Sleep Disorders in Childhood

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PRACTICE GAP

Significant knowledge and practice gaps among primary care providers pose barriers to adequate screening, identification, and treatment of sleep problems in children. Clinical exposure to sleep disorders remains relatively underemphasized during residency training. In this article, we provide an updated overview of the prevalence and treatment of common sleep disorders in childhood and adolescence.

OBJECTIVES *After completing this article, readers should be able to:*

1. Recognize sleep disorders and distinguish between categories of sleep disorders.
2. Identify the prevalence and presentation of common pediatric sleep disorders.
3. Summarize the commonly used assessment techniques to diagnose sleep disorders.
4. Offer the most up-to-date, evidence-based treatments for common sleep disorders.

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ABBREVIATIONS

AHI	apnea-hypopnea index
CBT-I	cognitive behavioral therapy for insomnia
DSWPD	delayed sleep-wake phase disorder
EDS	excessive daytime sleepiness
EMG	electromyography
FDA	Food and Drug Administration
HLA	human leukocyte antigen
IH	idiopathic hypersomnia
KLS	Kleine-Levin syndrome
MSL	mean sleep latency
MSLT	multiple sleep latency test
NREM	non–rapid eye movement
NT-1	narcolepsy type 1
NT-2	narcolepsy type 2
OSA	obstructive sleep apnea
PAP	positive airway pressure
PLMD	periodic limb movement disorder
PLMS	periodic limb movement of sleep
PSG	polysomnogram
RBD	rapid eye movement sleep behavior disorder
REM	rapid eye movement
RLS	restless legs syndrome
RSD	restless sleep disorder
SOAD	sleep-onset association disorder
SOREMP	sleep-onset rapid eye moment period
SSRI	selective serotonin reuptake inhibitor

INTRODUCTION

Sleep evolves from the newborn period through adulthood. Knowledge of these developmental changes is useful in evaluating sleep disorders. Newborns have no circadian rhythm, take frequent naps during the 24-hour day, and spend almost 50% of their total sleep time in rapid eye movement (REM) sleep. (1) Alignment of a baby's circadian rhythm to the solar day occurs during the first several months of infancy, such that a day-night rhythm is well-established by 6 months of age. Daytime sleep consolidates into 1 to 2 well-defined naps during toddlerhood, and naps are gradually discontinued during the preschool period. By adolescence, approximately 25% of the total sleep period is occupied by REM sleep. The cycling between REM and non-REM (NREM) sleep, referred to as the ultradian rhythm, similarly changes across development, with 50-minute cycles in infants and 90-minute cycles in older children. By early childhood, deeper stages of NREM sleep begin to cluster in the first half of the night. (1) The

recommended number of hours of daily sleep for infants, toddlers, preschool-age children, school-age children, and teenagers are 12 to 16, 11 to 14, 10 to 13, 9 to 12, and 8 to 10 hours, respectively. (2) Bearing in mind these developmental changes, daytime napping in school-age children is unusual and warrants further evaluation. NREM parasomnias (eg, sleep terrors or sleepwalking) generally cluster in the first half of the night, when NREM sleep predominates. Conversely, REM-related sleep apnea symptoms likely occur later in the night and may go undetected by a parent who checks on their sleeping child earlier in the night.

CLASSIFICATION OF SLEEP DISORDERS

The American Academy of Sleep Medicine has put forth the International Classification of Sleep Disorders, which broadly classifies sleep disorders into 6 major categories (Table 1). (3) Within these categories, disorders may additionally occur secondary to medical, substance, or psychiatric factors. For example, opiates may cause breathing problems in sleep. Caffeine may frequently be associated with insomnia or sleep-related movement disorders; caffeine is sometimes consumed unknowingly by those unaware of the ingredients of their favorite beverages. (4) Mood disorders may variably cause hypersomnia or insomnia. Therefore, a thorough history is vital in investigating the etiology of the two most common complaints seen in the sleep clinic: "cannot sleep" or "sleeping too much."

OBJECTIVE ASSESSMENT OF SLEEP DISORDERS

The most common sleep test used to confirm clinical suspicions is polysomnography (PSG). (5) This test essentially comprises several sensors to monitor sleep. Among these, electroencephalography, electrooculography, and chin electromyography (EMG) help distinguish wakefulness from REM and NREM sleep stages. Sensors for oronasal airflow, pulse oximetry, capnography, electrocardiography, and limb EMG are useful for measuring sleep-related breathing, movements, and other motor phenomena, such as parasomnias (Fig 1). A variation of the PSG is a continuous positive airway pressure titration study, during which noninvasive respiratory support is titrated to treat sleep apnea.

The multiple sleep latency test (MSLT) uses an abbreviated array of these sensors to quantify daytime sleep propensity. During this test, the patient is given five 20-minute nap opportunities spaced at 2-hour intervals in the day. The average time taken to fall asleep across all naps is termed the mean sleep latency (MSL). Normative data are available to help diagnose hypersomnia disorders.

Although sleep laboratory tests are crucial for investigating many sleep disorders, other assessment tools may be more accessible and appropriate, depending on the presenting sleep complaints. Sleep logs are manually entered daily diaries of sleep-wake patterns (Fig 2), and actigraphy uses a wristwatch-like device that measures body movements and ambient light to more objectively determine sleep-wake patterns across a 1- to 2-week period.

