is with the Centre for Sleep Research of the University of South Australia; Dr. Ruzicka is at the Sleep Disorders Center, of which Dr. Chervin is the director, within the Department of Neurology of the University of Michigan Medical School; Mr. Guire is from the Department of Biostatistics at the University of Michigan School of Public Health; Dr. Weatherly is in the Division of Pediatric Otolaryngology at the University of Kansas; Drs. Hodges and Giordani are with the Neuropsychology Section, Department of Psychiatry, University of Michigan Medical School

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►The publisher's final edited version of this article is available at [J Am Acad Child Adolesc Psychiatry](#)

Abstract

Objectives

Obstructive sleep apnea, a common indication for adenotonsillectomy in children, has been linked to behavioral morbidity. We assessed psychiatric diagnoses in children before and after adenotonsillectomy and examined whether baseline sleep apnea predicted improvement after surgery.

Method

Subjects of this prospective cohort study were children aged 5.0–12.9 years-old who had been scheduled for adenotonsillectomy ($n = 79$), or care for unrelated surgical conditions ($n=27$, among whom 13 had surgery after baseline assessment). Prior to intervention and one year later, subjects underwent structured diagnostic interviews and polysomnography. The main outcome measure was frequency of DSM-IV attention and disruptive behavior disorder diagnoses (A&DBDs) at baseline and follow-up.

Results

At baseline, A&DBDs were diagnosed in 36.7% of adenotonsillectomy subjects and 11.1% of controls ($p<.05$); attention-deficit/hyperactivity disorder was found in 27.8% and 7.4%, respectively ($p<.05$). One year later, group differences were non-significant, A&DBDs were diagnosed in only 23.1% ($p<.01$), and 50% of subjects with baseline attention-deficit/hyperactivity disorders no longer met diagnostic criteria.

Obstructive sleep apnea on polysomnography at baseline did not predict concurrent psychiatric morbidity or later improvement.

Conclusions

Attention and disruptive behavior disorders, diagnosed by DSM-IV criteria, were more common before clinically-indicated adenotonsillectomy than one year later. Surgery may be associated with reduced morbidity even among subjects lacking polysomnographic evidence of obstructive sleep apnea

[International Journal of Pediatric Otorhinolaryngology](#)

[Volume 70, Issue 9](#), September 2006, Pages 1555-1560

Obesity increases the risk for persisting obstructive sleep apnea after treatment in children

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Received 21 October 2005; revised 9 April 2006; Accepted 10 April 2006. Available online 3 July 2006.

Summary

Objective

To evaluate the impact of obesity at diagnosis on treatment outcomes in paediatric obstructive sleep apnea (OSA).

Methods

Children were included if they had both diagnostic and follow-up studies for OSA. Anthropological and polysomnographic data were collected at the time of both studies. Polysomnograms were scored using standard criteria and OSA was defined as a respiratory disturbance index (RDI) ≥ 5 . Obesity was defined as a body mass index standard deviation (z-) score (BMIsds) greater than 2, adjusted for age and gender.

Results

For 69 children (49 males), mean age was 7.1 ± 4.2 years and 29 (42%) children were obese. There was no significant difference in RDI between obese and non-obese children at diagnostic study. Following adenotonsillectomy the obese children had a significantly higher mean RDI (10.7 ± 15.6 versus 3.7 ± 4.3 ; $p = 0.01$). Disease resolution occurred in 77.5% of non-obese compared to 45% of obese children ($p = 0.011$). The odds ratio (OR) for persistent OSA in obese compared to non-obese children was 4.2 (95% CI: 1.5–11.9; $p = 0.005$). Using initial RDI as a covariate, these data show that obesity in children has an adjusted OR for persistent OSA after adenotonsillectomy 3.7 (95% CI: 1.3–10.8, $p = 0.016$).

Conclusion

For children, obesity at the time of diagnosis is a major risk for persisting OSA after treatment, regardless of the severity of initial disease.

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Polysomnographic Characteristics in Normal Preschool and Early School-Aged Children

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Abstract

OBJECTIVE. The objective of this study was to describe overnight polysomnographic measures in normal children aged 3 to 7 years. We conducted a retrospective analysis of normal polysomnographic evaluations from participants in 2 large community-based studies of sleep-disordered breathing among preschoolers and early school-aged children at Kosair Children's Hospital Sleep Medicine Research Center at the University of Louisville. Participants included 542 healthy children with ages ranging from 3.2 to 8.6 years.

RESULTS. Subjects were excluded from analysis if they had documented snoring during polysomnography, an obstructive apnea-hypopnea index of ≥ 1.0 , or a periodic leg-movement index of ≥ 5.0 . Because the greatest differences in polysomnography occurred between ages 5 and 6 years, analyses were performed for children 3 to 5 years and for ages ≥ 6 . Sleep cyclicity was distinct between age groups, with both showing an initial brief rapid-eye-movement period, which lengthened across the night, but only the older group showing a decrease in cycle length across the night. Average obstructive apnea indices were 0.03 per hour of total sleep time (TST) for 3- to 5-year-old children and 0.05 per hour of TST for ≥ 6 -year-old children, whereas central apnea indices were 0.82 and 0.45 per hour of TST, respectively. Older children spent a greater percentage of sleep time supine, and the apnea-hypopnea index differed according to body position. Twenty percent of all subjects had end tidal carbon dioxide values of >45 mm Hg, and 2.2% had recorded values >50 mm Hg during $\geq 50\%$ TST. High variance was present on all measures.

CONCLUSIONS. Developmental changes occur in several polysomnographic measures among normal children from 3 to 7 years of age, particularly during transition from preschool to early school age. Our findings in a large number of healthy community children comprise the most extensive compilation of normative reference values for laboratory-based pediatric polysomnography to date.

[Seminars in Pediatric Neurology](#)

[Volume 3, Issue 1](#), March 1996, Pages 23-28

Sleep Disorders in Childhood

Obstructive sleep apnea in children

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The obstructive sleep apnea syndrome is a common cause of morbidity during childhood. Childhood obstructive sleep apnea syndrome is usually secondary to adenotonsillar hypertrophy. Other risk factors include craniofacial anomalies, obesity, and neuromuscular disease. Symptoms include snoring and difficulty breathing during sleep. Definitive diagnosis is made by polysomnography. Normative polysomnographic parameters vary with age; thus age-appropriate norms must be used. In contrast to adults, children often manifest a pattern of persistent partial airway obstruction during sleep, rather than cyclical, discrete obstructive apneas. Most children are cured by tonsillectomy and adenoidectomy. However, some children require further therapy, such as continuous positive airway pressure.

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Reduced Time in Bed and Obstructive Sleep-Disordered Breathing in Children Are Associated With Cognitive Impairment

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2. [Jeffrey T. Barth](#), PhD^b,
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Abstract

OBJECTIVE. The purpose of this study was to determine if reduced time in bed as well as the degree of obstructive sleep-disordered breathing predicted the risk of impaired cognitive function in children with adenotonsillar hypertrophy suspected of having obstructive sleep-disordered breathing.

DESIGN. We studied 56 children, aged 6 to 12 years, with adenotonsillar hypertrophy referred for suspected obstructive sleep-disordered breathing. Children were given a sleep diary and underwent wrist actigraphy for 6 consecutive days and nights. On day 7, the children were given general cognitive tests, memory tests, and continuous performance tests followed by attended polysomnography that night. Parents completed snoring and behavior questionnaires.

RESULTS. Shorter mean time in bed for 6 nights and a history of nightly snoring were highly predictive of lower scores for the vocabulary and similarities cognitive function tests. Children who had a mean time in bed of 557 minutes and did not snore nightly were predicted to have vocabulary and similarities scores more than 1 standard deviation higher than children who had a

mean time in bed of 521 minutes and snored nightly. Shorter mean time in bed and the log of the apnea hypopnea index also predicted lower vocabulary and similarities scores. Greater night to night variability in time in bed was significantly predictive of lower vocabulary and similarities scores, but variability was not as predictive as mean time in bed. Neither mean time in bed nor the coefficient of variation of time in bed predicted other cognitive or behavioral scores.

CONCLUSIONS. Short or variable time in bed and nightly snoring or higher apnea hypopnea index predicted impaired vocabulary and similarities scores in children with adenotonsillar hypertrophy suspected of having obstructive sleep-disordered breathing. The degree of cognitive impairment attributable to short time in bed and obstructive sleep-disordered breathing is clinically very significant.

[The Journal of Pediatrics](#)

[Volume 127, Issue 6](#), December 1995, Pages 905-912

Home nasal continuous positive airway pressure in infants with sleep-disordered breathing

Christian Guilleminault MD, Rafael Pelayo MD, Alex Clerk MD, Damien Leger MD, Robert C. Bocian MD, PhD

Abstract

Objective: To review our experience with home nasal continuous positive airway pressure (CPAP) in infants with small upper airways and abnormal breathing during sleep. *Study design:* Seventy-four infants with sleep-disordered breathing and narrow upper airways, as identified by nocturnal polygraphic recording and endoscopic evaluation, were treated at home with nasal CPAP. Infants with craniofacial anomalies and trisomy 21, and infants who had been referred to us as having had “apparent life-threatening events,” made up the majority of the population. Because of the rapid growth of infants, regular follow-up visits were scheduled to adjust CPAP and mask size. *Results:* Seventy-two infants were successfully treated at home with nasal CPAP; there were two failures. Follow-up lasted from 5 months to 12 years. Compliance was not a problem, but home nasal CPAP was prescribed only for infants who lived close to our center and whose families and pediatricians were willing to support compliance. *Comments:* Home nasal CPAP requires careful, in-laboratory titration and regular follow-up to adjust both pressure and mask size. With the support of families and pediatricians, home nasal CPAP can be an effective treatment for infants with upper airway respiratory problems during sleep. In many cases, it can provide an interim solution, enabling physicians to plan surgery at an appropriate time and giving infants time to grow before having to undergo surgical stress. (J PEDIATR 1995;127:905-12)

Obstructive sleep disordered breathing in children: Beyond adenotonsillectomy[‡]

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2. Dominique Dorion MD, MSc²

Pediatric Pulmonology

[Volume 43, Issue 9](#), pages 837–843, September 2008

Abstract

Traditionally, adenotonsillectomy (AT) has long been the treatment of choice for obstructive sleep disordered breathing (SDB) in children. AT is usually considered a safe procedure, which cures 80% of children with SDB. Accumulated data have however challenged this overly simplistic view. Indeed, AT is invariably associated with significant morbidity, post-operative pain, and a mortality rate which, though low, cannot be ignored. In addition, aside from a recurrence of SDB at adolescence in an unknown percentage of cases, some recent results suggest that complete SDB cure is not achieved in as much as 75% of cases after AT. Interestingly, several treatment options have been recently proposed for replacing or complementing AT. Continuous positive airway pressure (CPAP) is now suggested in children with remaining SDB after AT; however, compliance and suitability of equipment remain important hurdles, especially in small children and infants. Anti-inflammatory treatments, including nasal glucocorticoids and/or the anti-leukotriene montelukast, appear to hold great promise. Finally, orthodontic treatments are an appealing option, with recent results in children suggesting that it is possible to improve or perhaps even cure SDB in a durable manner by enlarging the nasal passages and/or the oropharyngeal airspace. In conclusion, while we are currently in the midst of an exciting time with several new treatments being developed for childhood SDB, randomized controlled trials are urgently needed to delineate their indications. In the meantime, it appears that systematic detection of orthodontic anomalies and better collaboration with maxillofacial specialists, including orthodontists and/or dentists, is needed for deciding the best treatment options for childhood SDB. *Pediatr Pulmonol.* 2008; 43:837–843. © 2008 Wiley-Liss, Inc.

Sleep. 2009 March 1; 32(3): 343–350.

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Sleep Disturbances in Prepubertal Children with Attention Deficit Hyperactivity Disorder: A Home Polysomnography Study

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Abstract

Study Objectives:

To examine sleep architecture and reported sleep problems in children with ADHD and normal controls, while considering the roles of pertinent moderating factors.

Design:

Overnight sleep recordings were conducted in 15 children diagnosed with ADHD (DSM-IV) without comorbid psychiatric problems and in 23 healthy controls aged 7 to 11 years. Children were on no medication, in good health and did not consume products containing caffeine ≥ 7 days prior to the polysomnography (PSG) study. PSG evaluation was performed at each child's home; children slept in their regular beds and went to bed at their habitual bedtimes.

Measurements

Standard overnight multichannel PSG evaluation was performed using a portable polysomnography device. In addition, parents were asked to complete a sleep questionnaire.

Results:

Compared to controls, children in the ADHD group had significantly shorter duration of REM sleep, smaller percentage of total sleep time spent in REM sleep, and shorter sleep duration. In addition, the ADHD group had higher scores on the insufficient sleep and sleep anxiety factors than children in the control group.

Conclusions:

The present findings support the hypothesis that children with ADHD present sleep disturbances.

Citation:

Gruber R; Xi T; Frenette S; Robert M; Vannasinh P; Carrier J. Sleep disturbances in prepubertal children with attention deficit hyperactivity disorder: A home polysomnography study. *SLEEP* 2009;32(3):343-350.

Clinical Paper

Obstructive sleep apnea in children with syndromic craniosynostosis: long-term respiratory outcome of midface advancement

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Abstract

Almost 50% of patients with Apert, Crouzon or Pfeiffer syndrome develop obstructive sleep apnea (OSA), mainly due to midface hypoplasia. Midface advancement is often the treatment of choice, but the few papers on long-term outcome report mixed results. This paper aimed to assess the long-term respiratory outcome of midface advancement in syndromic craniosynostosis with OSA and to determine factors contributing to its efficacy. A retrospective study was performed on 11 patients with moderate or severe OSA, requiring oxygen, continuous positive airway pressure (CPAP), or tracheostomy. Clinical symptoms, results of polysomnography, endoscopy and digital volume measurement of the upper airways on CT scan before and after midface advancement were reviewed. Midface advancement had a good respiratory outcome in the short term in 6 patients and was ineffective in 5. In all patients without respiratory effect or with relapse, endoscopy showed obstruction of the rhino- or hypopharynx. The volume measurements supported the clinical and endoscopic outcome. Despite midface advancement, long-term dependence on, or indication for, CPAP or tracheostomy was maintained in 5 of 11 patients. Pharyngeal collapse appeared to play a role in OSA. Endoscopy before midface advancement is recommended to identify airway obstruction that may interfere with respiratory improvement after midface advancement

Dental considerations in upper airway sleep disorders: A review of the literature

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Abstract

Statement Of Problem. Upper airway sleep disorders are becoming recognized as common medical concerns. Multiple treatment options have been advocated, including the use of dental devices. Dental practitioners are being asked by the medical profession to become a part of the treatment team. This may be a challenging task because of the large number of dental devices available, rapid advancement in the understanding of this disease, and numerous publications.

Purpose. This article reviews the anatomic features and etiologic factors of upper airway sleep disorders and medical and dental treatment options. **Methods.** The literature review was conducted with an accepted literature research tool, PubMed, developed by the National Library of Medicine. Key words searched included “obstructive sleep apnea,” “sleep apnea,” “sleep disorders,” and “snoring.” **Conclusion.** Dental devices are indicated in snoring and mild-to-moderate obstructive sleep apnea patients after medical evaluation and referral. (J Prosthet Dent 1999;82:685-98.)

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- [European Journal of Orthodontics](#)
 - [Volume27, Issue1](#)
 - Pp. 82-90.

A comparison of the Twin Block and Herbst mandibular advancement splints in the treatment of patients with obstructive sleep apnoea: a prospective study

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Abstract

This prospective, randomized, crossover study of 16 patients with obstructive sleep apnoea (OSA) [12 males, four females; median body mass index (BMI) 29.2 kg/m² (range 23.8–51.1); median age 44.8 years (range 24.0–68.4)] analysed the efficacy of the Twin Block (TB) in relation to the Herbst appliance as a mandibular advancement splint (MAS). Each subject was fitted with a TB and Herbst MAS in a random order with a washout period of 2 weeks between appliances. Once each patient was subjectively happy with the performance of each appliance, questionnaires and a visual analogue scale (VAS) were used to determine differences in snoring, daytime sleepiness, quality of life, side-effects of the appliances and patient preference. All patients underwent overnight domiciliary sleep recordings prior to and after fitting each appliance in order to objectively assess sleep quality in terms of the apnoea-hypopnoea index (AHI), snoring frequency and arterial oxygen saturation.

The results suggested that there was no difference in the treatment performance of the TB and Herbst MAS for AHI ($P = 0.71$), snoring frequency ($P = 0.49$), arterial blood oxygen saturation ($P = 0.97$), quality of life and side-effects. The Herbst MAS proved to be the more effective appliance for reducing daytime sleepiness ($P = 0.04$) and was the more popular appliance among the patients. Side-effects with both appliances were minor and improved in the longer term. The TB MAS represents a viable alternative to the Herbst MAS in the treatment of patients with OSA.

