A Framework for the Assessment and Treatment of Sleep Problems in Children with Attention-Deficit/Hyperactivity Disorder

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There are several published guidelines describing the assessment and treatment of attention-deficit/hyperactivity disorder (ADHD), including practice parameters developed by the American Academy of Pediatrics (AAP)\textsuperscript{1,2}, the American Academy of Child and Adolescent Psychiatry (AACAP)\textsuperscript{3}, the Canadian Attention Deficit Hyperactivity Disorder Resource Alliance (CADDRA)\textsuperscript{4}, and the National Institute for Health and Clinical Excellence (NICE)\textsuperscript{5}. Recent research has indicated that primary care clinicians are aware of these guidelines and generally follow the clinical practice recommendations provided\textsuperscript{6}. However, while available ADHD practice parameters are fairly comprehensive, it is notable that the important role of sleep in the assessment and treatment of ADHD is either not mentioned at all (eg, AAP) or receives little focus. Therefore, the goal of this review is to provide pediatricians involved in the assessment and treatment of ADHD in school-aged children with a framework for evaluating and managing sleep-related concerns in the clinical setting.

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ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

ADHD is the most common childhood mental health disorder, affecting approximately 5% of school-aged children worldwide. Children are typically diagnosed with ADHD during the elementary school years, with boys being diagnosed more often than girls (sex ratio ranges from 3:1 to 8:1). ADHD is often chronic in nature with symptoms persisting into adolescence and adulthood in approximately two-thirds of children. Children with ADHD typically display a heterogeneous combination of disruptive behavior, academic underachievement, and difficulty with social and familial relations, as well as high rates of comorbidity with other clinical disorders. In fact, research has found that the vast majority (up to 87%) of children with ADHD meet criteria for one other mental health disorder and approximately half of all children diagnosed with ADHD have 2 or more comorbid disorders, with the most common being disruptive behavior disorders (ie, oppositional defiant disorder and conduct disorder), anxiety and mood disorders, and learning disabilities.

ADHD is conceptualized as a neurobiological disorder in which the primary cause is thought to result from a complex set of genetic factors, although nongenetic factors (eg, perinatal stress, prematurity, traumatic brain injury, maternal substance abuse during pregnancy) have also been postulated to play a role in the etiology of this disorder. These genetic and nongenetic factors are thought to influence brain structure (ie, the integrity of the prefrontal cortical-striatal network) and function (ie, neurotransmitter systems such as the catecholamine system), and ultimately affect behavior. In terms of theoretical models, the cognitive-energetic model is one that provides a particularly comprehensive framework for understanding the neurocognitive deficits associated with ADHD. This model indicates that problems associated with ADHD occur at 3 levels: (1) cognitive mechanisms (eg, response outputs such as motor organization), (2) energetic pools (eg, arousal, activation, and effort), and (3) executive functioning (eg, inhibition, working memory, planning). It is assumed that these problems are related to differences in the underlying neural architecture and modulator systems in individuals with ADHD.

ADHD increases the risk for numerous adverse health outcomes later in development, including substance abuse, motor vehicle accidents, and involvement with the justice system. As such, ADHD represents a significant burden to individuals, their families, and society. Given the heterogeneity of the disorder in its 3 recognized subtypes (namely Predominately Inattentive, Predominately Hyperactive-Impulsive, Combined), and its pervasive impact on children, it is often recommended that treatment involve multiple modalities, including behavioral, psychoeducational, and pharmacological interventions. Long-term prospective studies, however, such as the Multimodal Treatment Study of Children with ADHD (MTA), have suggested that an optimal level of pharmacological medication is the single most effective treatment for ADHD in most children, at least for the first year of treatment. Moreover, stimulant medication alone remains the most common treatment for ADHD.