Table 1. International Classification of Sleep Disorders–Third Edition (ICSD-3)

SLEEP DISORDER CATEGORY	SELECT EXAMPLES OF DISORDERS
Insomnia	1. Chronic: psychophysiological, inadequate sleep hygiene, behavioral insomnia of childhood 2. Short-term (acute or adjustment insomnia)
Circadian rhythm sleep-wake disorders	1. Delayed sleep-wake phase 2. Advanced sleep-wake phase 3. Irregular sleep-wake rhythm 4. Non–24-hour sleep-wake rhythm
Sleep-related breathing disorders	1. Sleep apnea (obstructive; central) 2. Sleep-related hypoventilation 3. Sleep-related hypoxemia
Central disorders of hypersomnolence	1. Narcolepsy (types 1 and 2) 2. Idiopathic hypersomnia 3. Kleine-Levin syndrome 4. Insufficient sleep
Parasomnias	1. NREM parasomnia: confusional arousals, sleepwalking, sleep terrors 2. REM parasomnia: nightmare disorder, REM sleep behavior disorder, recurrent isolated sleep paralysis
Sleep-related movement disorders	1. Restless legs syndrome 2. Periodic limb movement disorder 3. Bruxism 4. Rhythmic movement disorder

NREM=non–rapid eye movement, REM=rapid eye movement.
Modified from the ICSD-3 published by the American Academy of Sleep Medicine. (3) Only selected examples are presented. Please see the cited publication for a complete listing of known sleep disorders.

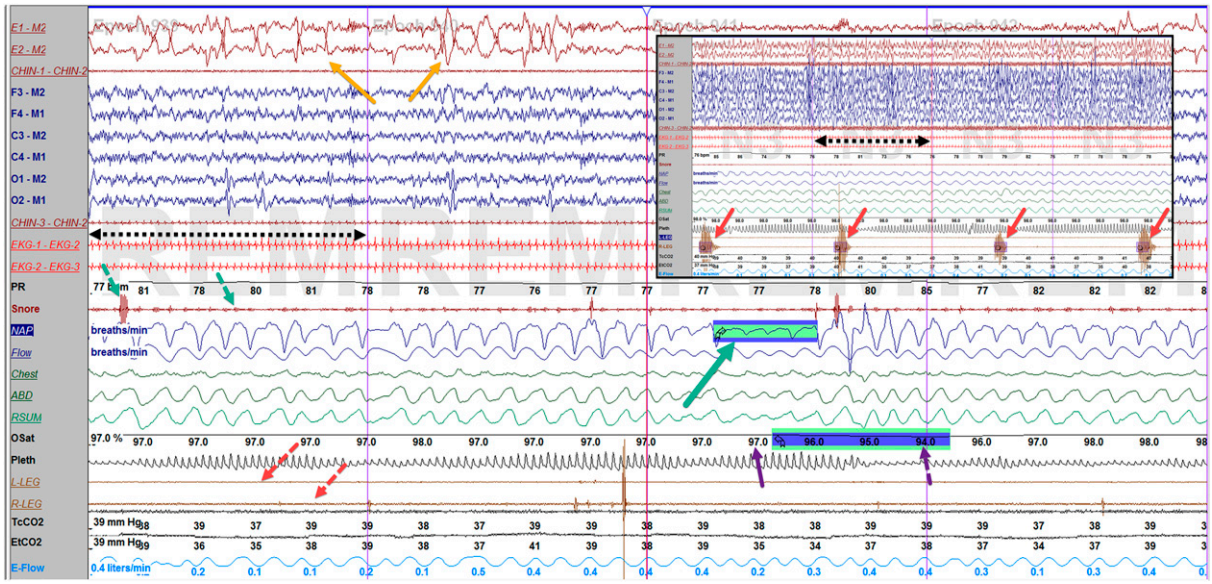

Figure 1. Two-minute sample showing a typical "hook-up" during overnight polysomnography. A 30-second time scale (double-headed broken black arrows) is denoted for both the main and inset figures. Sequentially arranged sensor channels are labeled from top to bottom (left margin) and include bilateral electrooculography (E1, E2), bilateral electroencephalography (F, C, O), chin electromyography (EMG), electrocardiography, pulse rate, snore microphone, oronasal airflow (NAP, flow), chest and abdominal effort, oximetry with pulse oximeter plethysmogram waveform (OSat, Pleth), bilateral leg EMG, and transcutaneous and end-tidal capnometry (TcCO2, ETCO2). The main figure shows this child having rapid eye movements of rapid eye movement (REM) sleep (yellow arrows) and snoring (broken green arrows). There is a single hypopnea event with reduced airflow with continued respiratory efforts (solid green arrow) with an associated 3% oxygen desaturation event from 97% (purple arrow) to 94% (broken purple arrow). There are no significant limb movements (red broken arrows). In contrast, the inset figure shows the same patient, at a different time, in non-REM sleep with a series of 4 prominent periodic limb movements (solid red arrows) but no respiratory events.

INSOMNIA

Insomnia is a sleep disorder that is diagnosed when a patient or caregiver reports one or more symptoms such as difficulty initiating sleep, difficulty maintaining sleep, waking earlier than desired, resistance to going to bed on an appropriate schedule, or difficulty sleeping without parent or caregiver intervention. These symptoms occur alongside one or more associated symptoms, including fatigue, impaired attention, irritability, daytime sleepiness, or dissatisfaction with sleep. (3) These reported sleep/wake complaints cannot be explained purely by inadequate sleep opportunity and must occur at least 3 times per week for at least 3 months to be classified as chronic insomnia disorder. For symptoms less than 3 months, the diagnosis of short-term insomnia disorder is used. The prevalence rate for insomnia diagnosis among children is 11%, but this prevalence rate is much higher (up to 40%) when insomnia symptoms are considered. (6)(7) Two common varieties of behavioral insomnia include sleep-onset association disorder (SOAD) and limit-setting sleep disorder, both of which tend to occur in childhood. Psychophysiological insomnia tends to occur in adolescents.