Advances in Psychiatric Treatment (2003) 9: 69-77

Misdiagnosing sleep disorders as primary psychiatric conditions

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Abstract

Sleep disorders are relevant to psychiatric practice in a number of ways, including the possibility that they may be misdiagnosed as fundamentally psychiatric conditions in patients of all ages. This risk exists in a wide range of collectively very common sleep disorders which need to be considered in explaining insomnia, excessive sleepiness or disturbed episodes of behaviour associated with sleep (parasomnias). Examples given include circadian sleep–wake cycle

disorders (such as the delayed sleep phase syndrome), obstructive sleep apnoea, narcolepsy, Kleine–Levin syndrome, sleep paralysis and rapid eye movement (REM) sleep behaviour disorder. Failure to recognise and treat such disorders is likely to cause and perpetuate psychological problems. Correct recognition requires familiarity with the range and manifestations of sleep disorders.

[Brain and Development](#)

[Volume 24, Issue 3](#), April 2002, Pages 145-149

Sleep apnoea in infancy and childhood: Considering two possible causes: obstruction and neuromuscular disorders

Neil Gordon  

Abstract

Two aspects of sleep apnoea in infancy and childhood are considered. First of all the obstructive sleep apnoea syndrome is reviewed; its causes, and types, and clinical differences depending on the age of the affected patient. Difficulties of diagnosis are discussed, as well as methods used to confirm the presence of the syndrome. Then means of treatment are considered, both medical and surgical.

The second part of the paper is concerned with a particular group of children, especially at risk of sleep apnoea; those suffering from neuromuscular disorders as these are likely to be of special interest to paediatric neurologists. These include neuropathies, myopathies such as Duchenne muscular dystrophy and myotonia, and disorders of the neuromuscular junction.

[The Journal of Pediatrics](#)

[Volume 127, Issue 5](#), November 1995, Pages 741-744

Neurocognitive deficits in morbidly obese children with obstructive sleep apnea

Susan K. Rhodes PhD, Kim C. Shimoda PhD, L.Randolph Waid PhD, Patrick Mahlen O'Neil PhD, Mary Joan Oexmann RD, Nancy A. Collop MD, Steven M. Willi MD

Abstract

Neurocognitive abilities were measured in 14 morbidly obese children, five of whom had obstructive sleep apnea as determined by polysomnography. As in adults, children with obstructive sleep apnea had deficits in learning, memory, and vocabulary. Moreover,

apneic/hypopneic events were inversely related to memory and learning performance among the entire sample. (J PEDIATR 1995; 127:741-4)

Sleep. 2007 December 1; 30(12): 1698–1703.

Sleep Disordered Breathing And Daytime Sleepiness Are Associated With Poor Academic Performance In Teenagers. A Study Using The Pediatric Daytime Sleepiness Scale (PDSS)

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Abstract

Study Objectives:

Inadequate sleep and sleep disordered breathing (SDB) can impair learning skills. Questionnaires used to evaluate sleepiness in adults are usually inadequate for adolescents. We conducted a study to evaluate the performance of a Spanish version of the Pediatric Daytime Sleepiness Scale (PDSS) and to assess the impact of sleepiness and SDB on academic performance.

Design:

A cross-sectional survey of students from 7 schools in 4 cities of Argentina.

Measurements:

A questionnaire with a Spanish version of the PDSS was used. Questions on the occurrence of snoring and witnessed apneas were answered by the parents. Mathematics and language grades were used as indicators of academic performance.

Participants:

The sample included 2,884 students (50% males; age: 13.3 ± 1.5 years)

Results:

Response rate was 85%; 678 cases were excluded due to missing data. Half the students slept <9 h per night on weekdays. The mean PDSS value was 15.74 ± 5.93 . Parental reporting of snoring occurred in 511 subjects (23%); snoring was occasional in 14% and frequent in 9%. Apneas were witnessed in 237 cases (11%), being frequent in 4% and occasional in 7%. Frequent snorers had higher mean PDSS scores than occasional or nonsnorers (18 ± 5 , 15.7 ± 6 and 15.5 ± 6 , respectively; $P < 0.001$). Reported snoring or apneas and the PDSS were significant univariate predictors of failure and remained significant in multivariate logistic regression analysis after adjusting for age, sex, body mass index, specific school attended, and sleep habits.

Conclusions:

Insufficient hours of sleep were prevalent in this population. The Spanish version of the PDSS was a reliable tool in middle-school-aged children. Reports of snoring or witnessed apneas and daytime sleepiness as measured by PDSS were independent predictors of poor academic performance.

[International Journal of Pediatric Otorhinolaryngology](#)

[Volume 70, Issue 3](#), March 2006, Pages 419-424

Neurocognitive abilities in children with adenotonsillar hypertrophy

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Objective

Sleep apnea is one of the most deleterious disorders in children with adenotonsillar hypertrophy because it can induce hypoxemia of brain. Sleep apnea may lead to failure to thrive or to physical and mental delay in development, including cognitive disturbances.

The aim of this study was to analyze the influence of adenotonsillar hypertrophy, causing obstructive sleep apnea on neurocognitive abnormalities.

We were interested in sensorimotor coordination, perception, memory, learning ability, concentration, focused attention and language reception.

Materials and methods

We examined 221 children. One-hundred and seventeen children had sleep apnea caused by adenotonsillar hypertrophy: 87 children aged 6–9 years and 34 children aged 10–13 years. The control group, without adenotonsillar hypertrophy, consisted of 104 healthy children. Both groups of children with and without apnea were examined psychologically to determine abilities and minor neurocognitive deficit. The token test (TT), diagnosis test of brain dysfunction (DCS-test), Luria auditory verbal learning test (LAVLT) and Rey complex figure test (RCFT) were applied to both groups. The tests: TT, DCS-test, RCFT were used to investigate the level of sensorimotor integration and perception processes. Memory and learning abilities were measured using LAVLT. The TT assessed language dysfunction in children.

Results

This study shows that adenotonsillar hypertrophy in children aged 6–9 years is associated with neurocognitive abnormalities such as: memory problems, concentration of attention deficits, learning disability, language dysfunction, lower sensorimotor integration and perception.

The older children (aged 10–13 years) with adenotonsillar hypertrophy had memory problems and learning disabilities. They are likely to be caused by of concentration of attention deficits. The older children were found to have more severe language dysfunction.

Conclusions

Our study shows that sleep apnea may lead to neurocognitive deficits. The results may be helpful in the process of making decision for or against surgery in doubtful cases.

It is important to know the problems connected with apnea in order to recognize them and help the child develop by providing adequate treatment and cognitive stimulation.

Impaired Spatial Learning and Hyperactivity in Developing Rats Exposed to Intermittent Hypoxia

ROW, BARRY W.; KHEIRANDISH, LEILA; NEVILLE, AND, JENNIFER J.; GOZAL, DAVID

Abstract

Obstructive sleep apnea (OSA) is a frequent medical condition and is associated with cognitive impairments in adults and with hyperactivity and decreased school performance in children. In an adult rodent model, intermittent hypoxia (IH), such as occurs in OSA, is associated with neurodegenerative changes in the hippocampus and cortex and with spatial learning deficits. Because a unique developmental window of neural vulnerability to IH is present, we hypothesized that exposure to IH throughout the vulnerable ages would result in increased behavioral impairments in the juvenile rat. Rat pups were therefore exposed to either room air or IH beginning at postnatal (PN) d 10 until PN d 30. Learning and memory were assessed *via* a standard place-training version of the Morris water maze beginning at PN d 25. Locomotor activity was assessed on PN d 29 and 30. Pups exposed to IH displayed significant spatial learning impairments, and exposed male rats but not female rats displayed increased locomotor activity in the open field. Collectively, these findings indicate that exposure to IH at an age that corresponds to the peak incidence of OSA in children induces substantial learning impairment and gender-dependent behavioral hyperactivity in the juvenile rat. We postulate that this novel experimental model may allow for future exploration of mechanisms underlying the neurobehavioral deficits of children with OSA.

Impact of Adenotonsillectomy on Behavior in Children With Sleep-Disordered Breathing†

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2. Yu-Shu Huang MD²,
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5. Li-Ang Lee MD¹

The Laryngoscope

[Volume 116, Issue 7](#), pages 1142–1147, July 2006

Abstract

Objectives/Hypothesis: Children with sleep-disordered breathing may experience behavioral and learning problems such as inattentiveness and hyperactivity. The aim of this study was to measure the impact of adenotonsillectomy on sleep-related adverse events and behavioral problems in children with sleep-disordered breathing.

Method: This prospective and interventional study enrolled 40 sleep-disordered breathing children (mean age, 8.4 ± 1.6 years) with hypertrophic tonsils and adenoids. All patients completed two polysomnographies, tests of variables of attention (TOVAs), and Child Behavior Checklists, one at baseline and the other 6 months after adenotonsillectomy.

Results: The apnea–hypopnea index ($P < .001$), TOVA scores ($P < .001$), and 8 of 9 individual domains of the Child Behavior Checklist scores ($P < .05$) significantly improved after surgery. However, the change in the apnea–hypopnea index was not negatively correlated with TOVA score ($r = -0.17$, $P = .38$).

Conclusion: Adenotonsillectomy could significantly improve behavior (TOVA) scores, but the improvement may not simply be attributable to changes in sleep apnea events.

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HEAD & NECK SURGERY

Vol. 133 No. 10, October 2007

Improved Behavior and Sleep After Adenotonsillectomy in Children With Sleep-Disordered Breathing

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Arch Otolaryngol Head Neck Surg. 2007;133(10):974-979.

Objective To determine changes in behavior and sleep in children before and after adenotonsillectomy for sleep-disordered breathing (SDB) using the validated Pediatric Sleep Questionnaire (PSQ) and Conners' Parent Rating Scale–Revised Short Form (CPRS-RS).

Design Prospective, nonrandomized study.

Setting Ambulatory surgery center affiliated with an academic medical center.

Patients A total of 117 consecutive children (61 boys and 56 girls) (mean [SD] age, 6.5 [3.1] years) who were clinically diagnosed as having SDB and who had undergone adenotonsillectomy. Complete follow-up data were available in 71 of 117 patients (61%).

Interventions Parents completed the PSQ and CPRS-RS before surgery and 6 months after surgery.

Main Outcome Measures Changes in age- and sex-adjusted T scores for all 4 CPRS-RS behavior categories (oppositional behavior, cognitive problems or inattention, hyperactivity, and Conners' attention-deficit/hyperactivity disorder [ADHD] index) were determined for each subject before and after surgery. Changes in PSQ scores from a select 22-item sleep-related breathing disorder subscale were also determined.

Results Preoperatively, the mean (SD) T scores on the CPRS-RS for oppositional behavior, cognitive problems or inattention, hyperactivity, and ADHD index were 59.4 (13.7), 59.5 (13.6), 62.0 (14.4), and 59.9 (13.4), respectively. A T score of 60.0 in any category placed a child in the at-risk group. Postoperatively, T scores for each category were 51.0 (9.6), 51.2 (8.8), 52.4 (10.52), and 50.6 (7.8), respectively. All changes were statistically significant ($P < .001$) and clinically significant by approximating a change of 1 SD from the baseline score. For the PSQ, the preoperative and postoperative mean (SD) scores were 0.6 (0.1) and 0.1 (0.1), respectively, on a scale of 0 to 1, with scores higher than 0.33 suggesting obstructive sleep apnea. Correlations between sleep and behavior scores were statistically significant before surgery ($P = .004$ for ADHD index and cognitive problems, $P = .008$ for oppositional behavior) and after surgery ($P = .049$ for cognitive problems, $P = .03$ for oppositional behavior). Higher baseline T scores for the CPRS-RS were associated with larger changes in T scores for the CPRS-RS in all 4 domains (oppositional behavior, cognitive problems or inattention, hyperactivity, and ADHD index).

Conclusions Children diagnosed as having SDB experience improvement in both sleep and behavior after adenotonsillectomy. The PSQ and CPRS-RS may be useful adjuncts for screening and following children who undergo adenotonsillectomy for SDB.

Author Affiliations: Departments of Otolaryngology–Head and Neck Surgery (Drs Wei and Weatherly) and Preventive Medicine and Public Health (Dr Mayo), University of Kansas School of Medicine, Kansas City; and Center for Biostatistics and Advanced Informatics (Dr Mayo and Ms Smith) and Developmental Disabilities Center (Dr Reese), University of Kansas Medical Center, Kansas City.

PEDIATRICS®

Increases in Overweight After Adenotonsillectomy in Overweight Children With Obstructive Sleep-Disordered Breathing Are Associated With Decreases in Motor Activity and Hyperactivity

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Abstract

Objective. To examine the effect of adenotonsillectomy (T&A) in children with obstructive sleep-disordered breathing on growth, hyperactivity, and sleep and waking motor activity.

Methods. We studied 54 children who were aged 6 to 12 years and had adenotonsillar hypertrophy and an obstructive apnea-hypopnea index of ≥ 1 before and 12 months after they all received adenotonsillectomy (T&A). We measured their height, weight, percentage overweight (patient BMI – BMI at 50th percentile)/BMI at 50th percentile * 100) and obtained a hyperactivity score from parent report on a standardized behavior questionnaire scale. A subset of 21 of these children were also studied for motor activity by wrist actigraphy for 7 consecutive days and nights before and 12 months after T&A.

Results. After T&A, mean obstructive apnea-hypopnea index decreased from 7.6 to 0.6. Height percentile did not change, but weight percentile increased; as a consequence, percentage overweight increased from 32.0% to 36.3%. Hyperactivity scores and total daily motor activity were reduced after T&A. From linear regression, the reduction in hyperactivity scores predicted an increase in percentage overweight. Reduced motor activity was correlated with increased percentage overweight.

Conclusions. An increase in percentage overweight after T&A in children with obstructive sleep-disordered breathing is correlated to decreased child hyperactivity scores and to decreased measured motor activity in the subset studied. These associations suggest that the increase in overweight may be attributable to reductions in physical activity and fidgeting energy expenditure.

Conduct Problems and Symptoms of Sleep Disorders in Children

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ABSTRACT

Objective

Conduct problems and hyperactivity are frequent among children referred for sleep-disordered breathing (SDB), restless legs syndrome, or periodic leg movements during sleep (PLMS), but children not referred to sleep centers have received little study.

Method

Parents of children aged 2 to 14 years were surveyed at two general clinics between 1998 and 2000. A Pediatric Sleep Questionnaire generated validated scores for SDB and PLMS. The Conners Parent Rating Scale (CPRS-48) produced an age- and sex-adjusted Conduct Problem Index (CPI) and Hyperactivity Index.

Results

Parents of about 1,400 children were approached; those of 872 (62%) completed the surveys. Bullying and other specific aggressive behaviors were generally two to three times more frequent among 114 children at high risk for SDB than among the remaining children. An association between high CPI and SDB scores ($p < .0001$) retained significance after adjustment for sleepiness, high Hyperactivity Index, stimulant use, or PLMS scores. Analogous results were obtained for the association between high CPI and PLMS scores.

Conclusions

Conduct problems were associated with symptoms of SDB, restless legs syndrome, and PLMS. Although these results cannot prove a cause-and-effect relationship, assessment for sleep disorders may provide a new treatment opportunity for some aggressive children.

Adenotonsillectomy for Obstructive Sleep Apnea in Children: Outcome Evaluated by Pre- and Postoperative Polysomnography[†]

1. Ron B. Mitchell MD

The Laryngoscope

[Volume 117, Issue 10](#), pages 1844–1854, October 2007

Abstract

Objective: To evaluate the outcome of adenotonsillectomy for obstructive sleep apnea (OSA) in children using objective data from polysomnography supplemented by subjective proxy reports from the OSA-18 quality of life instrument.

Study Design: Prospective cohort study.

Methods: Children 3 to 14 years of age with OSA diagnosed principally on the basis of polysomnography as having an obstructive apnea/hypopnea index (AHI) of 5 or greater underwent adenotonsillectomy. OSA was classified as mild ($\text{AHI} \geq 5 < 10$), moderate ($\text{AHI} \geq 10 < 20$), or severe ($\text{AHI} \geq 20$). Children enrolled in the study also had postoperative polysomnography 3 to 6 months after surgery. Caregivers completed the OSA-18 survey before surgery and within 6 months after surgery. Pearson correlation was used to compare the pre- and postoperative AHI values with the pre- and postoperative OSA-18 total scores. SAS procedures (SAS Corp., Cary, NC) were used for statistical analyses. A *P* value less than or equal to .05 was considered significant.