ADHD and Sleep

ADHD has one of the highest rates of sleep problems of all child mental health disorders. There have been numerous systematic reviews of the literature on the sleep characteristics of children with ADHD, as well as articles written about this relationship for clinical audiences. All reviews concur that parents of children with ADHD report more sleep problems than do parents of typically developing children. Prevalence estimates of sleep problems based on parent reporting have varied widely, but have been consistently high (ie, 50%–80%), depending on the operational
The definition of sleep problem used. The sleep problems most commonly reported by parents of children with ADHD are difficulties initiating or maintaining sleep, both of which typically shorten sleep duration and can cause problems for the family and child. Although sleep problems are common in children with ADHD, these are often overlooked and rarely included in research examining the comorbidity of ADHD. For example, the largest treatment trial of ADHD, the MTA study, examined comorbidities associated with ADHD but did not include sleep disorders. 

Sleep problems have also been shown to be related to ADHD subtype. Most research has indicated that children with the Combined subtype of ADHD have more sleep problems compared with children with the Inattentive or Hyperactive/Impulsive subtypes of ADHD. However, there is also some evidence that children with the Inattentive subtype of ADHD may be sleepier during the day than their typically developing peers, despite their nocturnal sleep being similar. A recent study also found that hypersomnia was more prevalent in the Inattentive subtype, whereas circadian rhythm problems were more prevalent in the Combined subtype. When interpreting these results, it is important to consider the potential confound of ADHD symptom severity across the subtypes and the possible impact of this on research findings.

The high rates of sleep problems reported by parents of children with ADHD are not often verified by research using objective measures of sleep (eg, actigraphy and polysomnography [PSG]). Although several individual research studies have found a higher rate of a specific sleep disorders (eg, sleep apnea) or a specific sleep architecture variation (eg, differences in rapid eye movement [REM] sleep), a meta-analysis by Sadeh and colleagues found that the only consistent finding across studies was a higher rate of periodic limb movement disorder (PLMD) in children with ADHD when compared with typically developing children. All other sleep disorders (eg, sleep apnea) and differences in sleep architecture were associated with ADHD through mediating factors including age, gender, and comorbidity. This finding is in contrast to results of the meta-analysis by Cortese and colleagues of PSG studies, which found that children with ADHD had higher scores on the index indicating sleep apnea. Unfortunately, periodic limb movements were not included in the analyses. The investigators of both of these meta-analyses highlight that there is wide variability across studies in terms of definitions and measurement of these sleep disorders, and that this variability may result in inconsistent findings across studies.

### STIMULANT MEDICATION AND SLEEP

Current estimates are that 2% to 9% of North American children receive stimulant medications for the treatment of ADHD, and standard practice has changed from twice-a-day regimes (ie, medication given morning and noon to provide coverage during school hours) to sustained-release formulations that treat symptoms inside and outside of school hours. Current treatment with stimulant medication has been reported to affect sleep, with stimulant treated children sleeping approximately 1 hour less per night during an acute medication trial. In particular, the trend toward the use of controlled-release preparations may have a significant impact on sleep in these children. In addition, there is preliminary evidence that stimulant medication may change the strength and timing of the circadian rhythm. Moreover, research has demonstrated that performance on a measure of sustained attention was most improved by medication in children with ADHD who had poor sleep quality as compared with children with ADHD with good sleep quality. This finding implies that sleep quality during pharmacological treatment of ADHD may moderate the effectiveness of stimulant medication in enhancing attention.
ADHD ASSESSMENT

ADHD and sleep disorders can present similarly, therefore it is difficult to know which disorder is causing the child’s inattention and/or impulsivity/hyperactivity. There are 3 possible relationships: (1) ADHD may cause sleep problems (eg, a child with ADHD develops insomnia as he or she is not able to slow down his or her thoughts to settle for sleep), (2) a primary sleep disorder may cause ADHD-like symptoms (eg, sleep apnea results in daytime sleepiness and as such the child displays difficulties with attention and increased motor activity), or (3) a third variable may cause both ADHD and sleep disorders or problems (eg, dysregulation of arousal resulting in ADHD and insomnia). It is important to take these 3 possible relationships between ADHD and sleep into consideration when conducting an ADHD assessment.