Sleep-Onset Association Disorder

SOAD is a form of insomnia in which a child needs parental presence and/or certain activities, such as bottle feeding, rocking, or watching television, to fall asleep or return to sleep after waking up in the night. Some developmental norms are important to be mindful of when considering this diagnosis. In infants younger than 5 to 6 months, night wakings are normative and driven primarily by nutritional need. However, in older infants, night wakings requiring parental involvement, often referred to as problematic night wakings, are more likely related to SOAD (8) and are associated with shorter and less consolidated sleep. (9)

To prevent and address these problematic infant night wakings and SOAD, preventive parental education can be provided at appointments during the third trimester, postpartum, and through the first 6 months of an infant's life. This education emphasizes the importance of consistent bedtime routines and consistent sleep schedules, and it offers guidance about appropriate parental handling during infant sleep initiation and night wakings to promote the development of independent sleep skills. (9) A common recommendation is that infants should be put to bed "drowsy but awake." This helps infants develop independent sleep initiation skills and enables sleep resumption without caregiver intervention after naturally occurring night wakings.

For families experiencing problematic infant night wakings, behavioral interventions, including either modified extinction or parental fading, can be introduced. (9) Modified

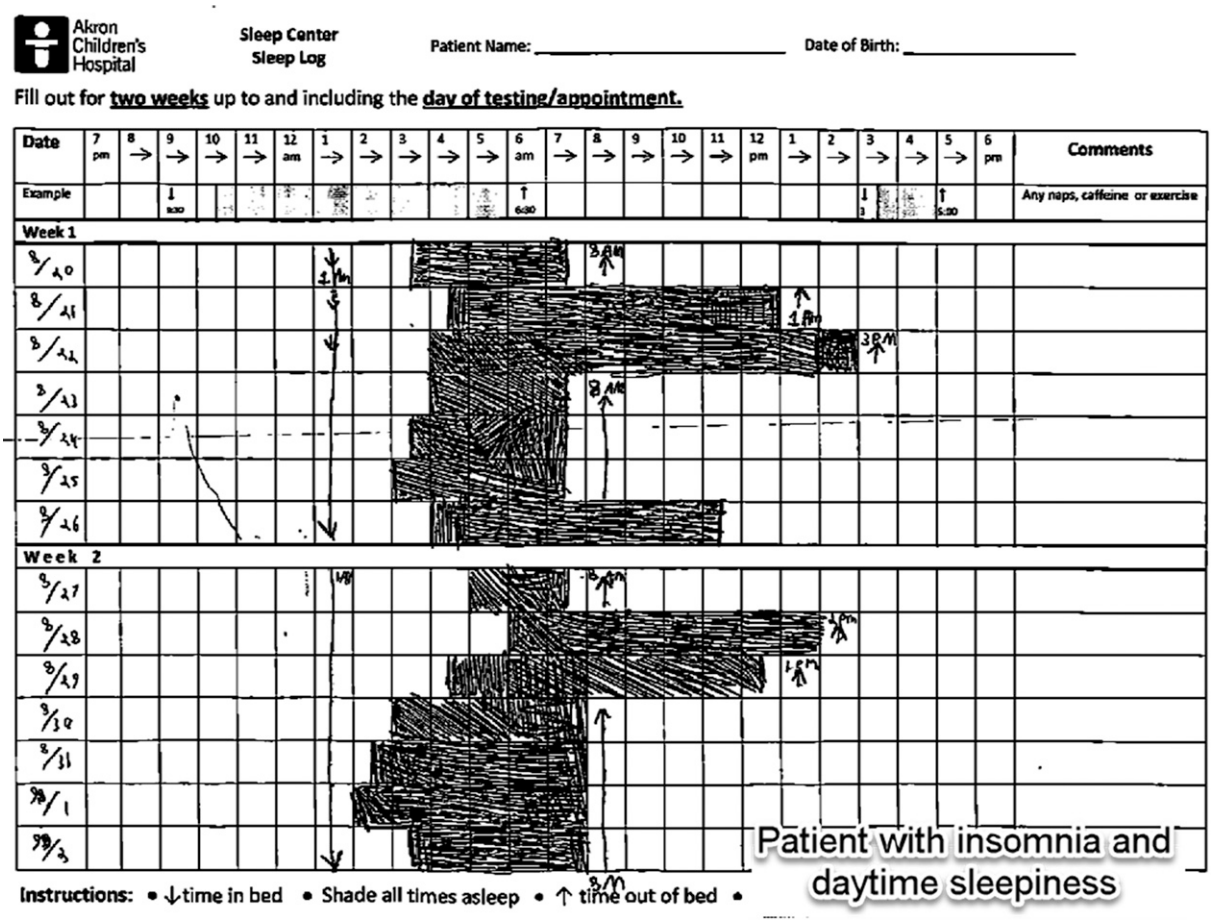

Figure 2. A typical 2-week sleep log. Down arrows denote entry into bed; up arrows, exit from bed; and shaded bars, estimated sleep periods. Dates are noted in the left column. Although this 15-year-old boy who presented with sleep-onset insomnia attempts to go to sleep around 1 AM each night, he does not fall asleep until approximately 2 to 4 AM most nights. He seems to maintain sleep until at least 12:30 to 3 PM on days when he is allowed to rise on his own. However, on other days, when he is forced to wake for school at 7:30 AM, he attains only approximately 3 to 5 hours of sleep.