Results: The study population included 79 healthy children, 40 of who were male. The mean age was 6.3 (range, 3.0–14.0) years. Only tonsillar size was correlated significantly with a high preoperative AHI. For all children, the preoperative AHI value was higher than the postoperative value. The mean preoperative AHI for the study population was 27.5, whereas the mean postoperative AHI was 3.5. This change was highly significant ($P < .001$). The percentage of children with normal polysomnography parameters after adenotonsillectomy ranged from 71% to 90% as a function of the criteria used to define OSA. It was highest when an obstructive apnea index less than 1 was used and lowest when an AHI less than 1 was used to define resolution of OSA. Overnight respiratory parameters after adenotonsillectomy were normal for all children with mild OSA. Three (12%) children with moderate preoperative OSA, and 13 (36%) children with severe preoperative OSA had persistent OSA after adenotonsillectomy. Resolution of OSA occurred in all children with a preoperative AHI less than or equal to 10 and in 73% of children with a preoperative AHI greater than 10. The mean total OSA-18 score and the mean scores for all domains showed significant improvement after surgery ($P < .001$). The preoperative AHI values had a fair correlation with the preoperative total OSA-18 scores ($r = 0.28$), but

postoperative AHI values had a poor correlation with the postoperative total OSA-18 scores ($r = 0.16$). Caregivers reported snoring some, most, or all of the time in 22 (28%) children; this group included all children with persistent OSA.

Conclusions: Adenotonsillectomy for OSA results in a dramatic improvement in respiratory parameters as measured by polysomnography in the majority of healthy children. Quality of life also improves significantly after adenotonsillectomy for OSA in children. However, the correlation between improvements in respiratory parameters and improvements in quality of life is poor. Severe preoperative OSA is associated with persistence of OSA after adenotonsillectomy. Postoperative reports of symptoms such as snoring and witnessed apneas correlate well with persistence of OSA after adenotonsillectomy.

[The Journal of Pediatrics](#)

[Volume 149, Issue 6](#), December 2006, Pages 803-808

Persistence of obstructive sleep apnea syndrome in children after adenotonsillectomy

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Objective

To investigate the relative contribution of various risk factors to the surgical outcome of adenotonsillectomy for obstructive sleep apnea syndrome in children.

Study design

Children ($n = 110$; mean age, 6.4 ± 3.9 years) underwent two polysomnographic evaluations before and after adenotonsillectomy. In addition, 22 control children were studied. History for allergy and family history of sleep-disordered breathing was taken before each polysomnographic evaluation.

Results

Significant changes in sleep stage percentages and sleep fragmentation were found in the postsurgery study compared with the presurgery study; 25% of the children had apnea/hypopnea index (AHI) ≤ 1 , 46% had AHI > 1 and < 5 , and 29% had AHI ≥ 5 in the postsurgery study. The

frequency of subjects with $AHI \leq 1$ after surgery was significantly lower among obese subjects ($P < .05$). Comparison between the children who had $AHI \leq 1$ after surgery and 22 control children showed complete normalization of sleep architecture after surgery.

Conclusions

Adenotonsillectomy yields improvements in respiratory abnormalities in children with obstructive sleep apnea syndrome. Complete normalization occurs in only 25% of the patients. Obesity and AHI at diagnosis are the major determinant for surgical outcome. When normalization of respiratory measures occurs after surgery, normalization of sleep architecture will also ensue.

PEDIATRICS®

Adenotonsillectomy in Children With Obstructive Sleep Apnea Syndrome Reduces Health Care Utilization

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Abstract

Objective. To investigate health care utilization of children with obstructive sleep apnea syndrome (OSAS) 1 year after adenotonsillectomy (T&A).

Methods. A longitudinal, case-controlled, prospective study was conducted at Clalit Health Care Services (CHS), a health maintenance organization in the southern region of Israel. We defined 3 groups of children: 1) children who had OSAS and were treated with T&A ($n = 130$); 2) children who had OSAS and did not undergo surgery ($n = 90$); and 3) control subjects who were matched

by age, sex, and area of residency ($n = 520$) and randomly selected from the CHS database. OSAS was verified with polysomnography studies in all patients. Indices of health care utilization were analyzed 1 year before and 1 year after T&A. Medical records in the emergency department and during hospitalization were reviewed for diagnosis before the polysomnography diagnosis.

Results. Mean age of all children with OSAS was 5.6 ± 3.6 years. Total annual health care costs were reduced by one third in children who underwent T&A, whereas there was no change in the control and untreated OSAS groups. T&A was associated with a 60% reduction in the number of new admissions, 39% reduction in emergency department visits, 47% reduction in the number of consultations, and 22% reduction in costs for prescribed drugs. In group 2, the total costs were similar in years 1 and 2.

Conclusions. T&A significantly reduces health care utilization in children with OSAS. Untreated children with moderate and severe OSAS will continue to consume high levels of health care resources. Increased morbidity among children with OSAS is mainly related to upper respiratory tract infections.

PEDIATRICS*

Nocturnal Pulse Oximetry as an Abbreviated Testing Modality for Pediatric Obstructive Sleep Apnea

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2. ‡Department of Respiratory Medicine, New Children's Hospital, University of Sydney, Sydney, Australia.

Abstract

Objective. To determine the utility of pulse oximetry for diagnosis of obstructive sleep apnea (OSA) in children.

Methods. We performed a cross-sectional study of 349 patients referred to a pediatric sleep laboratory for possible OSA. A mixed/obstructive apnea/hypopnea index (MOAHI) greater than or equal to 1 on nocturnal polysomnography (PSG) defined OSA. A sleep laboratory physician read nocturnal oximetry trend and event graphs, blinded to clinical and polysomnographic results. Likelihood ratios were used to determine the change in probability of having OSA before and after oximetry results were known.

Results. Of 349 patients, 210 (60%) had OSA as defined polysomnographically. Oximetry trend graphs were classified as positive for OSA in 93 and negative or inconclusive in 256 patients. Of the 93 oximetry results read as positive, PSG confirmed OSA in 90 patients. A positive oximetry trend graph had a likelihood ratio of 19.4, increasing the probability of having OSA from 60% to 97%. The median MOAHI of children with a positive oximetry result was 16.4 (7.5, 30.2). The 3 false-positive oximetry results were all in the subgroup of 92 children who had diagnoses other than adenotonsillar hypertrophy that might have affected breathing during sleep. A negative or inconclusive oximetry result had a likelihood ratio of .58, decreasing the probability of having OSA from 60% to 47%. Interobserver reliability for oximetry readings was very good to excellent ($\kappa = .80$).

Conclusions. In the setting of a child suspected of having OSA, a positive nocturnal oximetry trend graph has at least a 97% positive predictive value. Oximetry could: 1) be the definitive diagnostic test for straightforward OSA attributable to adenotonsillar hypertrophy in children older than 12 months of age, or 2) quickly and inexpensively identify children with a history suggesting sleep-disordered breathing who would require PSG to elucidate the type and severity. A negative oximetry result cannot be used to rule out OSA.

ARCHIVES OF
OTOLARYNGOLOGY—
HEAD & NECK SURGERY

Vol. 130 No. 4, April 2004

Long-term Changes in Quality of Life After Surgery for Pediatric Obstructive Sleep Apnea

Ron B. Mitchell, MD; James Kelly, PhD; Ellen Call, MS, CFNP; Naomi Yao, BA

Arch Otolaryngol Head Neck Surg. 2004;130:409-412.

Objective To study long-term changes in quality of life in children after adenotonsillectomy for obstructive sleep apnea (OSA) documented by polysomnography.

Design and Setting Prospective study of children with OSA at the University of New Mexico Children's Hospital, Albuquerque.

Methods Children who met inclusion criteria underwent adenotonsillectomy. Caregivers were asked to complete the OSA-18 quality of life survey prior to surgery (survey 1), within 7 months after surgery (short-term) (survey 2), and between 9 and 24 months after surgery (long-term) (survey 3). Scores from the preoperative and postoperative surveys were compared using the paired *t* test.

Results The study population included 34 children, 27 (79%) of whom were male. The mean age of the children at the time of inclusion in the study was 6.7 years (range, 3.0-16.8 years). The mean total score for survey 1 (76.7) was significantly higher ($P<.001$) than the mean total score for survey 2 (32.0) or for survey 3 (40.9). However, the domains of sleep disturbance and physical suffering were significantly lower ($P\leq.005$) in survey 2 than in survey 3. The differences in the domains of emotional distress, daytime problems, and caregiver concerns between survey 2 and survey 3 were not statistically significant.

Conclusions Caregivers perceive a long-term improvement in quality of life after adenotonsillectomy for OSA although these improvements are more pronounced in the short-term than in the long-term and are not uniform across all domains of the OSA-18 survey.

[Sleep](#). 2004 Feb 1;27(1):95-100.

A prospective study on the surgical outcomes of children with sleep-disordered breathing.

[Guilleminault C](#), [Li K](#), [Quo S](#), [Inouye RN](#).

Source

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Abstract

STUDY OBJECTIVE:

To prospectively evaluate the outcome of surgical treatment decisions made by a multidisciplinary team for children aged 18 months to 12 years with sleep-disordered breathing (SDB).

DESIGN AND SETTING:

A multidisciplinary team evaluated children referred to a sleep clinic for suspicion of SDB using polysomnography, questionnaires, and clinical evaluations. Suggestions for treatment (surgical,

medical, or orthodontic) were made and sent to referring providers. A follow-up evaluation, which included a repeat of all of the tests performed at baseline, was performed 3 months after treatment (and at 6 months for a subgroup of subjects). The clinical outcome of the recommended versus the performed treatment was compared.

PATIENTS:

56 successively evaluated children.

RESULTS:

Based on insurance plans, 11 children were treated by a surgeon on the multidisciplinary team, who followed all treatment recommendations. After treatment, 1 of the 11 children still had SDB. Forty-five children were referred to other specialists. Only 1 of these children had the team's treatment recommendations implemented. Twenty-six of the 45 children had residual symptoms. Twelve children had polysomnographic abnormalities with or without symptoms or snoring. Sixteen children (28.6%) underwent a second surgical procedure.

CONCLUSION:

There are misconceptions in the pediatric and otolaryngologic communities about the rationale for the surgical treatment of SDB. Interactions between mouth breathing, maxillofacial growth, and clinical symptoms associated with SDB are not well understood. Multidisciplinary evaluations of the anatomic abnormalities of children with SDB lead to better overall treatment.

[Journal of the American Academy of Child & Adolescent Psychiatry](#)

[Volume 38, Issue 10](#), October 1999, Pages 1285-1293

ARTICLE

Sleep Problems in Children With Attention-Deficit/Hyperactivity Disorder: Impact of Subtype, Comorbidity, and Stimulant Medication

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ABSTRACT

Objective

To determine the relationship of sleep problems to attention-deficit/hyperactivity disorder (ADHD), diagnostic subtype, comorbid disorders, and the effects of stimulant treatment.

Method

On the basis of clinical diagnostic interviews, children aged 6 to 12 years were assigned to 4 groups: unmedicated ADHD ($n = 79$), medicated ADHD ($n = 22$), clinical comparison ($n = 35$), and healthy nonclinical comparison ($n = 36$). These groups were compared on 2 sleep questionnaires completed by the parents that assessed current sleep problems and factors associated with sleep difficulties (i.e., sleep routines, sleep practices, child and family sleep history).

Results

Factor analysis revealed 3 sleep problem categories: dyssomnias, parasomnias, and sleep-related involuntary movements. Linear regression analyses showed that (1) dyssomnias were related to confounding factors (i.e., comorbid oppositional defiant disorder and stimulant medication) rather than ADHD; (2) parasomnias were similar in clinical and nonclinical children; and (3) the *DSM-IV* combined subtype of ADHD was associated with sleep-related involuntary movements. However, sleep-related involuntary movements were more highly associated with separation anxiety.

Conclusions

The results suggest that the relationship between sleep problems and ADHD is complex and depends on the type of sleep problem assessed as well as confounding factors such as comorbid clinical disorders and treatment with stimulant medication.

ARCHIVES OF
OTOLARYNGOLOGY—
HEAD & NECK SURGERY

Vol. 154 No. 6, June 2000

Parental and Self-report of Sleep in Children With Attention-Deficit/Hyperactivity Disorder

Judith A. Owens, MD, MPH; Rolanda Maxim, MD; Chantelle Nobile, BA; Melissa McGuinn, BA; Michael Msall, MD

Arch Pediatr Adolesc Med. 2000;154:549-555.

Objective To determine the prevalence of parent-reported and self-reported sleep disturbances in a sample of school-aged children with attention-deficit/hyperactivity disorder (ADHD).

Design Cross-sectional survey questionnaire.

Setting A multidisciplinary ADHD evaluation clinic in a children's teaching hospital (ADHD sample) and 3 elementary schools in southern New England (control sample).

Participants Forty-six unmedicated, school-aged children (mean age, 89.4 ± 18.7 months; 74% male) diagnosed as having ADHD by *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, criteria who had been screened for marked symptoms of sleep-disordered breathing, and 46 normal control children (mean age, 86.5 ± 16.9 months; 70% male).

Intervention None.

Main Outcome Measure Sleep habits and sleep disturbances reported by parents and children.

Results Children with ADHD had significantly higher (more sleep-disturbed) scores on all sleep subscales of the Children's Sleep Habits Questionnaire (parent measure) than did controls; average sleep duration as reported by parents was also significantly shorter in the ADHD group. Children with ADHD also reported their own sleep to be more disturbed than controls did on the Sleep Self-report, particularly on items relating to bedtime struggles (P range, .05-.001). There was a much higher correlation between parent and child sleep report items for the children with ADHD (mean correlation, 0.55) than for the control children.

Conclusions Sleep disturbances, particularly at bedtime, are frequently reported by both parents and children with ADHD. Children undergoing evaluation for ADHD should be routinely screened for sleep disturbances, especially symptoms of sleep-disordered breathing. The causes of sleep-onset delay in children with ADHD should be considered in designing intervention strategies for children with difficulty falling and staying asleep.

The Laryngoscope

[Volume 115, Issue 11](#), pages 2051–2055, November 2005

Child Behavior after Adenotonsillectomy for Obstructive Sleep Apnea Syndrome[†]

1. Ron B. Mitchell MD^{1,2,*},
2. James Kelly PhD¹

Abstract

Objective: To study the behavior of children with obstructive sleep apnea syndrome (OSAS) before and after adenotonsillectomy using a standardized behavioral rating scale completed by caregivers.

Design and Setting: Prospective study of children with OSAS at the University of New Mexico Children's Hospital, Albuquerque, New Mexico.

Methods: Children between 2.5 and 18 years of age were included in the study and underwent adenotonsillectomy if the results of polysomnography showed an obstructive apnea/hypopnea index (AHI) of 5 or greater. Caregivers completed the Behavior Assessment System for Children (BASC) before surgery and a second time within 6 months of surgery. Pre- and postoperative BASC t scores were compared using a paired t test. Repeated measures analysis of variance was used to evaluate the contributions of several covariants to these change scores.

Results: The study population included 52 children. The mean age was 7.1 (range 2.5–14.9) years, and the mean AHI was 16.2 (range 5.0–88.0). Preoperative mean BASC t scores for all behavioral scales and composites were greater than 50. The behavioral scales that showed significant improvement after adenotonsillectomy were aggression, atypicality, depression, hyperactivity, and somatization ($p \leq .001$). Age, ethnicity, parental education, parental income, and AHI were not correlated with changes in BASC scores.

Conclusions: A high proportion of children with OSAS have externalizing (hyperactivity and aggression) and internalizing (anxiety, depression, and somatization) behavioral problems. These problems improve significantly after adenotonsillectomy. The improvement is dramatic regardless of sex, age, ethnicity, parental education, parental income, or the relative severity of OSAS.

PEDIATRICS®

Sleep Problems Seldom Addressed at Two General Pediatric Clinics

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Abstract

Objective. Sleep disorders can cause substantial morbidity but often remain undiagnosed among adults. We identified a series of children with sleep-related symptoms and reviewed medical chart notes for the previous 2 years to determine how often sleep problems had been addressed.

Design. Observational.

Setting. Two university-affiliated but community-based general pediatrics clinics.

Patients. Children, ages 2.0 to 13.9 years, with clinic appointments.

Measures. Parental and child responses to a validated Pediatric Sleep Questionnaire (PSQ) were used to identify patients at risk for chronic sleep-disordered breathing, periodic leg movements during sleep, insomnia, or excessive daytime sleepiness. Chart notes written within the previous 2 years were searched for sleep-related symptoms, diagnoses, or treatments.

Results. A total of 830 questionnaires were completed; 1395 chart notes of 86 symptomatic participants (mean age: 6.6 ± 3.1 years; 51% male) with 103 identified sleep problems were reviewed. Fewer than 15% of patients had current chart notes that mentioned any of the PSQ-defined sleep problems; diagnoses were mentioned for 2 of 86 patients and no treatments were discussed. Among the 103 sleep problems, only 16 received mention in any past or current note; 10 had led to a diagnosis; 4 had led to intervention; and 3 were treated in a manner likely to be effective. Seventy-four of the sleep problems (72%) occurred in children whose charts did mention something about sleep, but such notations rarely related to concerns uncovered by the PSQ.

Conclusions. Children with PSQ-identified sleep problems at 2 general pediatrics clinics seldom had these problems addressed, diagnosed, or treated, despite discussions about some aspect of their sleep in the large majority of cases. These findings support expansion of clinician and parent education about sleep disorders in children.

