Clinical Pediatrics
2015, Vol. 54(8) 713–722

DOI: 10.1177/0009922814548673
cpj.sagepub.com
SAGE

Disordered Sleep as a Cause of Attention Deficit/Hyperactivity Disorder: Recognition and Management

Stanley Fischman, MD, FAPA[1], Damien P. Kuffler, PhD, Habil[2], and Cynthia Bloch, BSPT, MSIS[3]

Introduction

Sleep disorders are an underlying cause of attention deficit/hyperactivity disorder (ADHD),[1] but they are underdiagnosed in children.[2] Finding and treating sleep disorders is important because, as Chervin et al,[3(p1185)] stated, "Our data suggest that . . . 25% of all children with ADHD . . . could have their ADHD eliminated if their habitual snoring and any associated [sleep-related breathing disorders] were effectively treated."

The reported prevalence of children with ADHD varies among countries, from 3% to 16%. These differences have been attributed to differences among diagnostic methods.[4-7] In the United States in 2009, the prevalence of ADHD in children and adolescents was 9%, and the diagnosis rate was increasing.[8] Furthermore, contrary to earlier medical opinion, it is clear that up to 60% of individuals who suffered ADHD as children also experience symptoms as adults, often with profound effects, including more substance abuse, lower socioeconomic status, and higher divorce rate.[4-7]

ADHD and sleep disorders are also associated with other psychiatric, medical, and neurodevelopmental problems, such as major depression, bipolar disorder, autism spectrum disorders, aggression, poor communication and social skills, and obesity.[9-14] Mitigating or eliminating the symptoms of ADHD and possibly other behavioral disorders by treating an underlying sleep disorder may reduce or eliminate the need for treatment with medications.[15,16] This is of special importance to avoid potentially unnecessary long-term medication use.

This article describes the sleep disorders commonly affecting children and adolescents with ADHD and other disorders, the office assessment of these sleep disorders, and treatment strategies. Figure 1 provides a checklist for the office assessment.

Sleep Disorders

Obstructive Sleep Apnea Syndrome/Sleep-Disordered Breathing

The American Academy of Pediatrics recognizes obstructive sleep apnea syndrome (OSAS) as a common disorder, with a prevalence of 1.2% to 5.7%.[17,18] It is characterized by episodes in which the airway becomes blocked during the deepest, restorative levels of sleep.[19,20] The blockage causes blood oxygen levels to fall, and the carbon dioxide levels rise, triggering the arousal of the individual. These episodes can occur many times per hour, interfering with restorative sleep, and leading, in time, to chronic sleep deprivation.

The airway system is complicated, and it becomes even more so during deep states of sleep.[21] For example, nasal congestion, soft tissue hypertrophy (such as enlarged or swollen tonsils and adenoids), septal deviation, and the placement of the soft palate and uvula, as well as the arch of the hard palate, can significantly diminish airflow into the lungs.

Sleep-Related Movement Disorders (Restless Legs Syndrome)

Not all sleep disruptions are related to breathing problems. Sleep-related movement disorders, such as restless legs syndrome (RLS), can also contribute to ADHD.[22] Children with ADHD are diagnosed with RLS

[1]Stanford University School of Medicine, Stanford, CA, USA
[2]University of Puerto Rico, San Juan, Puerto Rico
[3]San Jose, CA, USA

Corresponding Author:
Damien P. Kuffler, Institute of Neurobiology, University of Puerto Rico, 201 Boulevard del Valle, San Juan, PR 00901, USA.
Email: dkuffler@hotmail.com

more often than controls.[23-25] Those with both conditions have slightly worse ADHD symptoms than ADHD children without RLS.[24,26,27]

Narcolepsy

Narcolepsy, a disorder of hypersomnia, is often diagnosed in adulthood; it is said to be underdiagnosed in children.[28-30] Excessive daytime sleepiness is a common complaint in childhood narcolepsy, and the restlessness that children use to combat the sleepiness can be misdiagnosed as ADHD.[29-31] In fact, many adults diagnosed with narcolepsy report a history of ADHD.[32] The 2 disorders can be confused even in adults.[33]

Diagnosing Sleep Disorders: History

Family History

Often, genetically determined craniofacial structures, such as a small or retrognathic jaw, may significantly impede the airway during restorative sleep.[34-39] One study suggested that up to 40% of the differences in sleep quality could be genetic.[40] As a result, a family history of OSAS can be helpful in the diagnosis. A patient with an immediate family member suffering from OSAS is up to twice as likely to receive that diagnosis; if there are multiple such family members, the odds increase still further.[41-43]

Race

Race, as it identifies common phenotypes, can also inform an OSAS evaluation. For example, compared with Caucasians, African American children are at higher risk of OSAS[44]; Asians appear to have a similar risk to Caucasians, but their symptoms are often more severe[45-47]; and Hispanics might have a higher risk, but it is unclear.[48]

Sleep Positions and Behavior

Children with ADHD often have restless sleep.[49-51] Frequent changes in sleep position could indicate OSAS: Everyone changes sleep position occasionally, but changing so frequently that bedclothes are tangled or on the floor by morning frequently indicates a sleep disorder.[52] A child with OSAS could also have night sweats as a symptom.[47,53]

Sometimes the sleep positions that children choose suggest sleep-disordered breathing. Some children try to minimize obstruction by adopting odd positions, such as prone, curled on hands and knees, with the neck hyperextended.[54,55] Many position themselves so they can breathe through their mouths and therefore awaken thirsty, with dry mouths.[56] A parent might also notice excessive nighttime drooling.

Excessive Daytime Sleepiness

Although many children with OSAS have difficulty awakening, excessive daytime sleepiness is often not a presenting complaint. One study that examined the sleepiness and hyperactivity of children with suspected sleep-disordered breathing found that they were both sleepier and more hyperactive than a control group.[57]

Though children with sleep disorders are more tired, their parents might not be aware because the indications might be obscured by the child's hyperactive behaviors, which are likely to be secondary to exhaustion. Therefore, the apparent absence of daytime sleepiness should not be used to rule out sleep-disordered breathing.