Differential Diagnosis

The goal of the ADHD assessment process is twofold; first, to “rule in” ADHD symptoms to confirm that the clinical presentation meets diagnostic criteria, and second, to “rule out” other possible diagnoses that would account for the ADHD symptoms. In other words, pediatricians should consider a differential diagnosis, which is a process of weighing the probability of one disorder versus another to best explain a patient’s symptoms. This step is often overlooked in the assessment and diagnosis of ADHD, yet is critical for understanding prognosis and for treatment planning.

Sleep disorders are an important consideration in the differential diagnosis of ADHD. The most comprehensive classification system of sleep disorders, the International Classification of Sleep Disorders (ICSD-2), organizes sleep disorders into 8 categories: (1) Insomnia, (2) Sleep-related breathing disorders, (3) Hypersomnias of central origin, (4) Circadian rhythm sleep disorders, (5) Parasomnias, (6) Sleep-related movement disorders, (7) Isolated symptoms and normal variants, and (8) Other sleep disorders. Although pediatric sleep disorders are well represented in the ICDS-2, it continues to be a challenge to identify sleep disorders within the context of the wide range of typical sleep behaviors in children.

Sleep problems are not specific to ADHD, but rather are a common symptom of many mental health disorders. For example, general sleep disturbances can be a symptom of major depression; decreased need for sleep can be a symptom of mania; refusal to sleep alone and persistent nightmares of separation are symptoms of separation anxiety, whereas the following are possible symptoms of generalized anxiety: becoming easily tired/appearing tired, difficulties falling or staying asleep, and restless unsatisfying sleep. Moreover, there is no sleep problem or sleep disorder that is associated specifically with ADHD. Therefore, screening for a range of potential sleep disorders and sleep problems should be undertaken as part of the ADHD assessment.

The first step in an ADHD assessment typically involves gathering information to better understand the concerns about the child and to conduct a screening for ADHD symptoms. This step should also include a screening for other possible explanations for the child’s presenting ADHD symptoms, including sleep disorders. During this initial meeting, the pediatrician should ask the parent about the child’s sleep. Therefore, the inclusion of a brief sleep screen is recommended as an integral component of this step in the ADHD diagnostic process. An example is the 5-item sleep-screening instrument called the BEARS (B = Bedtime issues, E = Excessive daytime sleepiness, A = night Awakenings, R = Regularity and duration of sleep, S = Snoring), which has been found to be user-friendly in a primary care setting (http://www.kidzzzsleepl.org).
Often parent and teacher questionnaires are used as part of this assessment process; however, these questionnaires rarely screen for sleep problems/disorders. Therefore, it is recommended that pediatricians include a questionnaire that will screen for sleep disorders and sleep problems. One such example is the Children’s Sleep Habits Questionnaire50 (http://www.kidzzzsleep.org), which is a parent-report survey that may be useful in identifying sleep problems. The questionnaire includes 45 items comprising 8 scales: (1) Bedtime resistance, (2) Sleep onset delay, (3) Sleep duration, (4) Sleep anxiety, (5) Night awakenings, (6) Parasomnias, (7) Sleep disordered breathing and (8) Daytime sleepiness. Elevated scores on any of these 8 scales or an overall score of more than 41 may indicate sleep problems that require further investigation. (See Spruyt and Gozal51 for a listing and critique of the most common pediatric sleep questionnaires.)