PEDIATRICS®

Obstructive Sleep Apnea in Children With Down Syndrome

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Abstract

Children with Down syndrome have many predisposing factors for the obstructive sleep apnea syndrome (OSAS), yet the type and severity of OSAS in this population has not been characterized. Fifty-three subjects with Down syndrome (mean age 7.4 ± 1.2 [SE] years; range 2 weeks to 51 years) were studied. Chest wall movement, heart rate, electrooculogram, end-tidal Po_2 and Pco_2 , transcutaneous Po_2 and Pco_2 , and arterial oxygen saturation were measured during a daytime nap polysomnogram. Sixteen of these children also underwent overnight polysomnography. Nap polysomnograms were abnormal in 77% of children; 45% had obstructive sleep apnea (OSA), 4% had central apnea, and 6% had mixed apneas; 66% had hypoventilation (end-tidal Pco_2 , >45 mm Hg) and 32% desaturation (arterial oxygen saturation $<90\%$). Overnight studies were abnormal in 100% of children, with OSA in 63%, hypoventilation in 81%, and desaturation in 56%. Nap studies significantly underestimated the presence of abnormalities when compared to overnight polysomnograms. Seventeen (32%) of the children were referred for testing because OSAS was clinically suspected, but there was no clinical suspicion of OSAS in 36 (68%) children. Neither age, obesity, nor the presence of congenital heart disease affected the incidence of OSA, desaturation, or hypoventilation. Polysomnograms improved in all 8 children who underwent tonsillectomy and adenoidectomy, but they normalized in only 3. It is concluded that children with Down syndrome frequently have OSAS, with OSA, hypoxemia, and hypoventilation. Obstructive sleep apnea syndrome is seen frequently in those children in whom it is not clinically suspected. It is speculated that OSAS may contribute to the unexplained pulmonary hypertension seen in children with Down syndrome.

PEDIATRICS®

Recognition of Sleep-disordered Breathing in Children

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Abstract

Objective. To determine whether upper airway resistance syndrome (UARS) can be recognized and distinguished from obstructive sleep apnea syndrome (OSAS) in prepubertal children based on clinical evaluations, and, in a subgroup of the population, to compare the efficacy of esophageal pressure (Pes) monitoring to that of transcutaneous carbon dioxide pressure (tcPco₂) and expired carbon dioxide (CO₂) measurements in identifying UARS in children.

Study Design. A retrospective study was performed on children, 12 years and younger, seen at our clinic since 1985. Children with diagnoses of sleep-disordered breathing were drawn from our database and sorted by age and initial symptoms. Clinical findings, based on interviews and questionnaires, an orocraniofacial scale, and nocturnal polygraphic recordings were tabulated and compared. If the results of the first polygraphic recording were inconclusive, a second night's recording was performed with the addition of Pes monitoring. In addition, simultaneous measurements of tcPco₂ and endtidal CO₂ with sampling through a catheter were performed on this second night in 76 children. These 76 recordings were used as our gold standard, because they were the most comprehensive. For this group, 1848 apneic events and 7040 abnormal respiratory events were identified based on airflow, thoracoabdominal effort, and Pes recordings. We then analyzed the simultaneously measured tcPco₂ and expired CO₂ levels to ascertain their ability to identify these same events.

Results. The first night of polygraphic recording was inconclusive enough to warrant a second recording in 316 of 411 children. Children were identified as having either UARS (n = 259), OSAS (n = 83), or other sleep disorders (n = 69). Children with small triangular chins, retroposition of the mandible, steep mandibular plane, high hard palate, long oval-shaped face, or long soft palate were highly likely to have sleep-disordered breathing of some type. If large tonsils were associated with these features, OSAS was much more frequently noted than UARS. In the 76 gold standard children, Pes, tcPco₂, and expired CO₂ measurements were in agreement for 1512 of the 1848 apneas and hypopneas that were analyzed. Of the 7040 upper airway resistance events, only 2314 events were consonant in all three measures. tcPco₂ identified only 33% of the increased respiratory events identified by Pes; expired CO₂ identified only 53% of the same events.

Conclusions. UARS is a subtle form of sleep-disordered breathing that leads to significant clinical symptoms and day and nighttime disturbances. When clinical symptoms suggest abnormal breathing during sleep but obstructive sleep apneas are not found, physicians may, mistakenly, assume an absence of breathing-related sleep problems. Symptoms and orocraniofacial information were not useful in distinguishing UARS from OSAS but were useful in distinguishing sleep-disordered breathing (UARS and OSAS) from other sleep disorders. The analysis of esophageal pressure patterns during sleep was the most revealing of the three techniques used for recognizing abnormal breathing patterns during sleep.

Twenty-four-hour Ambulatory Blood Pressure in Children with Sleep-disordered Breathing

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Obstructive sleep apnea causes intermittent elevation of systemic blood pressure (BP) during sleep. To determine whether obstructive apnea in children has a tonic effect on diurnal BP, 24-hour ambulatory blood pressure was obtained from 60 children with mean age of 10.8 ± 3.5 years. Thirty-nine children had obstructive apnea and 21 had primary snoring. Children with obstructive apnea had significantly greater mean BP variability during wakefulness and sleep, a higher night-to-day systolic BP, and a smaller nocturnal dipping of mean BP. Variability of mean arterial pressure during wakefulness was predicted by the desaturation, body mass, and arousal indices, whereas variability during sleep was predicted by apnea-hypopnea and body mass indices. Nocturnal BP dipping was predicted by the desaturation index. There were no significant differences in systolic, diastolic, or mean arterial BP during sleep between the groups. Diastolic BP during wakefulness was significantly different between the groups and correlated negatively with apnea-hypopnea index. We conclude that obstructive apnea in children is associated with 24-hour BP dysregulation and that, independent of obesity, the frequency of obstructive apnea, oxygen desaturation, and arousal contributes to abnormal BP control.

CHEST

Symptoms Related to Sleep-Disordered Breathing in White and Hispanic Children*

The Tucson Children's Assessment of Sleep Apnea Study

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1. **From the Arizona Respiratory Center (Drs. Goodwin, Babar, Morgan, Sherrill, and Quan), and the Children's Research Center (Dr. Kaemingk), University of Arizona College of Medicine, Tucson, AZ; and the Department of Pediatrics (Dr. Rosen), University of Minnesota School of Medicine, Minneapolis, MN.*
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Abstract

Study objectives: The Tucson Children's Assessment of Sleep Apnea (TuCASA) study is designed to investigate the prevalence and correlates of objectively measured sleep-disordered breathing (SDB) in preadolescent children. This article describes the parental report of sleep symptoms associated with SDB in Hispanic and white children.

Design: A 13-question sleep habits screening questionnaire designed to assess the severity of sleep-related symptoms associated with SDB in children 4 to 11 years of age.

Setting: Questionnaires were completed by the parents of children attending elementary school in the Tucson Unified School District, Tucson, AZ.

Participants: There were 1,494 questionnaires returned, which comprised a sample of whites (38%), Hispanics (45%), and other races (17%). Of these questionnaires, 1,214 were returned for the children of white (45.8%; 556 children) or Hispanic (54.2%; 658 children) ethnicity only. The primary analysis was completed on these 613 boys (50.5%) and 601 girls (49.5%).

Results: In the total sample of 1,494 children, parents were more likely to report excessive daytime sleepiness (EDS) in female children than in male children ($p < .01$), however, this association did not achieve significance in the sample of only white and Hispanic children ($p < .07$). Composite variables for EDS and witnessed apnea (WITAP) show that parents of Hispanic children were more likely to report EDS ($p < .01$) and WITAP ($p < .007$). Hispanic children were also more likely to have learning problems (LPs) [$p < .03$] and to snore frequently (SN) [$p < .02$] than were white children. There were no significant differences between boys and girls for SN or WITAP. Hispanic boys were more likely to have reports of EDS ($p < .02$) and LPs ($p < .04$) than white boys, however, there were no other significant differences in gender or ethnicity in reports of EDS or LPs for white or Hispanic boys and girls. Those children with frequent LPs were significantly more likely to have SN ($p < .001$), EDS ($p < .001$), and WITAP ($p < .001$). A

logistic regression model predicting LP resulted in significant adjusted odds ratios (ORs) of 2.4 for SN, 2.5 for EDS, and 2.1 for children aged 8 to 11 years. A similar model for EDS resulted in significant adjusted ORs of 3.2 for SN, 5.7 for WITAP, and 1.6 for female gender. Ethnicity was not significant in either model.

Conclusions: Hispanic children in the population-based TuCASA study experienced more frequent symptoms associated with SDB, such as SN, EDS, WITAP, and LPs, than did white children. Children with LPs are 2.4 times more likely to have SN, 2.5 times more likely to have EDS, and were 2.1 times more likely to be between the ages of 8 and 11 years. Children with EDS were 3.2 times more likely to have SN, 5.7 times more likely to have WITAP, and were 1.6 times more likely to be a girl.

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Associations of Obesity, Sleep-disordered Breathing, and Wheezing in Children

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Although it has been speculated that rising asthma rates may be partly due to increasing obesity, the causal mechanisms that relate these conditions are unclear. We assessed the extent to which sleep-disordered breathing (SDB) may explain associations between obesity and wheezing/asthma. A total of 788 participants (aged 8–11 years) in a community-based cohort study were classified according to two outcomes: wheezing and asthma. Sleep apnea was defined as an increased number of apneas and hypopneas on overnight monitoring. SDB was identified on the basis of either sleep apnea or habitual snoring. Multiple logistic regression models showed that children with wheeze were significantly more likely to be male (odds ratio [OR] 1.62; confidence interval [CI] 1.15, 2.29), black (OR 1.90; CI 1.35, 2.29), obese (OR 1.57; CI 1.10, 2.44), and have a maternal history of asthma (OR 1.93; CI 1.16, 3.22). Further adjustment for SDB attenuated the association between obesity and wheeze (OR 1.45; CI 0.93, 2.26), but did not substantially alter the association between obesity and asthma. We conclude that SDB and obesity each are associated with asthma and wheeze. The relationship between obesity and wheeze may be partly mediated by factors associated with SDB.

Sleep-disordered breathing, pharyngeal size and soft tissue anatomy in children

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We tested the hypothesis that pharyngeal geometry and soft tissue dimensions correlate with the severity of sleep-disordered breathing. Magnetic resonance images of the pharynx were obtained in 18 awake children, 7-12 yr of age, with obstructive apnea-hypopnea index (OAH) values ranging from 1.81 to 24.2 events/h. Subjects were divided into low-OAH ($n = 9$) and high-OAH ($n = 9$) groups [2.8 ± 0.7 and 13.5 ± 4.9 (SD) $P < 0.001$]. The OAH correlated positively with the size of the tonsils ($r^2 = 0.42$, $P = 0.024$) and soft palate ($r^2 = 0.33$, $P = 0.049$) and inversely with the volume of the oropharynx ($r^2 = 0.42$, $P = 0.038$). The narrowest point in the pharyngeal airway was smaller in the high-compared with the low-OAH group (4.4 ± 1.2 vs. 6.0 ± 1.3 mm; $P = 0.024$), and this point was in the retropalatal airway in all but two subjects. The airway cross-sectional area (CSA)-airway length relation showed that the high-OAH group had a narrower retropalatal airway than the low-OAH group, particularly in the retropalatal region where the soft palate, adenoids, and tonsils overlap ($P = 0.001$). The "retropalatal air space," which we defined as the ratio of the retropalatal airway CSA to the CSA of the soft palate, correlated inversely with the OAH ($r^2 = 0.49$, $P = 0.001$). We conclude that 7- to 12-yr-old children with a narrow retropalatal air space have significantly more apneas and hypopneas during sleep compared with children with relatively unobstructed retropalatal airways.

CHEST

Prevalence of Sleep Problems in Hong Kong Primary School Children*

A Community-Based Telephone Survey

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Abstract

Study objectives: To estimate the prevalence of snoring, witnessed sleep apnea, teeth grinding, primary and secondary nocturnal enuresis, and sleep duration in Hong Kong primary school children.

Design: Cross-sectional telephone questionnaire survey in a community.

Participants: A total of 3,047 6- to 12-year-old apparently healthy children.

Intervention: Those who agreed to the study were contacted by telephone. Survey questions were asked about the symptoms of the different sleep disorders, and the frequency of each positive symptom was noted for the preceding 1 week.

Outcome measures: Prevalence and risk factors of sleep disorders in Hong Kong primary school children.

Results: The prevalence of the following sleep symptoms was listed as follows: habitual snoring (10.9%), witnessed sleep apnea (1.5%), nocturnal enuresis (5.1%), and sleep teeth grinding (20.5%). Significant risk factors for habitual snoring included witnessed sleep apnea, mouth breathing during sleep, snoring in first-degree relatives, headache on rising, male gender, allergic rhinitis, and sleep teeth grinding. Significant risk factors for witnessed sleep apnea included habitual snoring, allergic rhinitis, tiredness on rising, and excessive daytime sleepiness. Poor academic results were associated with present of witnessed sleep apnea and absence of sleep teeth grinding. None of the sleep problem was associated with poor conduct results. The mean sleep duration was 8.79 h (SD 0.96).

Conclusions: This study provides epidemiologic data of sleep-disordered breathing, enuresis, sleep teeth grinding, and duration of sleep in Chinese primary school children in Hong Kong.

Adenotonsillectomy for Obstructive Sleep Apnea Syndrome in Young Children

Prevalence of Pulmonary Complications

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Arch Otolaryngol Head Neck Surg. 2006;132:476-480.

Objective To determine, in a series of children younger than 6 years undergoing adenotonsillectomy for treatment of clinical obstructive sleep apnea syndrome (OSAS), the effect of age on prevalence of postoperative respiratory complications. The primary objective was to define a practice standard for postoperative hospital admission.

Design Retrospective analysis.

Setting Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio.

Patients All children younger than 6 years who underwent adenotonsillectomy to treat OSAS from June 1, 1999, to May 31, 2001.

Main Outcome Measures The percentage of children younger than 3 years undergoing adenotonsillectomy to treat OSAS who experience a postoperative respiratory complication.

Results Of 2315 patients younger than 6 years undergoing an adenotonsillectomy for treatment of OSAS, 149 (6.4%) developed a postoperative respiratory complication. Even though there was a lower incidence of comorbid medical conditions in this cohort, children younger than 3 years were at a greater risk for developing a postoperative respiratory complication compared with those aged 3 to 5 years (9.8% vs 4.9%, $P < .001$). Logistic regression analysis revealed that children younger than 3 years had a nearly 2-fold increased risk for respiratory complications postoperatively (odds ratio, 1.98; 95% confidence interval, 1.41-2.77) when controlling for race and sex.

Conclusions Adenotonsillectomy to treat OSAS is associated with a significantly higher rate of postoperative respiratory complication in children younger than 3 years compared with children aged 3 to 5 years. Our results support hospital admission for all patients younger than 3 years undergoing adenotonsillectomy for treatment of OSAS.

Elevated Morbidity and Health Care Use in Children with Obstructive Sleep Apnea Syndrome

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Rationale: Health care use, a reliable measure of morbidity, is noticeably higher 1 yr before obstructive sleep apnea syndrome (OSAS) diagnosis in preschool children. It is not clear at what age OSAS-related morbidity becomes expressed.

Objective: To explore morbidity and health care use among children with OSAS starting from first year of life.

Methods: Case-control study, starting from the first year of life to date of OSAS diagnosis, among 156 patients (age range, 3–5 yr) and their pair-matched healthy control subjects, by age, sex, primary care physician, and geographic location.

Measurements: Patients with OSAS underwent nocturnal polysomnography studies. Medical records during hospital visits were reviewed for diagnosis. Variables of health care use were obtained from computerized databases of Clalit Health Care Services, the largest health maintenance organization in Israel.

Main Results: From the first year of life to date of OSAS diagnosis, children with OSAS had 40% more ($p = 0.048$) hospital visits, 20% more repeated (two or more) visits ($p < 0.0001$), and higher consumption of antiinfective and respiratory system drugs ($p < 0.0001$). Referrals of children with OSAS to otolaryngology surgeons and pediatric pulmonologists were higher from Year 1 ($p < 0.0001$) to date of OSAS diagnosis, especially in Year 4 (odds ratio, 9.4; 95% confidence interval, 4.2–21.1). The 215% elevation ($p < 0.0001$) in health care use of the OSAS group was due mainly to higher occurrence of respiratory tract morbidity ($p < 0.0001$).

Conclusions: Practitioners should be aware that starting in Year 1 until date of diagnosis, children with OSAS have higher health care use, mostly related to respiratory diseases.

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Effect of sleep apnea on cognition and mood

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Obstructive sleep apnea syndrome (OSAS) is a common disorder in adults and children, which is characterized by repetitive transient reversible upper airway obstructions during sleep. Due to disrupted sleep architecture and intermittent hypoxemia, OSAS leads to impaired daytime functioning in various neuropsychological and affective domains. The most common abnormalities are executive dysfunction, impaired vigilance, depression, and possibly anxiety and, in children, hyperactivity. Optimal treatment of OSAS with continuous positive airway pressure may reverse the cognitive and affective dysfunction, however, in some patients a residual impairment persists. This persistent deficit, despite effective treatment, raises the possibility of a remaining subtle structural brain damage; such damage has been demonstrated through the use of sensitive functional and other neuroimaging techniques. Prefrontal cortical damage may underlie the cognitive dysfunction in OSAS. Early recognition and treatment may prevent this untoward effect of OSAS.