A commonly used questionnaire for evaluating patients with suspected sleep disorders is the Epworth Sleepiness Scale. Unlike adults, however, children's scores on the scale were only weakly correlated with the results from their sleep studies.[57] A recent review of existing sleep questionnaires suggested others that were better indicators for children.[58] The 2 recommended questionnaires were the Sleep Disorders Inventory for Students and the Sleep Disturbance Scale for Children.[59]

Snoring

A 4-year study showed that snoring is a predictor of the worsening of a child's hyperactivity, as are other symptoms of sleep-disordered breathing.[60] Note, however, that although snoring can be a problem in children with OSAS, snoring is not always present. In one study, children with OSAS used home cardiorespiratory monitors to monitor their sleep and 25% to 47% of them did not have "loud snoring at least 1 to 2 times per week."[44,61] Another study checked for OSAS in children who either did not snore or rarely snored: 5% did, in fact, have obstructive sleep apnea.[61,62]

In adults, snoring is a common presenting symptom of OSAS; this is less true for children and this symptom, although helpful, is not critical for diagnosis. About 50% of adults snore, while estimates of the percentage of children who snore range from 3% to 27%.[37,63,64] The disparity in the estimates for children may have many causes, including parental reporting. One study found that although parents reported that their children did not snore or only occasionally snored, 2.3% actually had "pathologic" snoring, and another 6% had significant hypopnea when tested.[61]

Enuresis

Enuresis is more common in children with ADHD.[65] The frequency of enuresis is also positively correlated with snoring and adenotonsillar enlargement.[66,67] The National Kidney & Urologic Diseases Information Clearinghouse reports that, in the general population, the percentage of children with enuresis decreases with age, affecting 10% of 5-year-olds and dropping to 1% by age 18.[68] In contrast to the general population, 41% of children 4 years and older who were referred to a sleep center for suspected sleep-disordered breathing reported enuresis. After all the children in the study had polysomnography, it was found that those with OSAS were 30% more likely to have enuresis than those without.[66]

Based on these observations, it is not only important to ask patients presenting with symptoms of ADHD about enuresis but also to consider sleep disorders in any patient presenting with the complaint of enuresis.[65,69-71] Of great clinical importance is that treating OSAS is likely to decrease or resolve related enuresis.[71-75]

Restless Legs Syndrome

Symptoms of RLS can be difficult for a child to describe, so asking about a family history of the disorder may be very helpful.[76,77] Note that it is not necessarily helpful to ask the parent whether the child has these symptoms: One study showed that fewer than half of the parents of children diagnosed with definite or probable RLS were aware of the child's symptoms.[78]

Symptoms include paresthesias in the lower extremities and an intense need to move the legs, especially when resting or sleeping, since movement temporarily relieves the symptoms. In addition, some children report RLS symptoms when trying to sit quietly during the day, for example at school. The resulting restlessness and difficulty maintaining concentration can mimic the symptoms of ADHD.[78]

Growing pains in a child with ADHD can indicate restless legs syndrome. One small study found that of children with both ADHD and growing pains, 91% had RLS. In another study of more than 10 000 families, significantly more children with RLS had growing pains, compared with controls.[78]

Allergies

Children with ADHD are more likely to have allergies and, more specifically, allergic rhinitis, than controls.[79-82] Similarly, children with allergic rhinitis are more likely to have ADHD than controls.[83-85] The link between the 2 is likely the sleep disruption caused by the nasal congestion of allergic rhinitis.[83-85]

Of particular importance, allergic rhinitis can also result in mouth breathing, which can lead to changes in facial growth that may exacerbate the sleeping problem and therefore the ADHD. The changes can begin to reverse if treating the allergic rhinitis stops the mouth breathing.[86,87]

Diagnosing Sleep Disorders: Physical Examination

Soft Tissue and Craniofacial Problems

A number of soft tissue and craniofacial problems can predispose a child toward OSAS. Adenotonsillar hypertrophy is the most common.[34,36,88] Other soft tissue problems include enlarged turbinates and nasal congestion, possibly due to allergies, chronic rhinosinusitis, or a deviated septum.[88-90] Children with these issues often breathe through their mouths when awake.

Mouth breathing can cause a child to develop a narrow maxilla and mandibular retrognathia (also called mandibular hypoplasia), which are craniofacial problems also associated with OSAS.[91] Treating sleep-disordered breathing may lead to whole or partial reversal of craniofacial problems, according to 2 studies.[86,87] In one study, the mean age at the start of treatment was approximately 5 and a half years.[87]

A narrow skeletal maxilla and mandibular retrognathia are not the only craniofacial problems associated with OSAS. Midface hypoplasia can also indicate OSAS.[92,93] A child with midface hypoplasia can seem to have large eyes, forehead, and lower jaw; there is often an underbite. This problem appears, for example, in patients with Down's syndrome, as well as those with achondroplasia.[94,95]

Another soft tissue problem indicating possible OSAS is more opaque paranasal sinuses on MRI or CT scans.[89] Opacification can be caused by thick mucus or inflammation, especially from chronic sinus infections.