If sleep concerns are raised either during the interview or on the sleep questionnaire, then additional information about the child’s sleep is required. The pediatrician should consider asking the parent and/or youth (depending on the child’s age and ability level) to complete a sleep diary for 2 weeks. A graphic sleep diary that collects information about sleep quantity and quality is best, as patterns related to sleep problems (eg, late bedtime, short sleep, multiple night awakenings) are more obvious than when the information is collected in written format. Child-friendly sleep diaries can be ordered from the National Sleep Foundation at http://www.sleepfoundation.org/ or can be downloaded from www.kidzzzsleep.com. For a review of the various sleep measures, including sleep diaries and polysomnography, the reader is referred to Sheldon,52 Weiss27, and Lugimbuehl and Kohler.53

When collecting information about the child’s sleep, the pediatrician must consider several primary sleep disorders (eg, sleep apnea, PLMD/restless legs syndrome, circadian sleep disorders), as these can all result in increased inattention, impulsivity, and hyperactivity, and as such have the potential to be misdiagnosed as ADHD.25,27,46,54,55 A referral for a sleep study (ie, PSG study) is only necessary if the initial sleep assessment indicates that there may be a primary sleep disorder for which a PSG study is useful for diagnostic purposes (eg, sleep apnea, PLMD). For example, if the parent reports that the child snores loudly, at times has been heard to snort and gasp while sleeping, and tends to fall asleep in the car while being driven relatively short distances, then it would be appropriate for the child to have a PSG study to examine the possibility of sleep apnea.

Comorbid Diagnosis

Comorbidity refers to the presence of one (or more) disorders in addition to the primary disorder. As already noted, comorbidity is very common in children with ADHD, and has important implications for understanding prognosis and for developing treatment plans. A disorder is considered comorbid with ADHD if there is evidence for both disorders and if one disorder does not fully account for the symptoms of the other disorder. For example, a child who presents with ADHD and separation anxiety symptoms might receive a diagnosis of both disorders, and as such both of these disorders need to be considered in treatment planning. The most common comorbid sleep disorder seen in the context of an ADHD assessment is behavioral insomnia. Based on the ICSD-2, there are three types of behavioral insomnia of childhood (BIC): (1) Sleep onset association type (difficulties with initiating sleep as sleep onset is paired with an external cue such as a parent’s presence); (2) Limit setting type (parents are not consistent with limit setting at bedtime and/or reinforce behaviors incompatible with sleep); and (3) Combined type. Behavioral insomnias of childhood present clinically with bedtime resistance, difficulty falling asleep, and/or problems staying
Given that BIC is the most common sleep problem in school-aged children with ADHD, it is this comorbid sleep disorder that we will focus on in the Treatment Considerations section below.

**Assessment of Sleep Problems in Children Previously Diagnosed with ADHD**

As previously described, sleep problems should be evaluated in the initial ADHD assessment; however, reassessment of sleep problems may be required at a later date if new sleep problems arise or if past sleep problems are exacerbated. The assessment approach will depend on whether the child is on medication, and the type and dose of the medication. If the child is not on medication then the sleep assessment should proceed as outlined earlier. However, if the child is on stimulant medication, the impact of the medication on sleep must be determined. The most common impact of stimulant medication is delayed sleep onset, which often reduces sleep duration. If the parent reports that the sleep problem either started or worsened during the course of treatment with stimulants, consideration should be given to changing the timing and/or dose of the medication. There are many stimulant medications used in the treatment of ADHD, and all have different durations of effects and release properties. If changing the dose and/or timing of the stimulant medication is ineffective, a different stimulant or a nonstimulant medication could be considered for the treatment of ADHD. For a review of ADHD medications and their properties, see Kratochvil and colleagues or the following Web sites: [http://www.addwarehouse.com/shopsite_sc/store/html/article3.htm](http://www.addwarehouse.com/shopsite_sc/store/html/article3.htm); [http://www.caddra.ca/cms4/pdfs/medication-adhd-canada_April2010.pdf](http://www.caddra.ca/cms4/pdfs/medication-adhd-canada_April2010.pdf).

Some pediatricians recommend an additional dose of stimulant medication in the evening, as it is believed that difficulties falling asleep are the result of “rebound effects” (ie, increased irritability, agitation, and emotional liability) as the child’s daytime medication wanes. Although an additional dose is commonly used, there is no empirical evidence for this practice. In fact, of the few studies conducted, most have found that sleep onset is further delayed with an additional dose of medication. Other considerations in medication use include the presence of comorbid conditions. For example, treatment of ADHD symptoms with atomoxetine has been found to improve nocturnal enuresis associated with ADHD, and therefore could be considered when both ADHD and enuresis are diagnosed and in need of treatment.