extinction involves the parent placing their infant in bed awake and then checking on the infant periodically at regular time increments until the infant has fallen asleep. Parental fading involves the parent placing their infant in bed awake, while gradually fading their level of involvement (eg, keeping a hand on their infant as the infant falls asleep, then just standing near the infant as they fall asleep, and then sitting a little further from the infant as they fall asleep). This process helps to gradually train the infant to fall asleep independently. (9)

During interventions for SOAD, it is important to anticipate a potential extinction burst involving escalations in child attempts to achieve parental intervention (eg, more prolonged or intense infant crying in hopes that the parent will eventually give in). If parents observe this escalation, or extinction burst, they may assume that their intervention is not working. However, parents should be assured that this behavior is consistent with an extinction burst in the undesired behavior. Once the child learns that escalated crying is not effective for achieving parental intervention, the crying and resistance typically reduces. In fact, previous research has shown that, on average, infants cry for approximately 45 minutes in the first 3 to 4 days of this intervention before showing a reduction in crying. (10)

Limit-Setting Sleep Disorder

Limit-setting sleep disorder is insomnia characterized by ineffective parental limit setting at bedtime, which can result in bedtime stalling and refusal. To address these factors, providers should first encourage the use of consistent bedtime routines, which have been shown to reduce child bedtime resistance and other sleep problems. (11) During bedtime routines, firm limits on screen time and activating activities should be used, consistent with other general sleep hygiene recommendations (Table 2). Interactive visual schedules to represent the stepwise bedtime routine can help a child

Table 2. Sleep Hygiene Recommendations

• Practice a consistent sleep schedule, with consistent bedtimes and wake times across the week.
• Practice a consistent bedtime routine with calming activities to promote settling to sleep.
• Avoid spending time in bed awake, both during the day and at night. If you are not sleepy during the designated sleep window, get out of bed and do a relaxing activity in dim light before returning to bed once sleepy.
• Avoid daytime sleep.[a]
• Avoid use of electronics before bed.
• Avoid clock-watching in the night.
• Limit caffeine intake, particularly in the afternoon.
• Engage in regular physical activity but avoid strenuous exercise before bedtime.
• Keep the bedroom cool, dark, and quiet.
• Avoid eating a heavy meal before bedtime.

[a]Children younger than 5 years may still take regular naps.

stay on task and maintain consistency in implementation of the routine across nights, caregivers, and households, as needed. (12) The Bedtime Pass Program is also useful for setting limits on the child's attempts to call out or seek out parents after bedtime, which can further delay sleep onset. (13) The Bedtime Pass Program involves the parent providing the child with 1 to 3 bedtime passes that the child may exchange with their parent for predetermined reasons (eg, a drink of water, a hug, a question). Once the child is out of passes, the parent will remind them that they are out of passes and insist that they stay in bed, using minimal interaction with the child. The child can be motivated to exchange unused passes for a reward the next morning. Other techniques to effectively establish and reinforce bedtime expectations include the Good Morning Light, which is a nightlight programmed to change colors to signal the designated sleep and wake times, and the Sleep Fairy Positive Reinforcement Program. (14) With the Sleep Fairy Program, parents can inform their child that the "sleep fairy" will leave a small prize in the morning if the child follows the established sleep rules. These rules can be modified over time as the child's sleep behavior improves and advances.

Psychophysiological Insomnia

Psychophysiological insomnia is characterized by heightened arousal and conditioned sleep difficulty, resulting in an inability to initiate and/or maintain sleep and decreased functioning during wakefulness. (3) Commonly seen in adolescents, this form of insomnia can be effectively treated by cognitive behavioral therapy for insomnia (CBT-I). (15) Indeed, CBT-I has been established as the recommended first-line treatment for insomnia among adults. (16) CBT-I typically includes promotion of healthy sleep habits, teaching stimulus control, sleep restriction therapy, relaxation skills training, and cognitive modification of thoughts. (15)(16) Some patients may benefit from self-administered CBT-I tools, including phone apps such as the CBT-I coach app, SHUT-I, or SLEEPIO. (17)(18) These resources are easily accessible, low-cost, and effective. (19) If further intervention is deemed necessary, a referral to a behavioral sleep medicine specialist may be indicated. Credentialed behavioral sleep medicine providers can be identified on the Society of Behavioral Sleep Medicine website (www.behavioralsleep.org).

Pharmacologic Management of Insomnia

Behavioral interventions are the first-line treatment for insomnia, but a combined psychological and pharmacologic approach may be useful for certain populations (eg, those with neurodevelopmental disorders, pervasive developmental disorders, chronic medical conditions, and psychiatric disorders). (20) Although no medications are formally approved by the US Food and Drug Administration (FDA) for treating pediatric insomnia, there is expert consensus that medications may be of benefit if used rationally and judiciously. (20) As such, medications commonly prescribed include melatonin, hydroxyzine, trazodone, and clonidine.