Obesity

Obesity and ADHD demonstrate significant comorbidity.[96-100] Obesity and OSAS do, too.[36,39,101-103] ADHD children with sleep-disordered breathing are more likely to be obese than ADHD children without sleep-disordered breathing.[38] ADHD is also common among morbidly obese adults, and a study that checked for other comorbid conditions found that these patients also had a very high rate of sleep apnea.[104,105]

Atopic Dermatitis/Atopic Eczema

A child with both ADHD and atopic dermatitis (also called atopic eczema) should be evaluated for OSAS. The three conditions are strongly correlated, demonstrating that a child with ADHD and atopic dermatitis very often has a sleep disorder.[43] Similar results were obtained by Camfferman et al.[84]

Following up on Sleep Disorder Symptoms

If, after medical evaluation, OSAS or other sleep disorders are suspected, it should be confirmed by polysomnography and appropriate blood tests (eg, serum iron, ferritin, and total iron-binding capacity). The blood tests may assist with the diagnosis and treatment of RLS, especially in teenagers.[106]

If there are indications that allergic rhinitis is present, the problem should be confirmed through testing by an allergist so that it can be aggressively treated. Resolving congestion that causes mouth breathing can prevent craniofacial changes that cause continuing risk of OSAS, or possibly begin to reverse them if they are already present.[86,87,91]

Treatment Options

Surgical and nonsurgical options are available depending on the etiology and severity of the sleep disorder.[91]

Nonsurgical Options

Sleep Hygiene Training. Sleep hygiene training, sometimes combined with CBT, is an important part of improving sleep regularity and duration. Sleep hygiene includes having a calm, predictable bedtime routine in a dark and quiet room that is comfortable and without distractions. There should be no lights on clock faces. Similarly, turn off computers, cell phones, televisions, and so on since it is important to minimize exposure to bright lights.

Minimizing exposure to bright lights for 1 to 1.5 hours before bedtime is important because the light subdues or delays the adequate release of the melatonin necessary for sleep.[107] A 6-month follow-up showed that the improvements gained through sleep hygiene therapy were maintained.[108,109]

Continuous Pressure. CPAP is very effective in the treatment of OSAS, although there are issues that may interfere with its use in children. For example, as children grow, the masks require frequent refitting.[110,111]

Medication and Immunotherapy. Medication, immunotherapy, or both, are available to treat allergic rhinitis. Medications include oral and intranasal antihistamines, intranasal corticosteroids, and decongestants.[91,112-115] Immunotherapy, subcutaneously or orally delivered, has been shown effective for children in reducing sensitivities that lead to allergic rhinitis.[91,113,115-119] Immunotherapy is a longer term treatment: It produces lasting results, but they are not immediate.

Melatonin. Melatonin, in dosages of 3 to 6 mg, has been shown to be an effective treatment of insomnia in 6- to 14-year-old children with ADHD.[120] Studies suggest, however, that the decreased sleep latency did not affect the ADHD symptoms.[111,122] It could be that although the children using melatonin sleep more, they are still not sleeping enough. In the studies cited, even with the increased sleep, the children were getting less than the recommended amount for their age groups.

Orthodontia. Rapid maxillary expansion may be used to help correct an overly high arched palate. In one study, patients retained the improvements in their sleep apnea when rechecked 24 months following the completion of this treatment.[123]

Rapid maxillary expansion is not the only orthodontic treatment available to help resolve OSAS. A number of appliances are available, many of which reposition the jaw during sleep.[124] A jaw repositioning appliance has been shown effective for children as young as 3 years.[125,126]

Iron Supplements. Iron supplements for patients with RLS, especially if their serum ferritin and/or iron levels are low, have been shown in one study to help adolescents; however, more information is needed.[106,127,128]

Medication. Medications for patients with RLS, such as anticonvulsants, dopaminergic agents, opiates, and benzodiazepines have been reported as useful in adults.[129,130] As of 2011, none of these medications was approved for children by the Food and Drug Administration.[131]

Music Therapy. Learning to play a double-reed instrument (oboe or bassoon) or the didgeridoo (an Australian Aboriginal instrument) was found to be helpful in relieving mild to moderate OSAS in adults.[132,133]

Surgical Options

Adenotonsillectomy. Adenotonsillectomy appears to be the most common and effective surgical treatment of OSAS in children when soft tissues are involved. In a child with adenotonsillar hypertrophy or an enlarged uvula, this procedure is expected to treat not only the soft-tissue problem but also any accompanying OSAS.[134]

Adenotonsillectomy often also improves the hyperactivity that accompanies the OSAS. One study tested children with the problem who, pre-surgery, were significantly more hyperactive than a control group. At one year following their adenotonsillectomies, the hyperactive children had improved enough that the 2 groups were indistinguishable.[135]

Adenotonsillectomy is not necessarily a cure-all for OSAS and the associated ADHD if the child also has other OSAS risk factors, however. An observation that is highly correlated to the outcome of adenotonsillectomy in treating OSAS is to look at the child's throat when the child is sitting, neck extended, with tongue out. If you can see just the soft palate and base of the uvula at the soft palate, or even less, additional treatment after the adenotonsillectomy may be needed to cure the OSAS.[136]

Other Corrective Surgeries. Other corrective surgeries include septoplasty for a deviated septum, turbinectomy for enlarged and obstructing turbinates, corrective jaw surgery for mandibular hypoplasia, and the more extensive maxillomandibular advancement or maxillomandibular expansion surgery when required to open the airway.[91,113,137-143] Note that some surgeries, such as septoplasty, are not necessarily appropriate in young children.[91]

Conclusion

When assessing ADHD and other disorders such as depression, autism spectrum disorders, and obesity, physicians should consider sleep disorders as an underlying cause. This article has surveyed the literature, and described steps for determining whether a sleep disorder is likely: the family history; other clinical information, such as whether the patient has enuresis, snoring, or eczema; and a standard examination of the nose, throat, and other presenting physical features of the patient (see Figure 1). If the physician suspects a sleep disorder, the patient can be referred to a sleep specialist for confirmation. This review has also outlined possible treatments for sleep disorders.

IS THERE AN UNDERLYING SLEEP DISORDER?

HISTORY

Is there a family history of sleep disorders (e.g., OSAS, RLS)?

When the child sleeps, does the child experience:

- Enuresis
- Agitated sleep; bed clothes in marked disarray or on the floor
- Odd sleeping positions
- Gasping/stopping breathing during sleep
- Snoring
- Drooling

Does the child have:

- Allergies, especially allergic rhinitis
- Insomnia
- RLS symptoms
- Daytime sleepiness

Is the child hard to awaken in the morning?

Does the child awaken refreshed?