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Magnetic Resonance Imaging of the Upper Airway Structure of Children with Obstructive Sleep Apnea Syndrome

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The anatomical relationships between lymphoid, bony, and other tissues affecting the shape of the upper airway in children with obstructive sleep apnea syndrome (OSAS) have not been established. We therefore compared the upper airway structure in 18 young children with OSAS (age 4.8 ± 2.1 yr; 12 males and 6 females) and an apnea index of 4.3 ± 3.9 , with 18 matched control subjects (age, 4.9 ± 2.0 yr; 12 males and 6 females). All subjects underwent magnetic resonance imaging under sedation. Axial and sagittal T1- and T2-weighted sequences were obtained. Images were analyzed with image-processing software to obtain linear, area, and volumetric measurements of the upper airway and the tissues comprising the airway. The volume of the upper airway was smaller in subjects with OSAS in comparison with control subjects (1.5 ± 0.8 versus 2.5 ± 1.2 cm³; $p < 0.005$) and the adenoid and tonsils were larger (9.9 ± 3.9 and 9.1 ± 2.9 cm³ versus 6.4 ± 2.3 and 5.8 ± 2.2 cm³; $p < 0.005$ and $p < 0.0005$, respectively).

Volumes of the mandible and tongue were similar in both groups; however, the soft palate was larger in subjects with OSAS (3.5 ± 1.1 versus 2.7 ± 1.2 cm³; $p < 0.05$). We conclude that in children with moderate OSAS, the upper airway is restricted both by the adenoid and tonsils; however, the soft palate is also larger in this group, adding further restriction.

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Sleep-disordered breathing in overweight and obese children and adolescents: prevalence, characteristics and the role of fat distribution

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Abstract

Aims: To determine the prevalence of sleep-disordered breathing (SDB) in a clinical sample of overweight and obese children and adolescents, and to examine the contribution of fat distribution.

Methods: Consecutive subjects without chronic lung disease, neuromuscular disease, laryngomalacia, or any genetic or craniofacial syndrome were recruited. All underwent measurements of neck and waist circumference, waist-to-hip ratio, % fat mass and

polysomnography. Obstructive apnoea index ≥ 1 or obstructive apnoea–hypopnoea index (OAH) ≥ 2 , further classified as mild ($2 \leq \text{OAH} < 5$) or moderate-to-severe ($\text{OAH} \geq 5$), were used as diagnostic criteria for obstructive sleep apnoea (OSA). Central sleep apnoea was diagnosed when central apnoeas/hypopnoeas ≥ 10 s were present accompanied by > 1 age-specific bradycardia and/or > 1 desaturation $< 89\%$. Subjects with desaturation $\leq 85\%$ after central events of any duration were also diagnosed with central sleep apnoea. Primary snoring was diagnosed when: snoring was detected by microphone and normal obstructive indices and saturation.

Results: 27 overweight and 64 obese subjects were included (40 boys; mean (standard deviation (SD)) age 11.2 (2.6) years). Among the obese children, 53% were normal, 11% had primary snoring, 11% had mild OSA, 8% had moderate-to-severe OSA and 17% had central sleep apnoea. Half of the patients with central sleep apnoea had desaturation $< 85\%$. Only enlarged tonsils were predictive of moderate-to-severe OSA. On the other hand, higher levels of abdominal obesity and fat mass were associated with central sleep apnoea.

Conclusion: SDB is very common in this clinical sample of overweight children. OSA is not associated with abdominal obesity. On the contrary, higher levels of abdominal obesity and fat mass are associated with central sleep apnoea.

[The Journal of Pediatrics](#)

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Adenotonsillectomy Improves Sleep, Breathing, and Quality of Life But Not Behavior

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Objective

To obtain parental perspectives on changes in sleep, breathing, quality of life (QOL), and neurobehavioral measures after adenotonsillectomy.

Study design

This retrospective cohort study comprised otherwise healthy children evaluated for obstructive sleep apnea syndrome (OSAS) from 1993 to 2001. We compared those children who underwent adenotonsillectomy with those children who did not. The parents of 473 children (292 boys) 2 years of age and older were sent questionnaires to evaluate QOL and clinical and behavioral changes. For 94 children 3 years of age and older, behavioral changes were evaluated using the Conners' Parent Rating Scale-Revised (CPRS-R) for three different periods: pre-operatively/pre-polysomnography, postoperatively/postpolysomnography, and recently.

Results

One hundred and sixty-six questionnaires were returned (35%), 138 of which were complete with written consent provided. Compared with parents of unoperated children, parents of children who had adenotonsillectomy were more likely to report improvements in sleep, breathing, and QOL but not improvements in concentration, school performance, and intellectual or developmental progress. Both short and long term, there were no significant effects of adenotonsillectomy on any of the CPRS-R behavior subscales.

Conclusion

From a parental perspective, adenotonsillectomy frequently improves sleep, breathing, and QOL but does not often improve neurobehavioral outcomes

[Journal of the American Academy of Child & Adolescent Psychiatry](#)

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DSM-IV Diagnoses and Obstructive Sleep Apnea in Children Before and 1 Year After Adenotonsillectomy

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ABSTRACT

Objective

Obstructive sleep apnea, a common indication for adenotonsillectomy in children, has been linked to behavioral morbidity. We assessed psychiatric diagnoses in children before and after adenotonsillectomy and examined whether baseline sleep apnea predicted improvement after surgery.

Method

Subjects of this prospective cohort study were children ages 5.0 to 12.9 years old who had been scheduled for adenotonsillectomy ($n = 79$) or care for unrelated surgical conditions ($n = 27$, among whom 13 had surgery after baseline assessment). Before intervention and 1 year later, subjects underwent structured diagnostic interviews and polysomnography. The main outcome measure was frequency of *DSM-IV* attention and disruptive behavior disorder diagnoses at baseline and follow-up.

Results

At baseline, attention and disruptive behavior disorders were diagnosed in 36.7% of adenotonsillectomy subjects and 11.1% of controls ($p < .05$); attention-deficit/hyperactivity disorder was found in 27.8% and 7.4%, respectively ($p < .05$). One year later, group differences were nonsignificant; attention and disruptive behavior disorders were diagnosed in only 23.1% ($p < .01$), and 50% of subjects with baseline attention-deficit/hyperactivity disorder no longer met diagnostic criteria. Obstructive sleep apnea on polysomnography at baseline did not predict concurrent psychiatric morbidity or later improvement.

Conclusions

Attention and disruptive behavior disorders, diagnosed by *DSM-IV* criteria, were more common before clinically indicated adenotonsillectomy than 1 year later. Surgery may be associated with reduced morbidity, even among subjects lacking polysomnographic evidence of obstructive sleep apnea.

Cardiac remodelling and dysfunction in children with obstructive sleep apnoea: a community based study

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Abstract

Background: Childhood obstructive sleep apnoea (OSA) is suggested to be associated with cardiac structural abnormalities and dysfunction but existing evidence is limited and the treatment effect on echocardiographic outcome remains controversial.

Objective: To examine the presence of subclinical cardiac abnormalities in childhood OSA and the effects of treatment on cardiac changes.

Methods: Polysomnography (PSG) and echocardiographic examinations were performed in 101 children aged between 6 and 13 years who were invited from a community based questionnaire survey. They were classified into a reference group (apnoea–hypopnoea index (AHI) <1, n=35), mild OSA group (AHI 1–5, n=39) and moderate to severe group (AHI >5, n=27) based on the PSG results. Treatments, including adenotonsillectomy or nasal steroids, were offered to the mild and moderate to severe OSA groups.

Results: The moderate to severe OSA group had greater right ventricular (RV) systolic volume index (RVSVI), lower RV ejection fraction (RVEF) and higher RV myocardial performance index (RVMPI) than the reference group. They also had more significant left ventricular (LV) diastolic dysfunction and remodelling with larger interventricular septal thickness index (IVSI) and relative wall thickness than those with lower AHI values. The moderate to severe OSA group had an increased risk of abnormal LV geometry compared with the reference group (odds ratio 4.21 (95% CI 1.35 to 13.12)). Log transformed AHI was associated with RVSVI ($p=0.0002$), RVEF ($p=0.0001$) and RVMPI ($p<0.0001$), independent of the effect of obesity. Improvement in RVMPI, IVSI and E/e' were observed in those with a significant reduction in AHI (>50%) comparing 6 month with baseline data.

Conclusions: OSA is an independent risk factor for subclinical RV and LV dysfunction, and improvement in AHI is associated with reversibility of these abnormalities.

[Otolaryngology - Head and Neck Surgery](#)

[Volume 140, Issue 4](#), April 2009, Pages 455-460

Literature review

Adenotonsillectomy for obstructive sleep apnea in obese children: A meta-analysis

Presented at the American Academy of Otolaryngology–Head and Neck Surgery Annual Meeting, Chicago, Illinois, September 21, 2008.

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Objective

The purpose of this study was to determine the effectiveness of adenotonsillectomy (T&A) for treating obstructive sleep apnea (OSA) in obese children.

Review Methods

A meta-analysis of studies that reported sleep parameters in obese children with OSA before and after T&A. Data were analyzed using the random effects model. Statistical significance was $P \leq 0.05$.

Results

Data from four studies that included 110 children were analyzed. The mean sample size was 27.5 (range, 18-33). The mean body mass index z score was 2.81. The mean pre- and postoperative apnea-hypopnea index (AHI) was 29.4 (range, 22.2-34.3) and 10.3 (range, 6.0-12.2), respectively. The weighted mean difference between pre- and postoperative AHI was a significant reduction of 18.3 events per hour (95% confidence interval [CI], 11.2-25.5). The mean pre- and postoperative oxygen saturation nadir was 78.4 percent (range, 73.9%-81.1%) and 85.7 percent (range, 83.6%-89.9%), respectively. The weighted mean difference was a significant increase of the oxygen saturation nadir of 6.3 percent (95% CI, 3.9-8.7). Forty-nine percent of children had a postoperative AHI ≤ 5 , 25 percent of children had a postoperative AHI ≤ 2 , and 12 percent of children had a postoperative AHI ≤ 1 .

Conclusions

T&A improves but does not resolve OSA in the majority of obese children. The efficacy and role of additional therapeutic options require more study. The high incidence of obesity in children makes this a public health priority.

[Otolaryngology - Head and Neck Surgery](#)

[Volume 139, Issue 1](#), July 2008, Pages 83-86

Original research—pediatric otolaryngology

Polysomnographic outcome of adenotonsillectomy for obstructive sleep apnea in children under 5 years old

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Received 26 November 2006; revised 26 January 2007; Accepted 9 February 2007. Available online 26 June 2008.

Objective

To determine success rates after adenotonsillectomy for obstructive sleep apnea (OSA); postoperative polysomnogram (PSG) results were compared with preoperative results in children younger than 5 years.

Methods

Thirty-four children with a preoperative respiratory disturbance index (RDI) greater than 5 in rapid eye movement (REM) sleep underwent both preoperative and postoperative PSG with at least five of seven parameters recorded.

Results

Preoperatively, mean total RDI was 15.5, mean REM RDI was 39.6, and 25 (74%) had severe OSA (REM RDI > 20). Postoperatively, mean total RDI improved to 3 ($P < 0.001$), mean REM RDI to 7.4 ($P < 0.001$), and 4 remained severe. Overall 22 (65%) showed REM RDI in the normal range (<5), including all with a preoperative REM RDI less than 30.

Conclusion

On PSG criteria, most children with OSA significantly improved after adenotonsillectomy, but a number had persisting abnormalities. Postoperative PSG should be considered to identify unresolved OSA.

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A controlled study of sleep related disordered breathing in obese children

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Abstract

Background: Unlike the adult sleep related disordered breathing (SDB) patients who are typically obese, the relation between obesity and childhood SDB is not clear.

Aims: To investigate whether obese children are more at risk of obstructive SDB when compared to normal population, and whether this risk is potentiated by the presence of pharyngeal lymphoid tissue.

Methods: Forty six obese children (age 10.8 (SD 2.3) years; BMI 27.4 (SD 5.1)), and 44 sex and age matched normal weight children (age 11.7 (SD 2.1) years; BMI 18 (SD 1.8)) were studied. All children underwent a set of physical examinations (including the upper airways) and sleep studies.

Results: The obese children were different from the normal weight children in terms of type (predominantly obstructive), frequency, and severity of respiratory disturbances. Depending on the criteria used, 26% or 32.6% of obese children had SDB; 2.3% of normal controls had OAI ≥ 1 and 4.5% had RDI ≥ 5 . Presence of SDB was related to presence of tonsils (size >2 ; range 0–4) (OR 12.67, 95% CI 2.14 to 75.17) and BMI (OR 1.20, 95% CI 1.08 to 1.33).

Conclusions: Results suggest that obese children are at increased risk of obstructive SDB; the presence of any pharyngeal lymphoid tissue enlargement in obese children should therefore be aggressively managed.

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Adenotonsillectomy Outcomes in Treatment of Obstructive Sleep Apnea in Children

A Multicenter Retrospective Study

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Rationale: The overall efficacy of adenotonsillectomy (AT) in treatment of obstructive sleep apnea syndrome (OSAS) in children is unknown. Although success rates are likely lower than previously estimated, factors that promote incomplete resolution of OSAS after AT remain undefined.

Objectives: To quantify the effect of demographic and clinical confounders known to impact the success of AT in treating OSAS.

Methods: A multicenter collaborative retrospective review of all nocturnal polysomnograms performed both preoperatively and postoperatively on otherwise healthy children undergoing AT for the diagnosis of OSAS was conducted at six pediatric sleep centers in the United States and two in Europe. Multivariate generalized linear modeling was used to assess contributions of specific demographic factors on the post-AT obstructive apnea-hypopnea index (AHI).

Measurements and Main Results: Data from 578 children (mean age, 6.9 ± 3.8 yr) were analyzed, of which approximately 50% of included children were obese. AT resulted in a significant AHI reduction from 18.2 ± 21.4 to 4.1 ± 6.4 /hour total sleep time ($P < 0.001$). Of the 578 children, only 157 (27.2%) had complete resolution of OSAS (i.e., post-AT AHI < 1 /h total sleep time). Age and body mass index z-score emerged as the two principal factors contributing to post-AT AHI ($P < 0.001$), with modest contributions by the presence of asthma and magnitude of pre-AT AHI ($P < 0.05$) among nonobese children.

Conclusions: AT leads to significant improvements in indices of sleep-disordered breathing in children. However, residual disease is present in a large proportion of children after AT, particularly among older (> 7 yr) or obese children. In addition, the presence of severe OSAS in nonobese children or of chronic asthma warrants post-AT nocturnal polysomnography, in view of the higher risk for residual OSAS.

Follow-up on Metabolic Markers in Children Treated for Obstructive Sleep Apnea

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Rationale: In adults, obstructive sleep apnea (OSA) is associated with metabolic dysfunction that improves with treatment of OSA. No equivalent studies exist in children.

Objective: To examine the relationship between metabolic markers and OSA with time and treatment in children.

Methods: Metabolic markers measured on a fasting morning blood sample at diagnostic polysomnography and follow-up 1.3 ± 0.6 yr later.

Measurements and Main Results: Forty-five children (34 males), aged 6.9 ± 3.5 yr, and including 12 obese subjects, were in the final analysis. There were no differences in metabolic markers between children with and without OSA at initial study; however, obese children had significantly higher insulin (106.1 ± 72.1 vs. 66.7 ± 37.6 pmol/L; $p = 0.028$), insulin/glucose ratio (23.7 ± 14.3 vs. 14.7 ± 8.0 ; $p = 0.02$), and significantly lower high-density lipoprotein cholesterol (1.3 ± 0.2 vs. 1.6 ± 0.4 nmol/L; $p = 0.005$) than nonobese children. Twenty children underwent surgical removal of adenotonsillar tissue, whereas 12 children with OSA elected not to have treatment. OSA persisted after treatment in five children, and resolved in 27. Thirteen children did not have OSA on initial or follow-up studies. At follow-up, there was a small but significant improvement in total cholesterol in those children whose OSA was resolved (4.8 ± 0.8 to 4.7 ± 0.6 nmol/L; $p = 0.005$) and a trend for obese children with persisting OSA to have elevated insulin levels compared with obese children without OSA ($p = 0.07$).

Conclusion: Obesity appears to be the major influence on metabolic dysfunction in children with OSA, but these preliminary data also suggest that resolution or persistence of OSA may affect changes in metabolic function over time.

Polysomnography should be required both before and after adenotonsillectomy for childhood sleep disordered breathing.