CIRCADIAN RHYTHM SLEEP-WAKE DISORDERS

Circadian rhythm sleep-wake disorders involve misalignment of the biorhythms with the external environment (Table 1). Commonly seen in adolescents with a prevalence of 7% to 16%, delayed sleep-wake phase disorder (DSWPD) presents as a chronic and recurrent delay in sleep onset with an inability to fall asleep or wake at the desired time. (3)(21) Actigraphy or accurate sleep logs are very useful in the diagnosis (Fig 2). Behavioral treatment for DSWPD first involves the promotion of healthy sleep habits (Table 2). Further treatment of DSWPD depends on the severity of the disorder but typically involves either advancement of the sleep-wake phase or chronotherapy.

To advance the sleep-wake phase and to address the delayed endogenous melatonin secretion that individuals with DSWPD typically experience, (22) exogenous melatonin may be strategically administered a few hours

before endogenous dim light melatonin onset, and bright light therapy can be administered on waking (Fig 3). (23)(24) In humans with a typical day-night circadian rhythm, melatonin levels are low during the day and begin to rise when ambient light dims (ie, dim light melatonin onset). Broadly speaking, sleep onset occurs a couple of hours after dim light melatonin onset. (22) Although the identification of endogenous dim light melatonin onset can be challenging (eg, requiring analysis of plasma, saliva, or urine), research has established that it tends to occur between 7 PM and 9 PM in children aged 6 to 12 years, and approximately 30 minutes later as children age. (22) Research on the optimal dosing of melatonin for chronobiologic effects is still in its early stages, but based on current knowledge, practitioners can recommend 0.5 to 3.0 mg of melatonin approximately 3 hours before dim light melatonin onset. This would translate to melatonin administration approximately 5 hours before habitual sleep onset. (22) For bright light therapy, a broad spectrum lamp can be used, emitting 1,000 lux light, for 30 minutes at wake time. (2) As the sleep-wake phase is successfully advanced, with the patient going to bed earlier and waking earlier, the timing of the bright light therapy should also be gradually moved earlier, corresponding with the wake time each morning.

This phase advancement may suffice for cases of DSWPD that are less severe, in which only a few hours of phase advancement is needed. However, in more severe cases, chronotherapy may be necessary. Chronotherapy involves gradually moving the patient's sleep schedule around the 24-hour clock until the desired sleep-wake time is reached and then maintaining this sleep-wake time using sleep hygiene, melatonin, and bright light. (25)

SLEEP-RELATED BREATHING DISORDERS

Pediatric sleep-related breathing disorders can be categorized as conditions with airway obstruction (obstructive sleep apnea [OSA] syndrome), abnormal control of breathing (central sleep apnea syndrome), and ineffective gas exchange (hypoventilation). Of these, OSA syndrome is the most common. Obstructive breathing in sleep comprises a spectrum of conditions, ranging from snoring at the mild end to recurrent OSA at the severe end. OSA is characterized by prolonged partial, or intermittent complete, upper airway obstruction that disrupts normal ventilation during sleep and normal sleep patterns. (3) Snoring is reported in approximately 10% of children, whereas OSA is reported in 1% to 4% of children, with a peak prevalence between 2 and 6 years of age. (26)(27)(28) A higher prevalence of OSA is reported in children with obesity (10%–25%), craniofacial malformations (eg, 50% in achondroplasia), and Down syndrome (60%). (3)(26)(28). In addition, positive family history of OSA increases the risk of OSA in the child. (27) Predisposing factors include airway narrowing, high level of airway collapsibility, and abnormal control of breathing. The most common cause for OSA in children is anatomical obstruction due to large tonsils

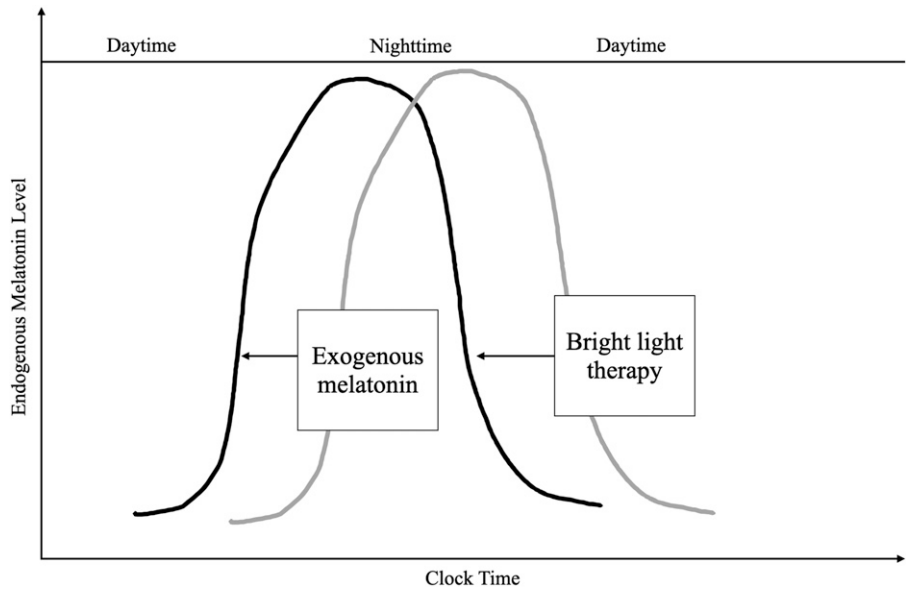

Figure 3. Drawing depicting how typical endogenous melatonin levels rise and fall across the 24-hour day. Relative to delayed sleep phase sleepers (gray line), people with a typical circadian phase (black line) have earlier melatonin rise when the ambient natural light dims (dim light melatonin onset). This rise usually begins 2 hours before natural sleep onset. Specific doses and timing of exogenous melatonin in the evening and application of bright light in the morning can be used to advance the phase earlier (direction of arrows). Modified from Jaquez et al. (24)

and adenoids. Increased airway collapsibility is contributory in children with obesity or neuromuscular disorders. (29)