PHYSICAL

Looking at the child's face, do you see:

- Small jaw
- Under-bite
- Significantly high arched palate

Looking at the child's airways, is there:

- Adenotonsillar hypertrophy
- Difficulty visualizing the back of the throat
- Deviated septum or enlarged turbinates

Does the child have:

- Mouth breathing
- Atopic dermatitis or ectopic eczema
- Obesity

Figure 1. Summary of Symptom Assessment.

Acknowledgments

We wish to thank Dr Rafael Pelayo, MD, Clinical Professor, Sleep Medicine Center, Stanford University School of Medicine, for providing suggestions about the article.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Bonuck K, Freeman K, Chervin RD, Xu L. Sleep-disordered breathing in a population-based cohort: behavioral outcomes at 4 and 7 years. *Pediatrics*. 2012;129:e857-e865.
2. Meltzer LJ, Johnson C, Crosette J, Ramos M, Mindell JA. Prevalence of diagnosed sleep disorders in pediatric primary care practices. *Pediatrics*. 2010;125:e1410-e1418.
3. Chervin RD, Dillon JE, Bassetti C, Ganoczy DA, Pituch KJ. Symptoms of sleep disorders, inattention, and hyperactivity in children. *Sleep*. 1997;20:1185-1192.
4. Amiri S, Fakhari A, Maheri M. Attention deficit/hyperactivity disorder in primary school children of Tabriz, North-West Iran. *Paediatr Perinat Epidemiol*. 2010;24:597-601.
5. Naseem S, Chaudhary B, Collop N. Attention deficit hyperactivity disorder in adults and obstructive sleep apnea. *Chest*. 2001;119:294-296.
6. Sánchez EY, Velarde S, Britton GB. Estimated prevalence of attention-deficit/hyperactivity disorder in a sample of Panamanian school-aged children. *Child Psychiatry Hum Dev*. 2011;42:243-255.
7. Schubert I, Köster I, Lehmkuhl G. The changing prevalence of attention-deficit/hyperactivity disorder and methylphenidate prescriptions: a study of data from a random sample of insurees of the AOK Health Insurance Company in the German State of Hesse, 2000-2007. *Dtsch Arztebl Int*. 2010;107:615-621.
8. Centers for Disease Control and Prevention. Increasing prevalence of parent-reported attention-deficit/hyperactivity disorder among children—United States, 2003 and 2007. *MMWR Morb Mortal Wkly Rep*. 2010;59:1439-1443.
9. Carotenuto M, Esposito M, Parisi L, et al. Depressive symptoms and childhood sleep apnea syndrome. *Neuropsychiatr Dis Treat*. 2012;8:369-373.
10. Davis C. Attention-deficit/hyperactivity disorder: associations with overeating and obesity. *Curr Psychiatry Rep*. 2010;12:389-395.
11. Faraone SV, Biederman J, Wozniak J. Examining the comorbidity between attention deficit hyperactivity disorder and bipolar I disorder: a meta-analysis of family genetic studies. *Am J Psychiatry*. 2012;169:1256-1266.
12. Mullin BC, Harvey AG, Hinshaw SP. A preliminary study of sleep in adolescents with bipolar disorder, ADHD, and non-patient controls. *Bipolar Disord*. 2011;13:425-432.
13. Perfect MM, Archbold K, Goodwin JL, Levine-Donnerstein D, Quan SF. Risk of behavioral and adaptive functioning difficulties in youth with previous and current sleep disordered breathing. *Sleep*. 2013;36:517-525.
14. Sivertsen B, Posserud MB, Gillberg C, Lundervold AJ, Hysing M. Sleep problems in children with autism spectrum problems: a longitudinal population-based study. *Autism*. 2012;16:139-150.
15. Huang Y-S, Guilleminault C, Lib H-Y, Yang C-M, Wua Y-Y, Chen N-H. Attention-deficit/hyperactivity disorder with obstructive sleep apnea: a treatment outcome study. *Sleep Med*. 2007;8:18-30.
16. Wei JL, Bond J, Mayo MS, Smith HJ, Reese M, Weatherly RA. Improved behavior and sleep after adenotonsillectomy in children with sleep-disordered breathing. *Arch Otolaryngol Head Neck Surg*. 2009;135:642-646.
17. Section on Pediatric Pulmonology, Subcommittee on Obstructive Sleep Apnea Syndrome. American Academy of Pediatrics. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics*. 2002;109:704-712.
18. Farber JM. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics*. 2002;110:1255-1257.
19. Marcus CL, Brooks LJ, Draper KA, et al; American Academy of Pediatrics. Diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics*. 2012;130:576-584.
20. Sinha D, Guilleminault C. Sleep disordered breathing in children. *Indian J Med Res*. 2010;131:311-320.
21. Migliori C, Gallina MR, Bona G. Practical applications of monitoring respiratory mechanics in newborn. *Minerva Pediatr*. 1999;51:57-64.
22. Picchietti DL, England SJ, Walters AS, Willis K. Periodic limb movement disorder and restless legs syndrome in children with attention-deficit hyperactivity disorder. *J Child Neurol*. 1998;13:588-594.
23. Silvestri R, Gagliano A, Aricò I, et al. Sleep disorders in children with attention-deficit/hyperactivity disorder (ADHD) recorded overnight by video-polysomnography. *Sleep Med*. 2009;10:1132-1138.
24. Wagner ML, Walters AS, Fisher BC. Symptoms of attention-deficit/hyperactivity disorder in adults with restless legs syndrome. *Sleep*. 2004;27:1499-1504.
25. Walters AS, Silvestri R, Zucconi M, Chandrashekariah R, Konofal E. Review of the possible relationship and hypothetical links between attention deficit hyperactivity disorder (ADHD) and the simple sleep related movement disorders, parasomnias, hypersomnias, and circadian rhythm disorders. *J Clin Sleep Med*. 2008;4:591-600.
26. Konofal E, Cortese S, Marchand M, Mouren MC, Arnulf I, Lecendreux M. Impact of restless legs syndrome and iron deficiency on attention-deficit/hyperactivity disorder in children. *Sleep Med*. 2007;8:711-715.
27. Zak R, Fisher B, Couvadelli BV, Moss NM, Walters AS. Preliminary study of the prevalence of restless legs syndrome in adults with attention deficit hyperactivity disorder. *Percept Mot Skills*. 2009;108:759-763.
28. McKenna L, McNicholas F. Childhood onset narcolepsy—a case report. *Eur Child Adolesc Psychiatry*. 2003;12:43-47.
29. Nevsimalova S. Narcolepsy in childhood. *Sleep Med Rev*. 2009;13:169-180.
30. Wise MS. Childhood narcolepsy. *Neurology*. 1998;50(2 suppl 1):S37-S42.