[Hoban TF.](#)

Source

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Improved Behavior and Sleep After Adenotonsillectomy in Children With Sleep-Disordered Breathing

Long-term Follow-up

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Arch Otolaryngol Head Neck Surg. 2009;135(7):642-646.

Objective To determine whether previously published changes are maintained over time in children after adenotonsillectomy for sleep-disordered breathing using the validated Pediatric Sleep Questionnaire (PSQ) and the Conners Parent Rating Scale-Revised: Short Form (CPRS-R:S).

Design Prospective, nonrandomized interventional study.

Setting Ambulatory surgery center affiliated with an academic medical center.

Patients Long-term follow-up data were available (ranging from 2.4 to 3.6 years after adenotonsillectomy) for 44 of the 71 patients who completed our initial study comparing PSQ and CPRS-R:S data before and 6 months after surgery.

Interventions Parents completed the PSQ and CPRS-R:S at least 2 years after surgery.

Main Outcome Measures Follow-up PSQ data and long-term changes in age- and sex-adjusted T scores for all 4 CPRS-R:S behavior categories (oppositional behavior, cognitive problems or inattention, hyperactivity, and the attention-deficit/hyperactivity disorder [ADHD] index) were determined for each patient. Linear mixed models were used to analyze the data.

Results Globally, across time, most variables remained below baseline levels ($P < .05$). There was a significant increase in PSQ scores during follow-up, but over this period they did not reach baseline levels. Comparing short-term with long-term follow-up, the Conners scores in all behavioral categories did not increase significantly (ADHD index, $P = .61$; cognitive problems or inattention, $P = .02$; hyperactivity, $P < .001$; and oppositional behavior, $P < .001$). The ADHD index at long-term follow-up was not different from that at baseline, a finding that might be attributable to the high degree of variability in this measure.

Conclusions Improvements in sleep experienced by children after adenotonsillectomy for sleep-disordered breathing were not as great 2.5 years after surgery as they were 6 months after surgery but were still significant compared with baseline levels. Improvements in behavior were maintained in all categories of the Conners scores except for the ADHD index.

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Child behavior and quality of life before and after tonsillotomy versus tonsillectomy

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Abstract

Objectives

Compare two techniques for pediatric tonsil surgery with respect to postoperative pain and morbidity and changes in sleep behavior, health related quality of life (HRQL) and benefits due to surgery.

Methods

67 children (4.5–5.5 years) with tonsillar hypertrophy and obstructive sleep-disordered breathing with or without recurrent tonsillitis were randomized to either regular tonsillectomy (TE) ($n = 32$) or intracapsular tonsillectomy/tonsillotomy (TT) ($n = 35$) with Radiofrequency surgical

technique (ellman Int.). Before TT/TE, the parents completed a validated Quality of Life survey of pediatric obstructive sleep apnea, the OSA-18 (Obstructive Sleep Apnea-18) and a standardized assessment of their children's behavior with the Child Behavior Checklist (CBCL). Six months after surgery, the parents repeated these measurements, and assessed the health related benefits of the surgery using the Glasgow Children's Benefit Inventory (GCBI).

Results

In the TT group, the children recorded less pain from the first day after surgery onwards, used fewer doses of painkillers and were pain-free 3 days earlier than the children in the TE group. Six months after surgery, there were no significant difference between TT and TE with regard to snoring and ENT-infections.

The differences in the total scores and in all the individual domains between the initial OSA-18 and post-surgery scores were all significant ($P < 0.0001$). The improvement in the total problem score measured with CBCL was also significant ($P < 0.01$) and there was no difference between the TT and TE children. The improvements in all subscores of the GCBI indicated a significant health benefit of both TT and TE.

Conclusions

TT with RF-surgery causes less pain and postoperative morbidity than regular TE and has an equal effect on snoring and recurrent infections.

Pre-school children with tonsillar hypertrophy and obstructive sleep-disordered breathing all show an impact on HRQL and behavior before surgery and improve dramatically just as much after TT as after TE. Therefore TT would be considered for treatment of small children.

PEDIATRICS®

Sleep-Disordered Breathing and Behaviors of Inner-City Children With Asthma

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Abstract

OBJECTIVE: To explore the relationship between sleep-disordered breathing (SDB) and behavioral problems among inner-city children with asthma.

METHODS: We examined data for 194 children (aged 4–10 years) who were enrolled in a school-based asthma intervention program (response rate: 72%). SDB was assessed by using the Sleep-Related Breathing Disorder Questionnaire that contains 3 subscales: snoring, sleepiness, and attention/hyperactivity. For the current study, we modified the Sleep-Related Breathing Disorder Questionnaire by removing the 6 attention/hyperactivity items. A sleep score of >0.33 was considered indicative of SDB. To assess behavior, caregivers completed the Behavior Problem Index (BPI), which includes 8 behavioral subdomains. We conducted bivariate analyses and multiple linear regression to determine the association of SDB with BPI scores.

RESULTS: The majority of children (mean age: 8.2 years) were male (56%), black (66%), and insured by Medicaid (73%). Overall, 33% of the children experienced SDB. In bivariate analyses, children with SDB had significantly higher (worse) behavior scores compared with children without SDB on total BPI (13.7 vs 8.8) and the subdomains externalizing (9.4 vs 6.3), internalizing (4.4 vs 2.5), anxious/depressed (2.4 vs 1.3), headstrong (3.2 vs 2.1), antisocial (2.3 vs 1.7), hyperactive (3.0 vs 1.8), peer conflict (0.74 vs 0.43), and immature (2.0 vs 1.5). In multiple regression models adjusting for several important covariates, SDB remained significantly associated with total BPI scores and externalizing, internalizing, anxious/depressed, headstrong, and hyperactive behaviors. Results were consistent across SDB subscales (snoring, sleepiness).

CONCLUSIONS: We found that poor sleep was independently associated with behavior problems in a large proportion of urban children with asthma. Systematic screening for SDB in this high-risk population might help to identify children who would benefit from additional intervention.

PEDIATRICS®

Short Sleep Duration and Behavioral Symptoms of Attention-Deficit/Hyperactivity Disorder in Healthy 7- to 8-Year-Old Children

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Abstract

OBJECTIVE. It has been hypothesized that sleep deprivation may manifest in children as behavioral symptoms rather than as tiredness, but only a few studies have investigated this hypothesis. The objective of our study was to evaluate whether short sleep is associated with behavioral symptoms of attention-deficit/hyperactivity disorder in 7- to 8-year-old children.

METHODS. We performed a cross-sectional study of children born in 1998 in Helsinki, Finland. The participants included 280 (146 girls, 134 boys) children with a mean age of 8.1 years (SD: 0.3; range: 7.4–8.8). Sleep quality was measured by using actigraphs. The Sleep Disturbance Scale for Children and the Attention-Deficit/Hyperactivity Disorder Rating Scale IV were administered to parents.

RESULTS. Children whose average sleep duration as measured by actigraphs was short (<10th percentile, ie, <7.7 hours) and had a higher hyperactivity/impulsivity score (9.7 vs 7.8 or 7.5) and a higher attention-deficit/hyperactivity disorder total score (17.3 vs 14.5 or 13.1) but a similar inattention score (7.6 vs 6.7 or 5.6) compared with children sleeping 7.7 to 9.4 hours or >9.4 hours. In multivariate statistical models, short sleep duration remained a statistically significant predictor of hyperactivity/impulsivity, and sleeping difficulties were associated with hyperactivity/impulsivity, inattention, and the total score. There were no significant interactions between short sleep and sleeping difficulties.

CONCLUSIONS. Children's short sleep duration and sleeping difficulties increase the risk for behavioral symptoms of attention-deficit/hyperactivity disorder.

[Journal of the American Academy of Child & Adolescent Psychiatry](#)

[Volume 46, Issue 2](#), February 2007, Pages 233-241

Effect of Melatonin on Sleep, Behavior, and Cognition in ADHD and Chronic Sleep-Onset Insomnia

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ABSTRACT

Objective

To investigate the effect of melatonin treatment on sleep, behavior, cognition, and quality of life in children with attention-deficit/hyperactivity disorder (ADHD) and chronic sleep onset insomnia.

Method

A total of 105 medication-free children, ages 6 to 12 years, with rigorously diagnosed ADHD and chronic sleep onset insomnia participated in a randomized, double-blind, placebo-controlled trial using 3 or 6 mg melatonin (depending on body weight), or placebo for 4 weeks. Primary outcome parameters were actigraphy-derived sleep onset, total time asleep, and salivary dim light melatonin onset.

Results

Sleep onset advanced by 26.9 ± 47.8 minutes with melatonin and delayed by 10.5 ± 37.4 minutes with placebo ($p < .0001$). There was an advance in dim light melatonin onset of 44.4 ± 67.9 minutes in melatonin and a delay of 12.8 ± 60.0 minutes in placebo ($p < .0001$). Total time asleep increased with melatonin (19.8 ± 61.9 minutes) as compared to placebo (-13.6 ± 50.6 minutes; $p = .01$). There was no significant effect on behavior, cognition, and quality of life, and significant adverse events did not occur.

Conclusions

Melatonin advanced circadian rhythms of sleep-wake and endogenous melatonin and enhanced total time asleep in children with ADHD and chronic sleep onset insomnia; however, no effect was found on problem behavior, cognitive performance, or quality of life. *J. Am. Acad. Child Adolesc. Psychiatry*, 2007;46(2):233-241.

Sleep in Children With Attention-Deficit/Hyperactivity Disorder: Meta-Analysis of Subjective and Objective Studies

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Accepted 20 April 2009. *Disclosure: Dr. Cortese has received financial support to attend medical meetings from Eli Lilly & Company and Shire Pharmaceuticals, and has been co-investigator in studies sponsored by GlaxoSmithKline, Eli Lilly & Company, and Genopharm. Dr. Faraone has received consulting fees from, has been on the advisory boards and speakers' bureaus of, or received research support from the National Institutes of Health, Shire, Pfizer, and Eli Lilly. Dr. Konofal has served on the advisory boards for Shire and UCB. He has consulted for Shire. He has served as a medical writer for Remidica and Janssen-Cilag. He has served on the speakers_bureau of UCB and served as a principal investigator in clinical trials for Eli Lilly & Company and Janssen-Cilag. Dr. Lecendreux has received industry research funding from Shire. He has served as a consultant for UCB and Shire. He has served as an investigator for Eli Lilly & Company and Shire.. Available online 22 August 2009.*

Abstract

Objective

To perform a meta-analysis of subjective (i.e., based on questionnaires) and objective (i.e., using poly-somnography or actigraphy) studies comparing sleep in children with attention-deficit/hyperactivity disorder (ADHD) versus controls.

Method

We searched for subjective and objective sleep studies (1987–2008) in children with ADHD (diagnosed according to standardized criteria). Studies including subjects pharmacologically treated or with comorbid anxiety/depressive disorders were excluded.

Results

Sixteen studies, providing 9 subjective and 15 objective parameters and including a total pooled sample of 722 children with ADHD versus 638 controls, were retained. With regard to subjective items, the meta-analysis indicated that children with ADHD had significantly higher bedtime resistance ($z = 6.94, p < .001$), more sleep onset difficulties ($z = 9.38, p < .001$), night awakenings ($z = 2.15, p = .031$), difficulties with morning awakenings ($z = 5.19, p < .001$), sleep disordered breathing ($z = 2.05, p = .040$), and daytime sleepiness ($z = 1.96, p = .050$) compared with the controls. As for objective parameters, sleep onset latency (on actigraphy), the number of stage shifts/hour sleep, and the apnea-hypopnea index were significantly higher in the children with ADHD compared with the controls ($z = 3.44, p = .001$; $z = 2.43, p = .015$; $z = 3.47, p = .001$, respectively). The children with ADHD also had significantly lower sleep efficiency on polysomnography ($z = 2.26, p = .024$), true sleep time on actigraphy ($z = 2.85, p = .004$), and average times to fall asleep for the Multiple Sleep Latency Test ($z = 6.37, p < .001$) than the controls.

Conclusions

The children with ADHD are significantly more impaired than the controls in most of the subjective and some of the objective sleep measures. These results lay the groundwork for future evidence-based guidelines on the management of sleep disturbances in children with ADHD.

[International Congress Series](#)

[Volume 1254](#), November 2003, Pages 185-190

Paediatric sleep disorders: the need for multidisciplinary sleep clinics

Luci D Wiggs

Abstract

The field of sleep disorders (SD) medicine crosses the boundaries of many medical specialties and disciplines. This paper aims to highlight the importance of a multidisciplinary approach to the assessment and treatment of SD in children, with particular reference to sleep-disordered breathing (SDB).

The link between SDB and other SD (e.g. various parasomnias, sleep-related anxiety) illustrates the need for a holistic approach to assessment since these co-existing SD can be the most overt symptoms. Further, different approaches to treatment of the various SD are likely to be called for.

Multidisciplinary care becomes particularly pertinent when dealing with clinical groups of children in which an increased prevalence of SD, including SDB, have been noted. Such groups include children with intellectual disabilities and those with neurological or psychiatric conditions. The nature of their basic condition may make it likely that SD will be overlooked

with the daytime consequences of the nocturnal disturbance (e.g. cognitive/behavioural problems) misattributed to the underlying condition.

Conclusion: An ideal national service would include a limited number of specialised sleep centres where a broad and multidisciplinary approach to the recognition, assessment and treatment of children's SD was possible.

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Obstructive sleep apnoea is associated with impaired pictorial memory task acquisition and retention in children

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Abstract

The aim of our study was to evaluate whether obstructive sleep apnoea (OSA) is associated with impaired acquisition and recall of a pictorial-based memory tasks in children.

54 children with OSA and 17 controls matched for age, sex and ethnicity underwent a sleep study (overnight polysomnogram). Before the sleep study subjects completed a 15-min pictorial memory task acquisition consisting of four trials, followed by a free-recall period to assess retention after 10 min and the following morning upon awakening.

Children with OSA had a higher obstructive apnoea/hypopnoea index (6.3 ± 1.5 events $\cdot$ h⁻¹ TST) than controls (0.6 ± 0.1 events $\cdot$ h⁻¹ TST) ($p < 0.0001$). Mean learning scores in controls over the four consecutive trials were incrementally better than in children with OSA for the four-trial set ($p < 0.0001$). Both immediate ($p < 0.0001$) and overnight recall performances were worse among

OSA children ($p < 0.0001$), who also exhibited declines in recall performance that was absent in controls ($p < 0.001$).

Differences in pictorial task acquisition trajectories suggest that children with OSA require more time and an increased number of learning opportunities to reach immediate and long-term recall performances that are reduced compared with controls. Thus, both acquisition and retention of newly learned material are compromised. These findings confirm and expand on the presence of known cognitive deficits in children with OSA.

Headache: The Journal of Head and Face Pain

[Volume 43, Issue 4](#), pages 362–368, April 2003

Migraine Headaches and Sleep Disturbances in Children

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Objective.—The aim of the present study was to investigate the prevalence of sleep disturbances in children with migraine headaches and to describe individual differences in sleep behaviors based on headache features (eg, frequency, duration, intensity).

Background.—A relationship between migraine headaches and sleep disturbances has been suggested in both children and adults, but there is a lack of research examining the relationship between specific headache features and the range of sleep behaviors in children.

Methods.—One hundred eighteen children, aged 2 to 12 years (mean, 9.1; standard deviation, 2.3) were evaluated for headaches at two pediatric neurology departments. Parents completed the Children's Sleep Habits Questionnaire and a standardized questionnaire regarding headache characteristics.

Results.—Parents reported a high rate of sleep disturbances in children, including sleeping too little (42%), bruxism (29%), child co-sleeping with parents (25%), and snoring (23%). Children with migraine headaches experienced more sleep disturbances compared to published healthy control norms. After controlling for child demographics, we found that the frequency and duration of migraine headaches predicted specific sleep disturbances, including sleep anxiety, parasomnias, and bedtime resistance.

Conclusions.—Children with migraine headaches have a high prevalence of sleep disturbances. The direction of the relationship between headaches and sleep is unknown. Regardless, interventions targeting sleep habits may improve headache symptoms, and effective treatment of headaches in children may positively impact sleep.

Adenotonsillectomy and obstructive sleep apnea in children: A prospective survey

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Abstract

Objective Prospective survey of children up to 14 years of age with OSA submitted to adenotonsillectomy.

Methods Clinical evaluation, with questionnaires and clinical scales evaluating facial structures including tonsils and Mallampati scales and otolaryngologic evaluation; nocturnal polysomnography and repeat evaluation three to five months postsurgery.

Results Of 207 successively seen children, 199 had follow-up polysomnography, and 94 had still abnormal sleep recording. Multivariate analysis indicates that Mallampati scale score 3 and 4, retro-position of mandible, enlargement of nasal inferior turbinates at +3 (subjective scale 1 to 3), and deviated septum were significantly associated with persistence of abnormal polysomnography (with high 95% CI for Mallampati scale and deviated septum).

Conclusion Mallampati scale scores are resultant of several facial factors involving maxilla, mandible, and oral versus oral breathing but add information on risk of partial response to adenotonsillectomy.