**TREATMENT CONSIDERATIONS**

The primary focus of this section is the treatment of behavioral insomnias of childhood (particularly sleep-onset association disorder), as this is the most common sleep disorder in both unmedicated and medicated children with ADHD. Additional information on behavioral insomnias of childhood can be found in an article elsewhere in this issue. Unfortunately, there is very little research on the effectiveness of interventions for insomnia specific to children with ADHD, which has resulted in this area being identified as a top research priority by a consensus group on insomnia in children. The evidence-based interventions for typically developing children are reviewed and, when possible, research focused on children with ADHD is highlighted; how these interventions could be modified for children with ADHD is also discussed. The treatment overview includes relevant behavioral, pharmacological, and complementary treatments for insomnia in school-aged children. This section ends with a brief overview of research that has evaluated specific interventions in children with ADHD for sleep disorders other than insomnia (eg, restless leg syndrome, PLMD, circadian disorders, and obstructive sleep apnea).
Behavioral Interventions

Given that pediatric sleep problems occur in the context of the parent-child relationship, many of the psychosocial treatments are behaviorally based parent management strategies. Mindell and colleagues conducted a systematic literature review of 52 behavioral intervention studies and reported that 94% of these interventions were efficacious in treating behavioral insomnia, and significantly improved sleep in 80% of children. Despite the strong efficacy data, caution needs to be exercised in generalizing these results to school-aged populations, as these studies were primarily focused on infants and young children. It is unfortunate that so little research has been conducted in school-aged children, as this age group accounts for the highest percentage of visits to primary pediatricians regarding sleep concerns. The most commonly used behavioral interventions for school-aged children are sleep hygiene, positive routines, faded bedtime with response cost, and cognitive strategies. These approaches are described in more detail below. Based on the findings of pediatric sleep research and knowing that children with ADHD have difficulty with cognitive processes and executive functions, it may be necessary to make some adaptations to behavioral interventions for treating insomnia in children with ADHD.

Sleep hygiene

Educating parents on the importance and implementation of good sleep hygiene for their children has received empirical support. Good sleep hygiene is achieved by several factors, some of which occur during the day and others at night. Diet is one daytime factor that plays an important role in promoting healthy sleep. For example, high levels of caffeine consumption during the day (eg, cola and chocolate), especially in the late afternoon and evening, can lead to delayed sleep onset. Another dietary issue that should be considered is the types of food children are consuming during the day. One study demonstrated that when children with ADHD were put on a diet consisting mainly of fruit, vegetables, rice, and meat, they complained less of physical problems and sleep problems than did children in a control group.

Another daytime factor that plays a role in sleep hygiene is physical activity (eg, exercise, outdoor activity). Studies with adults suggest that moderate physical activity is associated with sleep-promoting benefits. However, active play should be limited as bedtime approaches (eg, within 3 hours), as children should be engaging in quieter, relaxing activities to help them wind down, rather than being overstimulated before sleep. Activities involving electronics (eg, television and computer) should also be limited before bed, as these can also stimulate the child rather than have a calming effect. For example, Owens and colleagues found that increased duration of television watching, and television watching at bedtime, were both associated with increased sleep difficulties, especially when the television was in the child’s bedroom. It is recommended that all electronic devices (including cell phones, computers, and television) are turned off at least one hour before bedtime. The above recommendations are particularly important for children with ADHD, as these children tend to have more sedentary lifestyles, watch more television, and play more videogames than their typically developing peers.