The presenting symptoms for OSA can be grouped into nocturnal and daytime symptoms (Table 3). All children should be screened for snoring, per the American Academy of Pediatrics. (30) Suspicion for OSA is high when snoring occurs 3 or more nights per week, is loud, and is associated with restless sleep, daytime sleepiness, or daytime behavior problems. Physical examination must include evaluation of the general appearance, craniofacial characteristics, nasal anatomy, airway patency, and tonsillar size. However, these clinical characteristics, including tonsillar size, cannot reliably identify OSA. (31)(32)

Untreated pediatric OSA has been shown to result in neurocognitive, metabolic, and cardiac morbidity. (26) These effects could be mediated by intermittent hypoxemia, sympathetic activation, and sleep fragmentation resulting from recurrent airway obstruction. OSA may be associated with daytime attention problems, hyperactivity, and cognitive deficits, and these tend to improve with treatment. (33) In addition, abnormal blood pressure control, left ventricular hypertrophy, and left ventricular dysfunction have been reported. (34)(35) Metabolic effects include increased incidence of insulin resistance and fatty liver disease in obese children with OSA. (36)(37)(38)

OSA Diagnosis

A PSG provides an objective measurement of respiratory event frequency and ventilatory impairment during sleep and is the gold standard for diagnosis of OSA. (26)(27)(39) Events are classified as obstructive apneas or hypopneas based on the degree of airflow limitation. (39) The apnea-hypopnea index (AHI) is calculated as the number of apnea events plus hypopnea events per hour of sleep (Fig 1). In children, OSA is defined as an AHI greater than 1. (26) Experts classify the severity of OSA based on AHI scores, with AHI scores of 1 to 5, greater than 5 to 10, and greater than 10 deemed to be mild, moderate, and severe OSA, respectively. (39) Hypoventilation (carbon dioxide >50 mm Hg for >25% of sleep time) may be a key finding of obstructive breathing in children with obesity, Down syndrome, and neuromuscular disorders. (40) Alternative testing modalities, such as home sleep studies and overnight pulse oximetry, hold promise due to increased patient acceptance, reduced cost, and improved access but are not currently recommended for diagnosing pediatric OSA due to the high false-negative rate. (41)(42)

OSA Treatment

Children with suspected OSA should be referred to a sleep medicine specialist or an otolaryngologist (39) or should directly undergo a nocturnal PSG. (26)(39)(40) It is important to note that the American Academy of Otolaryngology–Head and Neck surgery guidelines recommend PSG only for children younger than 2 years, or if they exhibit comorbidities (eg, obesity, Down syndrome, craniofacial abnormalities, neuromuscular disorders, sickle cell disease, or mucopolysaccharidoses), or when the examination findings are not consistent with symptoms. (43)

OSA treatment is indicated for an AHI greater than 5 irrespective of OSA-associated comorbidities as well as for an AHI of 1 to 5 in the presence of OSA-associated comorbidities. (40) Adenotonsillectomy is generally considered the first-line treatment for OSA in otherwise healthy children aged 2 to 18 years with adenotonsillar hypertrophy. (26) Adenotonsillectomy is usually performed in the outpatient setting unless there is an increased risk of postoperative respiratory compromise due to young age (<2 years), severe OSA, obesity, or cardiac and craniofacial abnormalities. The success rate of adenotonsillectomy in otherwise healthy children aged 2 to 18 years is approximately 80%. (33) Risk factors for persistent OSA after adenotonsillectomy include obesity, severe OSA, and craniofacial abnormalities. (33) Weight loss improves OSA in overweight children and can be used in combination with other treatments for moderate to severe OSA syndrome or as the sole treatment for mild OSA. (44)(45)

Delivering positive airway pressure (PAP) via a mask continuously or via bilevel pressures distends/opens the

Table 3. Symptoms of Obstructive Sleep Apnea in Children

NOCTURNAL	DAYTIME
Snoring	Attention problems or poor academic performance in school
Pauses in breathing	Hyperactivity and other behavior problems
Labored breathing	Personality changes, such as being moody, cranky, or irritable
Restless sleep with tossing and turning	Sleepiness (eg, falling asleep in school or napping at unusual times)
Unusual sleep position (seated position, arched back, head tilted back)	Headaches on waking from sleep
Frequent awakenings from sleep	Hyponasal voice
Bed-wetting	Mouth breathing

airway during sleep and has been shown to improve OSA and its sequelae in children. (46) The PAP compliance rate in children is approximately 50%, with a higher compliance rate among children aged 6 to 12 years. (46)(47) PAP therapy, when tolerated, is very effective for OSA in children, especially those with Down syndrome. (48) PAP adherence may be improved with proper mask fitting and behavioral intervention by a psychologist.