Significance Adenotonsillectomy may not resolve obstructive sleep apnea in children.

The Association Between Sleep Disordered Breathing, Academic Grades, and Cognitive and Behavioral Functioning Among Overweight Subjects During Middle to Late Childhood

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Abstract

Study Objectives:

(1) to determine the associations of sleep disordered breathing (SDB) with behavioral functioning, cognitive test scores, and school grades during middle- to late-childhood, an under-researched developmental period in the SDB literature, and (2) to clarify whether associations between SDB and school grades are mediated by deficits in cognitive or behavioral functioning.

Design:

Cross-sectional correlative study.

Setting:

Office/hospital, plus reported functioning at home and at school.

Participants:

163 overweight subjects aged 10-16.9 years were divided into 4 groups based upon their obstructive apnea+hypopnea index (AHI) during overnight polysomnography and parent report of snoring: Moderate-Severe OSA (AHI > 5, n = 42), Mild OSA (AHI = 1-5, n = 58), Snorers (AHI < 1 + snoring, n = 26), and No SDB (AHI < 1 and nonsnoring, n = 37).

Measurements:

Inpatient overnight polysomnography, parent- and self-report of school grades and sleep, parent- and teacher-report of daytime behaviors, and office-based neuropsychological testing.

Results:

The 4 groups significantly differed in academic grades and parent- and teacher-reported behaviors, particularly inattention and learning problems. These findings remained significant after adjusting for subject sex, race, socioeconomic status, and school night sleep duration. Associations with SDB were confined to reports of behavioral difficulties in real-world situations, and did not extend to office-based neuropsychological tests. Findings from secondary analyses were consistent with, but could not definitively confirm, a causal model in which SDB affects school grades via its impact on behavioral functioning.

Conclusions:

SDB during middle- to late-childhood is related to important aspects of behavioral functioning, especially inattention and learning difficulties, that may result in significant functional impairment at school.

Citation:

Beebe DW; Ris MD; Kramer ME; Long E; Amin R. The association between sleep disordered breathing, academic grades, and cognitive and behavioral functioning among overweight subjects during middle to late childhood. *SLEEP* 2010;33(11):1447-1456.

PEDIATRICS®

Sleep Problems in Childhood Predict Neuropsychological Functioning in Adolescence

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Abstract

OBJECTIVES. Our goal was to examine the association between parent-rated sleep problems during childhood and neuropsychological functioning during adolescence.

PARTICIPANTS AND METHODS. Longitudinal prospective data on an entire birth cohort from Dunedin, New Zealand, were obtained. One thousand thirty-seven children were enrolled in the study (52% male). Parents reported on sleep problems when the study members were 5, 7, and 9 years of age. Neuropsychological functioning was assessed by using 7 tests when the participants were 13 years of age.

RESULTS. After adjusting for gender and socioeconomic status, persistent sleep problems during childhood predicted scores on 2 neuropsychological tests: the copy score of the Rey-Osterrieth Complex Figure Test and 2 measures of performance on the Halstead Trail Making Test. These results were substantively replicated when sleep was assessed at the 5- and 9-year (but not 7-year) assessments separately.

CONCLUSIONS. Sleep problems during childhood may be associated with certain aspects of neuropsychological functioning during adolescence. This adds to the growing body of literature suggesting that childhood sleep problems may be a risk indicator of later difficulties.

ARCHIVES OF
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Rapid Maxillary Expansion for the Treatment of Nasal Obstruction in Children Younger Than 12 Years

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Arch Otolaryngol Head Neck Surg. 2009;135(1):22-27.

Objective To assess short- and long-term effects of rapid maxillary expansion (RME) on nasal flow in young children. Since RME has been reported to positively influence nasal

obstruction in subjects with respiratory problems by reducing nasal resistance, a similar efficacy of RME could be expected in children with deciduous and/or mixed dentition who are affected by maxillary constriction and nasal obstruction from a different cause.

Design Prospective study of children younger than 12 years, with different grades of malocclusion and oral breathing. Data included active anterior rhinomanometry in both the supine and orthostatic positions, as well as radiographic cephalometric measurements.

Setting Tertiary care university hospital. Data were prospectively collected from 2005 to 2007.

Patients Nasal flow and resistance were measured in 65 children younger than 12 years, with mixed or deciduous dentition and different grades of malocclusion and oral breathing.

Main Outcome Measure Efficacy of RME for resolution of maxillary constriction.

Results After RME, an improvement of nasal flow and resistance has been recorded in patients, in the supine position, who presented both anterior and posterior obstruction. Less notable changes were shown in isolated forms of obstruction and in the orthostatic position.

Conclusion In cases of maxillary constriction and nasal airway obstruction, RME has proved to be efficient for the improvement of nasal respiration in children via a widening effect on the nasopharyngeal cavity.

: [American Journal of Rhinology](#), Volume 20, Number 4, July-August 2006 , pp. 385-393(9)

Nasal airway measurements in children treated by rapid maxillary expansion

Authors: Compadretti, Giacomo Ceroni; Tasca, Ignazio; Bonetti, Giulio Alessandri

Abstract:

Background: Rapid maxillary expansion is an orthodontic procedure that is commonly used to widen the maxilla. It is generally admitted that this technique is effective to correct palate narrowing, whereas there has not been agreement on the effect of this procedure in nasal parameters. The availability of a reliable and objective technique to assess the geometry of nasal cavities, such as acoustic rhinometry, stimulated the present investigation.

Methods: Twenty-seven children, undergoing rapid maxillary expansion, were evaluated by rhinomanometry and acoustic rhinometry. Postero-anterior radiographs were taken in 15 patients for cephalometric measurements. Examinations were performed before expansion treatment and after 12 month follow-up and compared to the measurements obtained from an untreated control group.

Results: With regard to rhinomanometry, we recorded a significant reduction in nasal airway resistance (NAR) after the orthodontic procedure only in decongestion. Using acoustic rhinometry, we found a significant increase in total minimum cross-sectional areas (TMCA) and total nasal volume (TNV) after the expansion both in basal and decongested conditions. Also, nasal cavity width and interzygomatic distance had a significant mean increase after the treatment. Comparison of measures between the control group and the treated group showed that the increase in TMCA and TNV, as well as the decrease in NAR, were significantly greater in the treated group in both basal and decongested conditions.

Conclusion: We demonstrated that rapid maxillary expansion is an effective procedure in widening nasal cavities with respect to an untreated control group and that the reported improvement in nasal breathing after palatal expansion, is a consequence of an increase in nasal size.

[Sleep Medicine](#)

[Volume 10, Issue 4](#), April 2009, Pages 471-478

NREM sleep instability changes following rapid maxillary expansion in children with obstructive apnea sleep syndrome

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Abstract

Objective

To evaluate NREM sleep microstructure in children with obstructive sleep apnea syndrome (OSAS) before and after one year of rapid maxillary expander (RME) treatment by means of the cyclic alternating pattern (CAP).

Methods

Nine children with OSAS aged 4–8 years (6 males, mean age 6.4 ± 1.97 years) and age-matched normal controls were included. All subjects underwent an overnight polysomnography in the sleep laboratory after one adaptation night, as a baseline evaluation; children with OSAS were recorded again after one year of RME treatment.

Results

After one year of treatment the OSAS group showed a longer duration of time in bed and sleep period time, a reduction in number of stage shifts compared to baseline recordings, and the apnea–hypopnea index decreased significantly. At baseline, the OSAS group had a higher CAP rate during slow-wave sleep and an increased A2 index compared to normal controls. After one year of RME application, children with OSAS showed an increase in CAP rate associated with an increase of A1 index during slow-wave sleep.

Conclusions

RME treatment almost normalized sleep architecture and improved sleep respiratory disturbances; however, sleep microstructure and respiratory parameters did not completely recover. The persistence of increased CAP rate in slow-wave sleep associated with an increase of A1 index might reflect a partial failure of orthodontic treatment. On the other hand, the rebound of A1 subtypes might be an indirect sign of an attempt to normalize sleep that has been disturbed by the respiratory events

M. Murat Ozbek, Ufuk T. Toygar Memikoglu, Ayse Tuba Altug-Atac, and Alan A. Lowe (2009) Stability of Maxillary Expansion and Tongue Posture. *The Angle Orthodontist*: March 2009, Vol. 79, No. 2, pp. 214-220.

Stability of Maxillary Expansion and Tongue Posture

M. Murat Ozbek^a, Ufuk T. Toygar Memikoglu^b, Ayse Tuba Altug-Atac^c, and Alan A. Lowe^d

Abstract

Objective: To evaluate the adaptive changes and the stability in tongue posture following rapid maxillary expansion (RME) in patients without any signs or symptoms of respiratory disturbances.

Materials and Methods: Growing subjects with maxillary constrictions and bilateral buccal crossbites were included in the treatment group ($n = 20$). A control group ($n = 20$) comprised subjects with normal dentoskeletal features. RME appliances were used in the treatment group, with an average active expansion of 15 ± 2 days. Cephalometric radiographs were traced and digitized to evaluate static tongue posture before RME and 6.75 ± 0.48 months after RME. Follow-up radiographic evaluations of 17 expansion cases were also performed after an average

of 29.25 ± 1.85 months. Independent and paired *t*-tests were conducted to evaluate changes in tongue posture within and between groups.

Results: Results revealed significant reductions of tongue-to-palate ($P < .05$) as well as hyoid bone-to-mandibular plane ($P < .01$) distances following RME. The new tongue posture was found to be stable during the follow-up period.

Conclusions: A higher tongue posture can be obtained with RME in children with no reported respiratory disturbances. (*Angle Orthod.* 2009;79;)

Rapid Maxillary Expansion Effects on Nocturnal Enuresis in Children

A Follow-up Study

Ulrike Schu"tz-Fransson^a; Ju"ri Kurol^b

ABSTRACT

Objective: To assess the effects of 10–14 days of rapid maxillary expansion (RME) on nocturnal enuresis (NE) in children who have long-standing resistance to medical therapy and to evaluate the long-term success rate after 10 years.

Materials and Methods: Twenty-three children with NE, aged 6–15 years old (mean age $\pm$ 10), who wet their bed almost every night and had never been dry were referred from pediatric specialists.

Mean RME was 6.5 mm (range $\pm$ 5–8), but only 7 of the 23 patients had lateral crossbites. Rhinomanometric measurements were taken before and after RME, and patients were interviewed

10 years after treatment.

Results: Positive effects of RME were observed in nearly 50% of the patients within 1 month of treatment: six were completely dry and five had notable improvements. Relapse in the overexpanded

arches to a normal transversal occlusion was noted within 1 year. No correlation was found between success and improved airways, familial heritage, school performance, or other social factors. Younger children responded better to the treatment. Results were stable at the 10-

year follow-up, and no adverse reactions were reported.

Conclusion: Orthodontic RME is a new option for treating children with NE who are resistant to medical therapy; the treatment has no adverse side effects.

[Sleep and Breathing](#)

[Volume 15, Number 2](#), 179-184, DOI: 10.1007/s11325-011-0505-1

Efficacy of rapid maxillary expansion in children with obstructive sleep apnea syndrome: 36 months of follow-up

[Maria Pia Villa](#), [Alessandra Rizzoli](#), [Silvia Miano](#) and [Caterina Malagola](#)

Abstract

Purpose

In view of the positive outcome of orthodontic treatment using rapid maxillary expansion (RME) on sleep-disordered breathing, we generated data on RME in children with obstructive sleep apnea (OSA) by evaluating objective and subjective data over a 36-month follow-up period, to determine whether RME is effective in the long-term treatment of OSA. We selected all patients with dental malocclusions and OSA syndrome (OSAS) confirmed by polysomnography.

Methods

Ten of the 14 children who completed the 12-month therapeutic trial using RME were enrolled in our follow-up study. The study was performed 24 months after the end of the RME orthodontic treatment. We enrolled all children presented with deep, retrusive or crossbite at the orthodontic evaluation. All subjects underwent an overnight polysomnography at the baseline, after 1 year of treatment and 24 months after the end of the orthodontic treatment. The children's mean age was 6.6 ± 2.1 years at entry and 9.7 ± 1.6 years at the end of follow-up.

Results

After treatment, the apnea hypopnoea index (AHI) decreased and the clinical symptoms had resolved by the end of the treatment period. Twenty-four months after the end of the treatment, no significant changes in the AHI or in other variables were observed.

Conclusions

RME may be a useful approach in children with malocclusion and OSAS, as the effects of such treatment were found to persist 24 months after the end of treatment.

[Current Treatment Options in Neurology](#)

[Volume 11, Number 5](#), 358-367, DOI: 10.1007/s11940-009-0040-6

Treatment options for obstructive sleep apnea

[Vivien C. Abad](#) and [Christian Guilleminault](#)

Abstract

Sleep apnea is a major public health problem that afflicts 9% of women and 24% of men 30 to 60 years of age. It is highly treatable, but when untreated, it has been associated with (but not necessarily linked to) increased probability of cerebral and coronary vascular disease, congestive heart failure, metabolic dysfunction, cognitive dysfunction, excessive daytime sleepiness, motor vehicle accidents, reduced productivity, and decreased quality of life. The gold standard for treatment in adults is positive airway pressure (PAP) therapy: continuous PAP (CPAP), bilevel PAP, autotitrating CPAP, or autotitrating bilevel PAP. Measures to increase compliance with PAP therapy include medical or surgical treatment of any underlying nasal obstruction, setting appropriate pressure level and airflow, mask selection and fitting, heated humidification, desensitization for claustrophobia, patient and partner education, regular follow-up with monitoring of compliance software, and attendance of support groups (eg, AWAKE). Adjunctive treatment modalities include lifestyle or behavioral measures and pharmacologic therapy. Patients with significant upper airway obstruction who are unwilling or unable to tolerate PAP therapy may benefit from surgery. Multilevel surgery of the upper airway addresses obstruction of the nose, oropharynx, and hypopharynx. A systematic approach may combine surgery of the nose, pharynx, and hypopharynx in phase 1, whereas skeletal midface advancement or tracheotomy constitutes phase 2. Clinical outcomes are reassessed through attended diagnostic polysomnogram performed 3 to 6 months after surgery. Oral appliances can be used for patients with symptomatic mild or moderate sleep apnea who prefer them to PAP therapy or for whom PAP therapy has failed or cannot be tolerated. Oral appliances also may be used for patients with severe obstructive sleep apnea who are unable or unwilling to undertake PAP therapy or surgery.

For children, the main treatment modality is tonsillectomy and adenoidectomy, with or without turbinate surgery. Children with craniofacial abnormalities resulting in maxillary or mandibular insufficiency may benefit from palatal expansion or maxillary/mandibular surgery. PAP therapy may be used for children who are not surgical candidates or if surgery fails.

ARCHIVES OF
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Variation of Patterns of Malocclusion by Site of Pharyngeal Obstruction in Children

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Arch Otolaryngol Head Neck Surg. 2010;136(11):1116-1120.
doi:10.1001/archoto.2010.187

Objective To correlate the type of dental occlusion and the type of pharyngeal lymphoid tissue obstruction in children.

Design Cross-sectional study.

Setting Ambulatory ear, nose, and throat clinic of Faculdade de Medicina da Universidade de São Paulo.

Patients One hundred fourteen children aged 3 to 12 years presenting with mouth breathing and snoring due to tonsil and/or adenoid enlargement.

Interventions Oroscopy and nasal fiber pharyngoscopy complemented by lateral head radiography to diagnose the type of obstruction, and clinical examination to evaluate the dental occlusion.

Main Outcome Measures Tonsil and adenoid obstruction (classified from grades 1-4) and sagittal, transverse, and vertical evaluation of dental occlusion.

Results Obstructive enlargement of both tonsils and adenoids was detected in 64.9% of the sample; isolated enlargement of the adenoids, in 21.9%; isolated enlargement of the palatine tonsils, in 7.0%; and nonobstructive tonsils and adenoids, in 6.1%. All types of pharyngeal obstruction were related to a high prevalence of posterior crossbite (36.8%). Statistically significant association was found between sagittal dental occlusion and the site of lymphoid tissue obstruction ($P = .02$). A higher rate of class II relationship (43.2%) was detected in the group with combined adenoid and tonsil obstructive enlargement. Isolated tonsil obstruction showed a higher rate of class III relationship (37.5%).

Conclusions Different sites of obstruction of the upper airway due to enlarged lymphoid tissue are associated with different types of dental malocclusion. Findings are relevant to orthodontic and surgical decision making in these mouth-breathing patients.

[Sleep and Breathing](#)

Mandibular advancement devices are an alternative and valid treatment for pediatric obstructive sleep apnea syndrome

[Maria Pia Villa](#), [Silvia Miano](#) and [Alessandra Rizzoli](#)

Abstract

Background

Orthodontic and craniofacial abnormalities have often been reported in pediatric sleep-disordered breathing (SDB). While the reversibility of these craniofacial abnormalities by means of adenotonsillectomy has yet to be established, orthodontic treatment based on oral appliances is considered to be a potential additional treatment for pediatric SDB.