The sleep environment is also important to consider as part of healthy sleep hygiene. A child should have a comfortable bed, with a quiet, dark (or lowly lit) room, and a comfortable room temperature. Children will not sleep as well if the environment is either too hot or too cold. If possible, children should not be punished by being confined to their room during the day, as they should learn to associate their bed/bedroom as a place for relaxation and sleep rather than play or worry.
A study by Weiss and colleagues examined the efficacy of sleep hygiene and melatonin treatment for stimulant-treated children and adolescents with ADHD who were experiencing insomnia (sleep-onset latency >60 minutes). In this study, children and adolescents were given a sleep hygiene intervention during which time parents were provided information on consistency in bedtime routines, as well as being instructed to avoid caffeine and naps. Findings indicated that less than 20% of the children were effectively treated with sleep hygiene alone. Based on this one study, it seems that for many children with ADHD (on stimulant medication), sleep hygiene strategies may be necessary but not sufficient to treat their symptoms of insomnia.

**Positive bedtime routines**

Establishing consistent bedtime routines for children can help them learn appropriate behaviors for bedtime and reduce the stress of going to bed. Positive bedtime routines involve a consistent bedtime each night and a consistent bedtime routine (ie, a set of activities to help the child get ready and wind down before bed). Bedtime routines work best if they occur in the same way each night, so the child knows exactly what will happen and when it will happen. Having the same activities occurring each night can help children calm down before bed, as novel or unexpected events can increase stimulation. Typical bedtime routines may include a reminder from parents that it will soon be time to get ready for bed, a snack, brushing teeth, washing up, getting pajamas on, a story/time with parents, and lights out. Parents should ensure that there is an appropriate amount of time for the bedtime routine, as it should not be a rushed process. The bedtime routine can also provide some positive one-on-one interaction between children and their parents. It is also important to have a wake time that is similar across weekends and weekdays, and the rule of thumb is no more than a 30 minutes difference between these two wake times.

One area where children with ADHD may have more difficulty than typically developing children is with the bedtime routine. Children with ADHD may benefit from more warnings before being called to bed so that they know that bedtime is coming. These children may also require an increased number of prompts during the bedtime routine to keep them on track and to help them transition from one activity to the next in a timely manner. The routine should be structured in a way to allow for sufficient time to complete each activity (eg, brushing teeth), but not so much time that the child has opportunities to become distracted. Because children with ADHD may have difficulty following through with multi-step instructions, parents should give their child instructions one step at a time. It may also be helpful to have the bedtime routine posted (with pictorial representations of the activities for younger children) in a location where the child can see it, and can check off each activity as it is completed. This method may be particularly beneficial to children with ADHD, as it gives them a visual reminder of the bedtime routine in a step-by-step fashion. These modifications may help parents of children with ADHD, and the children themselves, follow the bedtime routine with more success.

**Faded bedtime with response cost**

A faded bedtime with response cost is a process whereby the child is put to bed at a specific time and if he or she is not able to fall asleep within a predetermined time (eg, 20 minutes), he or she has to leave his or her bed and engage in a quiet activity for a pre-set length of time without being permitted to fall asleep (ie, response cost). The point is to make associations for the child so that he or she falls asleep when in bed (ie, stimulus control). Once the child is falling asleep within the first 20 minutes of being placed in bed for a few consecutive nights, the bedtime is moved...
earlier by 15- to 30-minute increments until the goal bedtime is reached. A consistent wake time needs to be put in place as well. This technique focuses on increasing appropriate bedtime behaviors instead of reducing less appropriate bedtime behaviors, and also results in sleep restriction so the child is tired when going to bed.