31. Akintomide GS, Rickards H. Narcolepsy: a review. *J Neuropsychiatr Dis Treat*. 2011;7:507-518.
32. Kotagal S. Narcolepsy in childhood. In: Sheldon SH, ed. *Principles and Practice of Pediatric Sleep Medicine*. Philadelphia, PA: Elsevier Saunders; 2005:171-182.
33. Oosterloo M, Lammers GJ, Overeem S, de Noord I, Kooij JJ. Possible confusion between primary hypersomnia and adult attention-deficit/hyperactivity disorder. *Psychiatry Res*. 2006;143:293-297.
34. Benninger M, Walner D. Obstructive sleep-disordered breathing in children. *Clin Cornerstone*. 2007;9(suppl 1):S6-S12.
35. Breslin JH, Edgin JO, Bootzin RR, Goodwin JL, Nadel L. Parental report of sleep problems in Down syndrome. *J Intellect Disabil Res*. 2011;55:1086-1091.
36. Chang SJ, Chae KY. Obstructive sleep apnea syndrome in children: epidemiology, pathophysiology, diagnosis and sequelae. *Korean J Pediatr*. 2010;53:863-871.
37. de Carlos F, Cobo J, Díaz Esnal B, Fernández Mondragón MP, Macías Escalada E, Puente Rodríguez M. Chronic snoring and obstructive sleep apnea-hypopnea syndrome in children [in French]. *Orthod Fr*. 2003;74:431-457.
38. Goraya JS, Cruz M, Valencia I, et al. Sleep study abnormalities in children with attention deficit hyperactivity disorder. *Pediatr Neurol*. 2009;40:42-46.
39. Wasilewska J, Kaczmarski M. Obstructive sleep apnea-hypopnea syndrome in children [in Polish]. *Wiad Lek*. 2010;63:201-212.
40. Casale M, Pappacena M, Rinaldi V, Bressi F, Baptista P, Salvinelli F. Obstructive sleep apnea syndrome: from phenotype to genetic basis. *Curr Genomics*. 2009;10:119-126.
41. Lam JC, Sharma SK, Lam B. Obstructive sleep apnoea: definitions, epidemiology & natural history. *Indian J Med Res*. 2010;131:165-170.
42. Redline S, Tishler PV. The genetics of sleep apnea. *Sleep Med Rev*. 2000;4:583-602.
43. Romanos M, Gerlach M, Warnke A, Schmitt J. Association of attention-deficit/hyperactivity disorder and atopic eczema modified by sleep disturbance in a large population-based sample. *J Epidemiol Community Health*. 2010;64:269-273.
44. Rosen CL, Larkin EK, Kirchner HL, et al. Prevalence and risk factors for sleep-disordered breathing in 8- to 11-year-old children: association with race and prematurity. *J Pediatr*. 2003;142:383-389.
45. Anuntaseree W, Rookkapan K, Kuasirikul S, Thongsuksai P. Snoring and obstructive sleep apnea in Thai school-age children: prevalence and predisposing factors. *Pediatr Pulmonol*. 2001;32:222-227.
46. Brooks LJ. Diagnosis and evaluation of obstructive sleep apnoea in children. *Ann Acad Med Singapore*. 2008;37:701-705.
47. Chau KW, Ng KK, Kwok KL, Cheung MY. Survey of children with obstructive sleep apnea syndrome in Hong Kong of China. *Chin Med J (Engl)*. 2004;117:657-660.
48. Loredo JS, Soler X, Bardwell W, Ancoli-Israel S, Dimsdale JE, Palinkas LA. Sleep health in U.S. Hispanic population. *Sleep*. 2010;33:962-967.
49. Corkum P, Davidson F, Macpherson M. A framework for the assessment and treatment of sleep problems in children with attention-deficit/hyperactivity disorder. *Pediatr Clin North Am*. 2011;58:667-683.
50. Gruber R, Sadeh A, Ravia A. Instability of sleep patterns in children with attention-deficit/hyperactivity disorder. *J Am Acad Child Adolesc Psychiatry*. 2000;39:495-501.
51. Hvolby A, Jørgensen J, Bilenberg N. Actigraphic and parental reports of sleep difficulties in children with attention-deficit/hyperactivity disorder. *Arch Pediatr Adolesc Med*. 2008;162:323-329.
52. Silva VC, Leite AJ. Quality of life in children with sleep-disordered breathing: evaluation by OSA-18. *Braz J Otorhinolaryngol*. 2006;72:747-756.
53. Kahn A, Groswasser J, Sottiaux M, et al. Clinical symptoms associated with brief obstructive sleep apnea in normal infants. *Sleep*. 1993;16:409-413.
54. Jaffa T, Scott S, Hendriks JH, Shapiro CM. ABC of sleep disorders. Sleep disorders in children. *BMJ*. 1993;306:640-643.
55. Cuhadaroglu C, Keles N, Erdamar B, et al. Body position and obstructive sleep apnea syndrome. *Pediatr Pulmonol*. 2003;36:335-338.
56. Moturi S, Avis K. Assessment and treatment of common pediatric sleep disorders. *Psychiatry (Edgmont)*. 2010;7:24-37.
57. Melendres CS, Lutz JM, Rubin ED, Marcus CL. Daytime sleepiness and hyperactivity in children with suspected sleep-disordered breathing. *Pediatrics*. 2004;114:768-775.
58. Spruyt K, Gozal D. Pediatric sleep questionnaires as diagnostic or epidemiological tools: a review of currently available instruments. *Sleep Med Rev*. 2011;15:19-32.
59. Bruni O, Ottaviano S, Guidetti V, et al. The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. *J Sleep Res*. 1996;5:251-261.
60. Chervin RD, Ruzicka DL, Archbold KH, Dillon JE. Snoring predicts hyperactivity four years later. *Sleep*. 2005;28:885-890.
61. Lumeng JC, Chervin RD. Epidemiology of pediatric obstructive sleep apnea. *Proc Am Thorac Soc*. 2008;5:242-252.
62. O'Brien LM, Holbrook CR, Mervis CB, et al. Sleep and neurobehavioral characteristics of 5- to 7-year-old children with parentally reported symptoms of attention-deficit/hyperactivity disorder. *Pediatrics*. 2003;111:554-563.
63. Wang RC, Elkins TP, Keech D, Wauquier A, Hubbard D. Accuracy of clinical evaluation in pediatric obstructive sleep apnea. *Otolaryngol Head Neck Surg*. 1998;118:69-73.
64. Erler T, Paditz E. Obstructive sleep apnea syndrome in children: a state-of-the-art review. *Treat Respir Med*. 2004;3:107-122.
65. Shreeram S, He JP, Kalaydjian A, Brothers S, Merikangas KR. Prevalence of enuresis and its association with attention-deficit/hyperactivity disorder among U.S. children:

results from a nationally representative study. *J Am Acad Child Adolesc Psychiatry*. 2009;48:35-41.
66. Brooks LJ, Topol HI. Enuresis in children with sleep apnea. *J Pediatr*. 2003;142:515-518.
67. Sakellaropoulou AV, Hatzistilianou MN, Emporiadou MN, et al. Association between primary nocturnal enuresis and habitual snoring in children with obstructive sleep apnoea-hypopnoea syndrome. *Arch Med Sci*. 2012;8: 521-527.
68. Petrican P, Sawan MA. Design of a miniaturized ultrasonic bladder volume monitor and subsequent preliminary evaluation on 41 enuretic patients. *IEEE Trans Rehabil Eng*. 1998;6:66-74.
69. Bascom A, Penney T, Metcalfe M, et al. High risk of sleep disordered breathing in the enuresis population. *J Eurol*. 2011;186:1710-1713.
70. Brooks LJ. Enuresis and sleep apnea. *Pediatrics*. 2005;116:799-800.
71. Waleed FE, Samia AF, Samar MF. Impact of sleep-disordered breathing and its treatment on children with primary nocturnal enuresis. *Swiss Med Wkly*. 2011;141:w13216.
72. Basha S, Bialowas C, Ende K, Szeremeta W. Effectiveness of adenotonsillectomy in the resolution of nocturnal enuresis secondary to obstructive sleep apnea. *Laryngoscope*. 2005;115:1101-1103.
73. Firoozi F, Batniji R, Aslan AR, Longhurst PA, Kogan BA. Resolution of diurnal incontinence and nocturnal enuresis after adenotonsillectomy in children. *J Urol*. 2006;175:1885-1888.
74. Weider DJ, Sateia MJ, West RP. Nocturnal enuresis in children with upper airway obstruction. *Otolaryngol Head Neck Surg*. 1991;105:427-432.
75. Weissbach A, Leiberman A, Tarasiuk A, Goldbart A, Tal A. Adenotonsilectomy improves enuresis in children with obstructive sleep apnea syndrome. *Int J Pediatr Otorhinolaryngol*. 2006;70:1351-1356.
76. Maheswaran M, Kushida CA. Restless legs syndrome in children. *Medscape Gen Med*. 2006;8:79.
77. Simakajornboon N, Kheirandish-Gozal L, Gozal D. Diagnosis and management of restless legs syndrome in children. *Sleep Med Rev*. 2009;13:149-156.
78. Turkdogan D, Bekiroglu N, Zaimoglu S. A prevalence study of restless legs syndrome in Turkish children and adolescents. *Sleep Med*. 2011;12:315-321.
79. Brawley A, Silverman B, Kearney S, et al. Allergic rhinitis in children with attention-deficit/hyperactivity disorder. *Ann Allergy Asthma Immunol*. 2004;92:663-667.
80. Chen MH, Su TP, Chen YS, et al. Attention deficit hyperactivity disorder, tic disorder, and allergy: Is there a link? A nationwide population-based study. *J Child Psychol Psychiatry*. 2013;54:545-551.
81. Chen MH, Su TP, Chen YS, et al. Comorbidity of allergic and autoimmune diseases among patients with ADHD: a nationwide population-based study [published online February 11, 2013]. *J Atten Disord*. doi:10.1177/1087054712474686.
82. Suwan P, Akaramethathip D, Noipayak P. Association between allergic sensitization and attention deficit hyperactivity disorder (ADHD). *Asian Pac J Allergy Immunol*. 2011;29:57-65.
83. Shyu CS, Lin HK, Lin CH, Fu LS. Prevalence of attention-deficit/hyperactivity disorder in patients with pediatric allergic disorders: a nationwide, population-based study. *J Microbiol Immunol Infect*. 2012;45:237-242.
84. Camfferman D, Kennedy JD, Gold M, Martin AJ, Winwood P, Lushington K. Eczema, sleep, and behavior in children. *J Clin Sleep Med*. 2010;6:581-588.
85. Tsai MC, Lin HK, Lin CH, Fu LS. Prevalence of attention deficit/hyperactivity disorder in pediatric allergic rhinitis: a nationwide population-based study. *Allergy Asthma Proc*. 2011;32:41-46.
86. Vargervik K, Miller AJ, Chierici G, Harvold E, Tomer BS. Morphologic response to changes in neuromuscular patterns experimentally induced by altered modes of respiration. *Am J Orthod*. 1984;85:115-124.
87. Zettergren-Wijk L, Forsberg CM, Linder-Aronson S. Changes in dentofacial morphology after adeno-/tonsillectomy in young children with obstructive sleep apnoea—a 5-year follow-up study. *Eur J Orthod*. 2006;28:319-326.
88. Contencin P, Guilleminault C, Manach Y. Long-term follow-up and mechanisms of obstructive sleep apnea (OSA) and related syndromes through infancy and childhood. *Int J Pediatr Otorhinolaryngol*. 2003;67(suppl 1):S119-S123.
89. Arens R, Sin S, Willen S, et al. Rhino-sinus involvement in children with obstructive sleep apnea syndrome. *Pediatr Pulmonol*. 2010;45:993-998.
90. Ramos RT, Salles C, Gregório PB, Barros AT. Evaluation of the upper airway in children and adolescents with cystic fibrosis and obstructive sleep apnea syndrome. *Int J Pediatr Otorhinolaryngol*. 2009;73:1780-1785.
91. Ahn YM. Treatment of obstructive sleep apnea in children. *Korean J Pediatr*. 2010;53:872-879.
92. Katz ES, D'Ambrosio CM. Pathophysiology of pediatric obstructive sleep apnea. *Proc Am Thorac Soc*. 2008;5: 253-262.
93. Paditz E. Sleep disorders in infancy—aspects of diagnosis and somatic background [in German]. *Prax Kinderpsychol Kinderpsychiatr*. 2006;55:103-117.
94. Ng DK, Hui HN, Chan CH, et al. Obstructive sleep apnoea in children with Down syndrome. *Singapore Med J*. 2006;47:774-779.
95. Zucconi M, Weber G, Castronovo V, et al. Sleep and upper airway obstruction in children with achondroplasia. *J Pediatr*. 1996;129:743-749.
96. Agranat-Meged AN, Deitcher C, Goldzweig G, Leibenson L, Stein M, Galili-Weisstub E. Childhood obesity and attention deficit/hyperactivity disorder: a newly described comorbidity in obese hospitalized children. *Int J Eat Disord*. 2005;37:357-359.
97. Albayrak Ö, Pütter C, Volckmar AL, et al; Psychiatric GWAS Consortium: ADHD Subgroup. Common obesity risk alleles in childhood attention-deficit/hyperactivity disorder. *Am J Med Genet B Neuropsychiatr Genet*. 2013;162B:295-305.
98. Erhart M, Herpertz-Dahlmann B, Wille N, Sawitzky-Rose B, Hölling H, Ravens-Sieberer U. Examining the