Discussion

Oral appliances may help improve upper airway patency during sleep by enlarging the upper airway and/or by decreasing upper airway collapsibility, thereby enhancing upper airway muscle tone. Orthodontic therapy should be encouraged in pediatric OSAS, and an early approach may permanently modify nasal breathing and respiration, thereby preventing obstruction of the upper airway.

Am. J. Respir. Crit. Care Med., Volume 165, Number 1, January 2002, 123-127

Randomized Controlled Study of an Oral Jaw-Positioning Appliance for the Treatment of Obstructive Sleep Apnea in Children with Malocclusion

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To evaluate the clinical usefulness and tolerability of an oral jaw-positioning appliance in the treatment of obstructive sleep apnea syndrome in children, we studied 32 patients (mean age, 7.1 ± 2.6 yr; 20 males) with symptoms of obstructive sleep apnea, malocclusion, and a baseline apnea index > 1 event/h. A group of 19 subjects was randomly assigned to a 6-mo trial of an oral appliance; the remainder acted as control subjects. At baseline and after the trial all patients underwent physical examination, a standard polysomnography, and orthodontic assessment. A modified version of the Brouillette questionnaire related to obstructive sleep apnea symptoms was administered to parents before and after the trial and a clinical score was calculated. Of the 32 subjects enrolled, 4 treated subjects and 5 control subjects were lost to follow-up. Polysomnography after the trial showed that treated subjects all had significantly lower apnea index ($p < 0.001$) and hypopnea index values ($p < 0.001$) than before the trial, whereas in untreated control subjects these values remained almost unchanged. Clinical assessment before and after treatment showed that in 7 of the 14 subjects (50%) the oral appliance had reduced (a fall of at least 2 points in the respiratory score) and in 7 had resolved the main respiratory symptoms, whereas untreated patients continued to have symptoms. In conclusion, treatment of obstructive sleep apnea syndrome with an oral appliance in children with malocclusion is effective and well tolerated.

Dental arch morphology in children with sleep-disordered breathing

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Abstract

The aim of the present study was to examine the effects of nocturnal breathing disorders such as obstructive sleep apnoea (OSA) and snoring on developing dental arches. The study group comprised 41 children (22 males, 19 females, mean age 7.2 years, standard deviation 1.93) with diagnosed OSA. Age- and gender-matched groups of 41 snoring and 41 non-obstructed control children were selected. Orthodontic examination was carried out and dental impressions were taken. Malocclusions were diagnosed clinically and 13 linear variables were measured from the dental casts. The differences between the dental arch measurements of the OSA, snoring, and control groups were studied using analysis of variance followed by Duncan's multiple comparison method.

Children with diagnosed OSA had a significantly increased overjet, a reduced overbite, and narrower upper and shorter lower dental arches when compared with the controls. Snoring children had similar but not as significant differences as OSA children when compared with the controls. There were more children with an anterior open bite (AOB) in the OSA group ($P = 0.016$) and with a Class II or asymmetric molar relationship in the groups of OSA ($P = 0.013$) and snoring ($P = 0.004$) subjects compared with the non-obstructed controls. There were more subjects with mandibular crowding ($P = 0.002$) and with an AOB ($P = 0.019$) with an increasing obstructive apnoea–hypopnoea index (AHI).

These findings are in agreement with previous studies of the effects of increased upper airway resistance on dental arch morphology and can be explained by long-term changes in the position of the head, mandible, and tongue in order to maintain airway adequacy during sleep.

Improvement of bruxism after T & A surgery

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Abstract

Bruxism or tooth grinding is an oral habit that frequently occurs during sleep. Some authors suggest it is associated to sleep apnea. **Objective:** The main goal of this study is compare the incidence of bruxism before and after adenotonsillectomy (T & A surgery) in children with sleep-disordered breathing. **Methods:** This is a prospective study in which we evaluated 69 consecutive children from the Otolaryngology Department of the University of São Paulo Medical School in pre- and post-surgical periods of adenotonsillectomy. Before and after surgery parents answered a questionnaire about sleep-disturbed breathing and bruxism. Children were submitted to E.N.T. examination and speech pathologist evaluation. The orthodontist inspected malocclusion. Before surgery all the 69 children presented sleep apnea and 45.6% presented bruxism. Malocclusion could be found in 60.71%. Three months after surgery none of the children presented breathing problems and only 11.8% presented bruxism. There was no difference in malocclusion. **Conclusion:** This study suggests that there is a positive correlation between sleep-disordered breathing and bruxism. There was an important improvement of bruxism after T & A surgery. Otolaryngologists must be aware that this pernicious sleep disorder is associated to airway obstruction and so, it must be considered when evaluating T & A hyperplasia.

Upper airway resistance syndrome in children: A clinical review

Christian Guilleminault , ^{1, a}, Andrei Khramtsov^a

Available online 6 June 2006.

Upper airway resistant syndrome (UARS) is more common in children than is obstructive sleep apnea syndrome (OSAS). Age will color the symptoms associated with the syndrome. UARS must be looked for in families with adult sleep-disordered breathing. Polygraphic recording during sleep will show flow limitation with usage of nasal cannula/pressure transducer system, but the abnormal breathing during sleep may be indicated also by burst of tachypnea without saturation drops. Esophageal pressure monitoring may be the only way to confirm a suspected diagnosis. A mild developmental anomaly of the craniofacial skeleton is often seen in these children even in the presence of enlarged tonsils and adenoids. Children with sleep-disordered breathing should have a maxillomandibular examination to assess the need for orthodontic treatment to expand the oral cavity.

CHEST

The Nose and Sleep-Disordered Breathing*

What We Know and What We Do Not Know

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Abstract

The relationship between sleep-disordered breathing (SDB) and nasal obstruction is unclear. In order to better understand, we performed an extensive computer-assisted review and analysis of

the medical literature on this topic. Data were grouped into reports of normal control subjects, patients with isolated nasal obstruction, and those with SDB. We conclude that SDB can both result from and be worsened by nasal obstruction. Nasal breathing increases ventilatory drive and nasal occlusion decreases pharyngeal patency in normal subjects. Nasal congestion from any cause predisposes to SDB. Although increased nasal resistance does not always correlate with symptoms of congestion, nasal congestion typically results in a switch to oronasal breathing that compromises the airway. Moreover, oral breathing in children may lead to the development of facial structural abnormalities associated with SDB. We postulate that the switch to oronasal breathing that occurs with chronic nasal conditions is a final common pathway for SDB.

[International Journal of Pediatric Otorhinolaryngology](#)

[Volume 73, Issue 9](#), September 2009, Pages 1234-1241

The development of sleep disordered breathing from 4 to 12 years and dental arch morphology

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Abstract

Objective

To track the development of sleep disordered breathing (SDB) as well as dento-facial morphology in cohort of children by having them complete a questionnaire at ages 4, 6 and 12. Clinical examination, sleep studies (at ages 4 and 12) and orthodontic evaluation were carried out on all who were reported to snore regularly and children who did not snore at all.

Results

Out of the original group of 615 children, 64% (393) answered the inquiry on all three occasions. Of those, 27 snored regularly and 231 did not snore at all at the age of 12. There were differences between those groups on all answers, especially prevalence of oral breathing: 78% versus 5% ($p < 0.001$). The prevalence of OSA decreased from 3.1% at the age of 4 to 0.8% at age 12 and the severity decreased from a mean AHI 14.8 at 4 to a mean AHI of 1.95 at age 12. The minimum prevalence of snoring regularly was estimated to 4.2% at 12 years compared to 5.3% at 4, calculated for the original cohort of 644 children. The odds for a child who snored regularly at 4 or 6 years to be snoring regularly also at age 12 was 3.7 times greater than for a not snoring child

in spite of surgery (OR 3.7, 95% CI 2.4–5.7). 63 children had undergone surgery due to snoring by age 12. 14 of them never snored and 17 snored regularly at the age 12. The dental arch was narrower in the children snoring regularly at 4, 6 and 12 years compared to not snoring children. Cross-bites were more common among snoring children than among non-snoring children, at 4 and 6 as well as at 12.

Conclusion

The prevalence of regular snoring is about the same from 4 to 12 years independent of surgery, but the prevalence of OSA decreased considerably. The children *snoring regularly* generally have a narrower maxilla compared to children *not snoring*. Surgery in young children is necessary but “cures” the snoring only temporary.

CHEST

Risk Factors for Sleep Bruxism in the General Population*

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Abstract

Objective: Sleep bruxism can have a significant effect on the patient’s quality of life. It may also be associated with a number of disorders. However, little is known about the epidemiology of sleep bruxism and its risk factors in the general population.

Design: Cross-sectional telephone survey using the Sleep-EVAL knowledge based system.

Settings: Representative samples of three general populations (United Kingdom, Germany, and Italy) consisting of 158 million inhabitants.

Participants: Thirteen thousand fifty-seven subjects aged ≥ 15 years (United Kingdom, 4,972 subjects; Germany, 4,115 subjects; and Italy, 3,970 subjects).

Intervention: None.

Measurements: Clinical questionnaire on bruxism (using the *International Classification of Sleep Disorders* [ICSD] minimal set of criteria) with an investigation of associated pathologies (*ie*, sleep, breathing disorders, and psychiatric and neurologic pathologies).

Results: Grinding of teeth during sleep occurring at least weekly was reported by 8.2% of the subjects, and significant consequences from teeth grinding during sleep (*ie*, muscular discomfort on awakening, disturbing tooth grinding, or necessity of dental work) were found in half of these subjects. Moreover, 4.4% of the population fulfilled the criteria of ICSD sleep bruxism diagnosis. Finally, subjects with obstructive sleep apnea syndrome (odds ratio [OR], 1.8), loud snorers (OR, 1.4), subjects with moderate daytime sleepiness (OR, 1.3), heavy alcohol drinkers (OR, 1.8), caffeine drinkers (OR, 1.4), smokers (OR, 1.3), subjects with a highly stressful life (OR, 1.3), and those with anxiety (OR, 1.3) are at higher risk of reporting sleep bruxism.

Conclusions: Sleep bruxism is common in the general population and represents the third most frequent parasomnia. It has numerous consequences, which are not limited to dental or muscular problems. Among the associated risk factors, patients with anxiety and sleep-disordered breathing have a higher number of risk factors for sleep bruxism, and this must raise concerns about the future of these individuals. An educational effort to raise the awareness of dentists and physicians about this pathology is necessary.

[Otolaryngology - Head and Neck Surgery](#)

[Volume 134, Issue 6](#), June 2006, Pages 979-984

The effectiveness of tonsillectomy and adenoidectomy in the treatment of pediatric obstructive sleep apnea/hypopnea syndrome: A meta-analysis

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Objective

Present and evaluate the currently available literature reporting on the effectiveness of adenotonsillectomy (T/A) in treating obstructive sleep apnea/hypopnea syndrome (OSAHS) in uncomplicated pediatric patients.

Study design and setting

Systematic review of the literature and meta-analysis of the reduction of the polysomnogram (PSG)-measured Apnea Hypopnea Index (AHI events/hour) resulting from T/A and the overall success rate of T/A in normalizing PSG measurements (%).

Results

Fourteen studies met the inclusion criteria. Mean sample size was 28. All were case series (level 4 evidence). The summary change in AHI was a reduction of 13.92 events per hour (random effects model 95% CI 10.05-17.79, $P < 0.001$) from T/A. The summary success rate of T/A in normalizing PSG was 82.9% (random effects model 95% CI 76.2%-89.5%, $P < 0.001$).

Conclusion/significance

T/A is effective in the treatment of OSAHS. However, success rates are far below 100%, which could have far-reaching pediatric public health consequences

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Updated systematic review of tonsillectomy and adenoidectomy for treatment of pediatric obstructive sleep apnea/hypopnea syndrome

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Abstract

Objective

Perform an updated systematic review and meta-analysis to determine the cure rate of tonsillectomy and adenoidectomy (T&A) for pediatric obstructive sleep apnea/hypopnea syndrome (OSAHS).

Methods

A systematic review was performed to identify English-language studies that evaluate the treatment of pediatric (age < 20 years) OSAHS patients with T&A using polysomnography as a metric of cure. Twenty-three studies fit the inclusion criteria and a meta-analysis was performed to determine the overall success. Meta-analysis was also performed to determine the success in obese and comorbid populations vs cohorts of healthy children.

Results

The meta-analysis included 1079 subjects (mean sample size of 42 patients) with a mean age of 6.5 years. The effect measure was the percentage of pediatric patients with OSAHS who were successfully treated (k = 22 studies) with T&A based on preoperative and postoperative PSG data. Random-effects model estimated the treatment success of T&A was 66.3 percent, when cure was defined per each individual study. When “cure” was defined as an apnea-hypopnea index (AHI) of <1 (k = 9 studies), random-effects model estimate for OSAHS treatment success with T&A was 59.8 percent. Postoperative mean AHI was significantly decreased from preoperative levels.

Conclusions

Contrary to popular belief, meta-analysis of current literature demonstrates that pediatric sleep apnea is often not cured by T&A. Although complete resolution is not achieved in most cases, T&A still offers significant improvements in AHI, making it a valuable first-line treatment for pediatric OSAHS.

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Intracapsular coblation tonsillectomy and adenoidectomy for the treatment of pediatric obstructive sleep apnea/hypopnea syndrome

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Abstract

Objective: To report the findings of five years' experience using standardized coblation intracapsular tonsillectomy with adenoidectomy for treatment of pediatric sleep apnea.

Study Design: Case series.

Methods: A five-year retrospective analysis of coblation tonsillectomy performed by a single department for sleep apnea was completed.

Results: A total of 159 tonsillectomy and adenoidectomy (T&A) cases performed with coblation technique were reviewed. The mean preoperative apnea-hypopnea index (AHI) was 17.8 and mean postoperative AHI was 3.3. Polysomnogram (PSG) normalization (AHI < 1), was achieved in 54.7% patients. Normalization of PSG data was achieved in only 42.2% of overweight patients (body mass index [BMI] $\geq$ 85th percentile). Based on regression analysis, Friedman tongue position (III and IV) and elevated AHI were determined to be independent predictors of poor response to T&A.

Conclusions: Contrary to popular belief, a review of 159 cases demonstrates that T&A does not always result in normalization of polysomnographic data. Although complete resolution is not achieved in most cases, T&A offers significant improvements in AHI. Predictive variables such as BMI, FTP, and AHI should be taken into account when designing a treatment plan. It is important to recognize the need for close follow-up and early detection of residual disease in the pediatric population.

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The effect of adenotonsillectomy on changes of position during sleep in pediatric obstructive sleep apnea syndrome

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Abstract:

Background:

It is unknown whether adenotonsillectomy influences changes of position during sleep in children with obstructive sleep apnea syndrome (OSAS). The aim of this study was to evaluate the effect of adenotonsillectomy on changes of position during sleep as determined by polysomnography in children with OSAS.

Methods:

Forty-four polysomnograms from 22 children with OSAS were analyzed. We compared the frequency of positional changes during sleep and the distribution of sleep positions before and after adenotonsillectomy.

Results:

Adenotonsillectomy significantly improved all respiratory parameters studied. The arousal index and sleep efficiency were improved among the sleep parameters. There was a significant decrease in the total number of positional changes during sleep ($p < 0.001$) and positional change index ($p < 0.001$). The proportion of sleep time spent in the supine position was significantly increased ($p = 0.001$), and the proportions spent in lateral ($p = 0.003$) and up ($p = 0.018$) positions were significantly decreased.

Conclusion:

Significant changes were found in the frequency of positional changes during sleep and the distribution of sleep positions in children with OSAS after adenotonsillectomy.

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Sleep patterns in children with attention-deficit/hyperactivity disorder, tic disorder, and comorbidity

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Background: In children, attention-deficit/hyperactivity disorder (ADHD), tic disorder (TD), and their coexistence (ADHD + TD comorbidity) are very common and clinically important. Associated sleep patterns and their clinical role are still insufficiently investigated. This study aimed at characterizing these sleep patterns in children with ADHD, TD, and ADHD + TD

comorbidity and determining whether, in ADHD + TD, the factors ADHD and TD may affect the sleep pattern in an independent (additive) or in a complex (interactive) manner.

Method: By means of polysomnography, sleep patterns were investigated in 4 groups of unmedicated 8.0–16.4-year-old children (healthy controls, ADHD-only, TD-only, and ADHD + TD). Each group consisted of 18 subjects matched for age, gender, and intelligence.

Results: ADHD was primarily characterized by increase in rapid eye movement (REM) sleep, whereas TD patients displayed lower sleep efficiency and elevated arousal index in sleep. In children with ADHD + TD, both effects appeared. No interaction between the ADHD and TD factors was found for any of the sleep parameters. Significant correlations between sleep patterns and clinical symptoms were found.

Conclusions: ADHD and TD are characterized by specific sleep alterations. When coexisting, the two disorders alter the sleep pattern in an additive manner, suggesting a high impact on clinical and therapeutic perspectives.

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