**Sleep interventions for children with ADHD**

There is only one published study examining behaviorally based sleep interventions for children with ADHD. Mullane and Corkum examined the effect of a 5-week behavioral intervention for 3 unmedicated children with ADHD and difficulties initiating and/or maintaining sleep. Parents were provided with a manual and received weekly telephone sessions with a paraprofessional facilitator to review material covered in the manual. The topics covered in the treatment manual included the following: (1) basic sleep physiology and the different types of sleep problems/disorders, their impact, and treatments, (2) sleep hygiene and bedtime routines, (3) faded bedtime strategy with a response cost and positive reinforcement, (4) implementing a faded bedtime strategy and reward program, and (5) fine tuning and fading the program. Results indicated that children’s sleep improved and that these gains were generally maintained at the 3-month follow-up. These findings provided a foundation for a larger randomized controlled trial completed by Corkum and colleagues. This trial evaluated the efficacy of their sleep intervention method in typically developing children and children with ADHD (who comprised ~30% of the total sample of 54 children aged 6–12 years). Preliminary analyses indicate that the treatment group had significantly improved sleep compared to the wait-list control group, and that children with ADHD were as responsive to the treatment as typically developing children (Penny Corkum, PhD, Fiona Davidson, BSc, Lingley-Pottie, et al, unpublished data, 2009).

In older children and adolescents, the inclusion of cognitive strategies such as relaxation and guided imagery may be helpful in reducing anxiety and psychological arousal at bedtime. Although there is a strong research base for these strategies with adults who suffer from insomnia, there is no research on the effectiveness in school-aged children.

**Pharmacological Interventions**

Sleep disorders are one of the primary reasons for the use of medication in children. A survey of community-based pediatricians in the United States showed that the use of prescription and over-the-counter medications in treating sleep problems in children is relatively common, with approximately one-fourth of children with sleep problems being prescribed a medication. The results from a recent survey of child psychiatrists also indicated that there is a wide range of variability in the medications and approaches used to treat insomnia in children. In this study, α-agonists were most commonly used for treating children with ADHD or other neurodevelopmental delays; however, our knowledge of the efficacy and safety of these medications for children is limited because of a lack of clinical medication trials for children with sleep disorders and sleep problems. There are currently no medications approved for use in children with insomnia in the United States, and furthermore, recent clinical guidelines emphasize that pharmacologic treatment is rarely the first-line approach and should instead be combined with sleep hygiene and behavioral interventions.

The general classes on medications used for the treatment of insomnia in children with ADHD in clinical practice settings include sedative-hypnotic medicines, benzodiazepines, nonbenzodiazepines, ramelteon, and melatonin. The discussion of pharmacological interventions here is limited to only those medications for which some empirical data exist regarding use in children with ADHD and insomnia. A nonbenzodiazepine hypnotic agent, zolpidem, has been researched for its effectiveness in treating pediatric sleep-onset
insomnia in children with ADHD. In a controlled clinical trial, a dose of 0.25 mg/kg per day (to a maximum of 10 mg/d) of zolpidem was not effective in reducing sleep-onset insomnia in youths between the ages of 6 and 17 years based on actigraphy and PSG. Reported side effects of zolpidem included dizziness, headaches, and hallucinations.

A commonly prescribed medication for children with ADHD and insomnia is clonidine, an α-agonist. Clonidine has been found to be helpful in treating children with ADHD and sleep problems, due to its sedating effects for insomnia. Clonidine has a duration of action between 3 and 5 hours and a half life of 12 to 16 hours. It is typically given orally at bedtime, and its effects last for approximately 4 hours in children. Although there is evidence that clonidine may be effective for managing sleep problems in children with ADHD, case study reports show that some children have experienced adverse responses to clonidine, including low blood pressure and weight loss. Case study reports have also identified withdrawal effects including shortness of breath, high blood pressure, and tachycardia, and there are concerns with the interactions with stimulant medications. Sleep and clonidine research on adults has also shown that medium to high doses of clonidine may decrease REM sleep. These reports indicate that pediatricians should exercise caution when prescribing clonidine, and monitor the child for side effects and withdrawal effects as well as appropriate dosage.