relationship between attention-deficit/hyperactivity disorder and overweight in children and adolescents. *Eur Child Adolesc Psychiatry*. 2012;21:39-49.
99. Holtkamp K, Konrad K, Müller B, et al. Overweight and obesity in children with attention-deficit/hyperactivity disorder. *Int J Obes Relat Metab Disord*. 2004;28:685-689.
100. Kim J, Mutyala B, Agiovlasitis S, Fernhall B. Health behaviors and obesity among US children with attention deficit hyperactivity disorder by gender and medication use. *Prev Med*. 2011;52:218-222.
101. Arens R, Muzumdar H. Childhood obesity and obstructive sleep apnea syndrome. *J Appl Physiol*. 2010;108: 436-444.
102. Narang I, Mathew JL. Childhood obesity and obstructive sleep apnea. *J Nutr Metab*. 2012;2012:134202.
103. Tripuraneni M, Paruthi S, Armbrecht ES, Mitchell RB. Obstructive sleep apnea in children. *Laryngoscope*. 2013;123:1289-1293.
104. de Zwaan M, Gruss B, Müller A, et al. Association between obesity and adult attention-deficit/hyperactivity disorder in a German community-based sample. *Obes Facts*. 2011;4:204-211.
105. Levy LD, Fleming JP, Klar D. Treatment of refractory obesity in severely obese adults following management of newly diagnosed attention deficit hyperactivity disorder. *Int J Obes*. 2009;33:326-334.
106. Kryger MH, Otake K, Foerster J. Low body stores of iron and restless legs syndrome: a correctable cause of insomnia in adolescents and teenagers. *Sleep Med*. 2002;3:127-132.
107. Boyce PR. *Human Factors in Lighting*. 2nd ed. London, England: Taylor & Francis; 2003.
108. Paine S, Gradisar M. A randomised controlled trial of cognitive-behaviour therapy for behavioural insomnia of childhood in school-aged children. *Behav Res Ther*. 2011;49:379-388.
109. Tikotzky L, Sadeh A. The role of cognitive-behavioral therapy in behavioral childhood insomnia. *Sleep Med*. 2010;11:686-691.
110. Estivill SE, Miró NR. Continuous positive airway pressure treatment in sleep-related respiratory disorders in children [in Spanish]. *Acta Otorrinolaringol Esp*. 2010;61:74-79.
111. Sawyer AM, Gooneratne N, Marcus CL, Ofer D, Richards KC, Weaver TE. A systematic review of CPAP adherence across age groups: clinical and empiric insights for developing CPAP adherence interventions. *Sleep Med Rev*. 2011;15:343-356.
112. Bachert C. A review of the efficacy of desloratadine, fexofenadine, and levocetirizine in the treatment of nasal congestion in patients with allergic rhinitis. *Clin Ther*. 2009;31:921-944.
113. Meltzer EO, Caballero F, Fromer LM, Krouse JH, Scadding G. Treatment of congestion in upper respiratory diseases. *Int J Gen Med*. 2010;3:69-91.
114. Nayak AS. Mometasone furoate monohydrate nasal spray for the treatment of nasal congestion in allergic rhinitis. *Expert Rev Clin Immunol*. 2008;4:143-155.
115. Scadding G. Optimal management of nasal congestion caused by allergic rhinitis in children: safety and efficacy of medical treatments. *Pediatr Drugs*. 2008;10:151-162.
116. Ciprandi G, Cadario G, Di Gioacchino GM, et al. Sublingual immunotherapy in children with allergic polysensitization. *Allergy Asthma Proc*. 2010;31:227-231.
117. Hankin CS, Cox L, Bronstone A, Wang Z. Allergy immunotherapy: reduced health care costs in adults and children with allergic rhinitis. *J Allergy Clin Immunol*. 2013;131:1084-1091.
118. Larenas-Linnemann DE, Pietropaolo-Cienfuegos DR, Calderón MA. Evidence of effect of subcutaneous immunotherapy in children: complete and updated review from 2006 onward. *Ann Allergy Asthma Immunol*. 2011;107:407-416.
119. Nelson HS. Efficacy and safety of allergen immunotherapy in children. *Ann Allergy Asthma Immunol*. 2006;96(2 suppl 1):S2-S5.
120. Bendz LM, Scates AC. Melatonin treatment for insomnia in pediatric patients with attention-deficit/hyperactivity disorder. *Ann Pharmacother*. 2010;44:185-191.
121. Mohammadi MR, Mostafavi SA, Keshavarz SA, et al. Melatonin effects in methylphenidate treated children with attention deficit hyperactivity disorder: a randomized double blind clinical trial. *Iran J Psychiatry*. 2012;7:87-92.
122. Van der Heijden KB, Smits MG, Van Someren EJW, Ridderinkhof KR, Gunning WB. Effect of melatonin on sleep, behavior, and cognition in ADHD and chronic sleep-onset insomnia. *J Am Acad Child Adolesc Psychiatry*. 2007;46:233-241.
123. Villa MP, Rizzoli A, Miano S, Malagola C. Efficacy of rapid maxillary expansion in children with obstructive sleep apnea syndrome: 36 months of follow-up. *Sleep Breath*. 2011;15:179-184.
124. Hoffstein V. Review of oral appliances for treatment of sleep-disordered breathing. *Sleep Breath*. 2007;11:1-22.
125. Schessl J, Rose E, Korinthenberg R, Henschen M. Severe obstructive sleep apnea alleviated by oral appliance in a three-year-old boy. *Respiration*. 2008;76:112-116.
126. Villa MP, Bernkopf E, Pagani J, Broia V, Montesano M, Ronchetti R. Randomized controlled study of an oral jaw-positioning appliance for the treatment of obstructive sleep apnea in children with malocclusion. *Am J Respir Crit Care Med*. 2002;165:123-127.
127. Picchietti MA, Picchietti DL. Advances in pediatric restless legs syndrome: iron, genetics, diagnosis and treatment. *Sleep Med*. 2010;11:643-651.
128. Trotti LM, Bhadriraju S, Becker LA. Iron for restless legs syndrome. *Cochrane Database Syst Rev*. 2012;5:CD007834.
129. National Institute of Neurological Disorders and Stroke. Restless legs syndrome fact sheet. 2011. Updated July 25, 2014. http://www.ninds.nih.gov/disorders/restless_legs/detail_restless_legs.htm. Accessed August 11, 2014.
130. Proctor A, Bianchi MT. Clinical pharmacology in sleep medicine. *ISRN Pharmacol*. 2012;2012:914168.
131. Frenette E. Restless legs syndrome in children: a review and update on pharmacological options. *Curr Pharm Des*. 2011;17:1436-1442.