Supplemental oxygen can be used to correct oxygen desaturations during sleep in children with severe OSA who are not candidates for surgical treatment and do not tolerate PAP therapy. It can also be used as a bridge to definitive therapy. Of note, hypercapnia may occur with oxygen supplementation and should be ruled out before prescribing home oxygen. Dental procedures (eg, rapid maxillary expansion) may benefit children who have both OSA and a narrow palate. Mandibular advancement devices are an option in selected patients. (40) Recently, hypoglossal nerve stimulator implants have shown promise in adolescents with both Down syndrome and severe OSA, despite adenotonsillectomy. (49) Alternate treatment options for mild OSA include nasal corticosteroid spray or watchful waiting for 6 months. (50) PSG-confirmed resolution of OSA has been demonstrated in up to 50% of school age children with mild to moderate OSA without specific intervention. (33)

The current management paradigms for OSA commonly use abnormal PSG as a criterion for initiation of treatment. However, improvement in behavioral outcomes after adenotonsillectomy have been shown even in snoring children who do not meet PSG criteria for OSA. (33) Results of the Pediatric Adenotonsillectomy Trial for Snoring are awaited to guide the management of children with mild or subclinical obstructive sleep–disordered breathing in the future. (51)

HYPERSOMNOLENCE DISORDERS

Excessive daytime sleepiness (EDS) is defined as "the inability to stay awake and alert during the major waking episodes of the day, resulting in periods of irrepressible need for sleep or unintended lapses into drowsiness or sleep." (3) Pediatric EDS has a prevalence of approximately 30% and may also manifest as emotional lability, inattentive-hyperactive behaviors, or deteriorating school performance. (3)(52)(53) The modified Epworth Sleepiness Scale and other screening questionnaires may help distinguish EDS from lack of energy or fatigue. (54)(55) In clinical practice, EDS most frequently results from insufficient sleep or inadequate sleep hygiene habits, including late evening alerting activities such as sports or work, caffeine use, or media consumption. (56) Outside of these lifestyle-related factors, EDS in a school-age child should be taken seriously, and a host of interacting etiologies should be considered (Table 4). Central disorders of hypersomnolence include narcolepsy, idiopathic hypersomnia, and Kleine-Levin syndrome (KLS). (3) These central disorders are a distinct category of disorders where EDS cannot be ascribed to other untreated sleep or circadian rhythm disorders. (3)

Narcolepsy

Narcolepsy comprises a tetrad of symptoms, including EDS for longer than 3 months, cataplexy, sleep paralysis, and hypnagogic hallucinations, with a prevalence of 1 in 2,000 in the United States. (57) Although onset is usually in the second decade, the classic symptoms may not manifest all at once, and diagnosis is often delayed 15 years or more. (58)(59) By definition, EDS is seen in 100% of narcolepsy cases, with daily periods of irrepressible sleep, unexpected "sleep attacks," or extreme "sleep inertia" (ie, propensity to continue sleeping), with confusion or even aggression on forced awakening. (3)(54) Daytime naps are generally refreshing, whereas nighttime sleep may be disrupted with frequent awakenings. (3) Sleep paralysis (waking up from sleep unable to move), and visual or auditory hallucinations at wake-sleep transitions may be reported in 33% to 80% of patients. (3) Cataplexy manifests as a sudden, brief

Table 4. Common Causes of Excessive Daytime Sleepiness

LOW SLEEP QUANTITY	POOR SLEEP QUALITY (INTERRUPTED SLEEP)	CIRCADIAN MISALIGNMENT	CENTRAL DISORDERS OF HYPERSOMNIA
• Behavioral insomnia of childhood • Sleep initiation insomnia • Inadequate sleep hygiene (eg, caffeine, TV watching) • RLS with delay in sleep onset • Environmental factors (eg, noisy, hot, cold, bright)	• Sleep-related breathing disorders (eg, OSA, CSA) • Sleep-related movement disorder (eg, PLMS, RLS) • Medical disorders (eg, asthma, eczema, GE reflux) • Environmental factors (eg, noisy, hot, cold, bright)	• Delayed sleep-wake phase disorder • Irregular sleep-wake rhythm disorder • Non–24-h sleep-wake rhythm disorder	• Narcolepsy • Idiopathic hypersomnia • Kleine-Levin syndrome • Behaviorally induced insufficient sleep • Hypersomnia due to medication, substance, or psychiatric disorder

Modified from Owens (54) and Kotagal (56).
CSA=central sleep apnea, GE=gastroesophageal, OSA=obstructive sleep apnea, PLMS=periodic limb movement of sleep, RLS=restless legs syndrome.

(usually <2 minutes), bilaterally symmetrical loss of skeletal muscle tone precipitated by strong emotions (eg, laughter). Consciousness is preserved, but deep tendon reflexes are transiently suppressed. The suddenness of the spell may mimic syncope or seizure. (60) Mild cataplexy may present with facial droop, ocular ptosis, jaw sagging, tongue protrusion, or unsteady gait. (3) Childhood narcolepsy may coincide with onset of obesity or precocious puberty. (61)

PSG followed by an MSLT the next day are indicated when narcolepsy is suspected. Overnight PSG serves to eliminate alternate causes for EDS (eg, OSA) and document adequate sleep total time. The MSLT tests for daytime sleep propensity. Any sleep-onset REM periods (SOREMPs), defined as REM sleep occurring within 15 minutes of sleep onset, are noted. In the appropriate clinical context, an MSL of 8 minutes or less on the MSLT and a total of 2 or more SOREMPs counted between the PSG and the MSLT are diagnostic. (3) This test is invalid for children younger than 6 years. Careful pretest planning is required to reduce false-positive results from medication effect or poor sleep habits. A urine drug screen is recommended in teenagers. (62)