The most common medication used to treat sleep problems in children with ADHD is the supplement melatonin. Giving children with ADHD synthetic melatonin has been found to be effective in decreasing sleep-onset latency. In unmedicated children with ADHD, melatonin in large doses (ie, 5 mg) before bedtime was found to decrease sleep onset and increase sleep duration; however, the supplement was not effective in improving daytime problem behaviors or cognitive performance. Although melatonin appears to be effective at improving sleep problems in children in the short term, there is limited research on its efficacy in the long term, although one study did find that children taking melatonin for an average of 3.7 years continued to benefit. No adverse effects have been noted in some studies, whereas other studies have found that melatonin use has been associated with a lowered seizure threshold and exacerbation of asthma symptoms, and may contribute to delayed onset of puberty in children. In addition, there is no consensus on the best therapeutic dose of melatonin and the formulation is not well regulated so varying responses can occur.

There is a small body of literature examining the use of other complementary and alternative medicine and strategies (see Larzelere and colleagues for a review). Most of this work has been done in infants and adults, with next to no research on school-aged children. Although some parents report anecdotally that these treatments are effective at improving their children’s sleep problems, such reports have not be verified by research.

Treatment of Other Common Comorbid Primary Sleep Disorders in Children with ADHD

Movement disorders: periodic limb movement disorder, restless leg syndrome
PLMD is characterized by periodic episodes of repetitive and involuntary rhythmic movements of the legs during sleep. The core symptoms of restless legs syndrome (RLS) include the urge to move the legs that worsens when resting, such as in the evening or at bedtime. Research has shown that lower serum ferritin levels have been associated with PLMD and RLS in children with ADHD, and children with lower levels of serum ferritin had higher scores on objective measures of problems sleep and symptoms of ADHD. Treatment with supplemental iron has been anecdotally reported to alleviate RLS symptoms in children, although no randomized trials have been conducted.
Circadian rhythm disorders
Melatonin is used to treat circadian rhythm disorders, specifically delayed sleep phase disorder, which is characterized by a delayed sleep episode relative to the desired clock time. This delay can result in daytime sleepiness, symptoms of sleep-onset insomnia, and difficulty awakening at the desired time. Adult data suggest that optimal timing and dose may be different for melatonin used as a chronobiotic. Chronotherapy (ie, successively delaying sleep-onset times around the clock until the actual sleep-onset time is realigned with a desired earlier bedtime) and bright light therapy (ie, use of light boxes to emit full-spectrum fluorescent light and filter out ultraviolet wavelengths) have been suggested in the literature as potential treatments for sleep problems in children with ADHD. To date there has been very little research on these interventions. There is one case study, which found that a combination of chronotherapy and a behavioral intervention was successful in a young girl with ADHD and delayed sleep phase insomnia. Positive benefits from morning bright light therapy was reported in one study of adults with ADHD and in a single case study of a child with ADHD.

Obstructive sleep apnea
Although there is compelling evidence that treatment of obstructive sleep apnea can improve neurocognitive functioning, including attention, in typically developing children, there are few studies that have examined the outcome of treatments for sleep apnea specifically in children diagnosed with ADHD. One recent study examined treatment outcomes for children with ADHD and mild sleep apnea that were self-selected into 3 groups: methylphenidate treatment, surgical treatment (adenotonsillectomy), and no treatment. The surgical group demonstrated the greatest improvement in ADHD symptoms. Several other studies have also demonstrated the benefits that children with ADHD and obstructive sleep apnea can experience after surgical treatment. These results underscore the importance of treating obstructive sleep apnea in the context of ADHD, and potentially speak to the need for differential diagnosis between ADHD and sleep.

SUMMARY
Although there are many unanswered questions, it is clear that ADHD and sleep are intimately linked and that sleep needs to be considered in the assessment and treatment of ADHD. Sleep disorders can mimic ADHD symptoms, therefore an assessment that includes sleep in the differential diagnosis is critical. Sleep disorders can also coexist with ADHD, and can modify prognosis and treatment responses. Given the lack of efficacy and safety data for the pharmacological treatment of sleep problems in children, it is critical that pediatricians use behavioral intervention strategies, such as sleep hygiene and positive bedtime routines, as a first line of treatment.

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