132. Puhan MA, Suarez A, Cascio CL, Zahn A, Heitz M, Braendli O. Didgeridoo playing as alternative treatment for obstructive sleep apnoea syndrome: randomised controlled trial. *BMJ*. 2006;332:266-270.
133. Ward CP, York KM, McCoy JG. Risk of obstructive sleep apnea lower in double reed wind musicians. *J Clin Sleep Med*. 2012;8:251-255.
134. Baugh RF, Archer SM, Mitchell RB, et al; American Academy of Otolaryngology–Head and Neck Surgery Foundation. Clinical practice guideline: tonsillectomy in children. *Otolaryngol Head Neck Surg*. 2011;144(1 suppl):S1-S30.
135. Chervin RD, Ruzicka DL, Giordani BJ, et al. Sleep-disordered breathing, behavior, and cognition in children before and after adenotonsillectomy. *Pediatrics*. 2006;117:e769-e778.
136. Guilleminault C, Huang Y-S, Glamann C, Li K, Chan A. Adenotonsillectomy and obstructive sleep apnea in children: a prospective survey. *Otolaryngol Head Neck Surg*. 2007;136:169-175.
137. Caples SM, Rowley JA, Prinsell JR, et al. Surgical modifications of the upper airway for obstructive sleep apnea in adults: a systematic review and meta-analysis. *Sleep*. 2010;33:1396-1407.
138. Giarda M, Brucoli M, Arcuri F, Benech R, Braghiroli A, Benech A. Efficacy and safety of maxillomandibular advancement in treatment of obstructive sleep apnoea syndrome. *Acta Otorhinolaryngol Ital*. 2013;33:43-46.
139. Guilleminault C, Li KK. Maxillomandibular expansion for the treatment of sleep-disordered breathing: preliminary result. *Laryngoscope*. 2004;114:893-896.
140. Holty JE, Guilleminault C. Maxillomandibular advancement for the treatment of obstructive sleep apnea: a systematic review and meta-analysis. *Sleep Med Rev*. 2010;14:287-297.
141. Segal S, Eviatar E, Berenholz L, Kessler A, Shlamkovitch N. Inferior turbinectomy in children. *Am J Rhinol Allergy*. 2003;17:69-73.
142. Sullivan S, Li K, Guilleminault C. Nasal obstruction in children with sleep-disordered breathing. *Ann Acad Med Singapore*. 2008;37:645-648.
143. Varghese R, Adams NG, Slocumb NL, Viozzi CF, Ramar K, Olson EJ. Maxillomandibular advancement in the management of obstructive sleep apnea. *Int J Otolaryngol*. 2012;2012:373025.