Narcolepsy is subclassified as type 1 (NT-1) and type 2 (NT-2). (3) The more common NT-1 results from hypothalamic hypocretin (orexin) deficiency. Most patients with NT-1 carry the human leukocyte antigen (HLA) DQB1*0602 subtype and exhibit cataplexy. (63) However, HLA typing is not diagnostic of NT-1 because up to 38% of the general population carries this marker. Association with certain infections (eg, influenza H1N1) and a specific adjuvant-associated influenza vaccine suggests that interacting genetic and environmental factors mediate autoimmune loss of hypocretin neurons. (64)

NT-1 is diagnosed either by an abnormal MSLT result and cataplexy or by a low cerebrospinal fluid hypocretin-1 level (<110 pg/mL). (3) NT-2 is defined by an abnormal MSLT result without cataplexy or cerebrospinal fluid hypocretin abnormalities. Only approximately half of patients with NT-2 carry HLA-DQB1*0602. (63) Less commonly, narcolepsy may be associated with paraneoplastic disorders, hypothalamic lesions, myotonic dystrophy, and Prader-Willi syndrome. (3)(65)

Other Hypersomnias

Idiopathic hypersomnia (IH) presents with EDS for longer than 3 months, long total daily sleep needs (>12–14 hours), unrefreshing naps, sleep inertia, and absent cataplexy. The PSG and MSLT together show fewer than 2 SOREMPs and may record an MSL of less than 8 minutes. (3) KLS is a rare disorder that presents in teenagers, with cyclical EDS accompanied by behavioral changes (eg, hyperphagy, anorexia, hypersexuality) and altered cognition and mood. During the sleepy phase, the patient may sleep 16 to 20 hours a day and cycles may last from 2 days to 5 weeks, with relapses usually multiple times a year but at least once every 18 months. Children are normal between episodes. (3) There are no confirmatory tests for KLS. (66)

Treatment of Hypersomnia

Narcolepsy and IH are lifelong diseases, whereas KLS tends to resolve over several years. (3)(66) Narcolepsy management includes attention to good sleep habits, regular exercise, judiciously planned daytime naps, and specialized educational plans. (54) In older teens, driving safety, alcohol avoidance, and career counseling are important. (56) Alerting agents such as amphetamine and methylphenidate may be useful. Modafinil is FDA approved for individuals older than 17 years with the warning for Stevens-Johnson syndrome, psychosis, and oral contraceptive failure. (67) Tricyclic antidepressants or selective serotonin (SSRI)/norepinephrine reuptake inhibitors such as venlafaxine, protriptyline, or clomipramine are useful for cataplexy. (56) Sodium oxybate and the newer low-sodium formulation of mixed oxybate salts are FDA approved for children older than 7 years for both EDS and cataplexy in narcolepsy. The oxybates are unique in that they are administered at night in divided doses. Of note, the American Academy of Sleep Medicine has recently published evidence-based guidelines for patients with central disorders of hypersomnolence using the GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) process and advised a "conditional recommendation" for modafinil and sodium oxybate for pediatric narcolepsy but no recommendations for KLS or IH. (68)

PARASOMNIAS

Parasomnias are defined as "undesirable physical events or experiences that occur during entry into sleep, within sleep, or during arousal from sleep." (3) Human consciousness comprises 3 states: wake, NREM sleep, and REM sleep. A blurring of state boundaries and involuntary activation of primitive locomotor centers (central pattern generators) in the brain stem and spinal cord are believed to result in a complex amalgamation of behaviors, experiences, mentation, and recall. (69) Broadly, the various parasomnias may occur in NREM or REM sleep (Table 1).

NREM Parasomnias

Confusional arousals involve moaning, crying, or sitting up in bed with a confused appearance. (3) Sleep terrors begin with a sudden piercing scream associated with profound autonomic activity, including pupillary dilatation, sweating, tachypnea,

and tachycardia. (3) Sleepwalking usually involves glassy-eyed wandering out of bed in an aimless or semi-purposeful manner, but sometimes agitated, dangerous, violent, or uncharacteristic behaviors may occur (eg, urinating in unusual places, exiting home). (70)

NREM parasomnias are relatively common in children of both sexes. The prevalence of confusional arousals is approximately 17.3% among children 3 to 13 years of age. (3) Sleep terrors peak at age 1.5 years (34.4% prevalence) and sleepwalking at age 10 years (13.4% prevalence), with approximately one-third of children with sleep terrors going on to develop sleepwalking in later childhood. (71) The prevalence of sleepwalking is higher for children who have one or both parents who had historically sleepwalked. (71) In contrast, adults have a lower rate of sleepwalking (1.5%) and confusional arousals (2.9%–4.2%). (3)(72)

As a group, NREM parasomnias generally arise from deep sleep (NREM stage 3), which is typically most prominent in the first one-third of the night. These parasomnias often last a few minutes but may well exceed 30 minutes. (67) The eyes are generally open yet the child is difficult to awaken, resists or responds poorly to parental intervention, and has very limited or no recall of the event afterward. (3)(67)

Psychiatric pathology is rarely associated. (70) Untreated OSA, gastroesophageal reflux, anxiety, and neurodevelopmental disorders (eg, autism) may increase the risk. (56)(73) Sleep deprivation, social stress, external or internal stimuli (eg, ringing of a phone, fever, full bladder), and certain medications (eg, sedatives) may prime or trigger such events. (3) As a differential diagnosis, certain nocturnal epilepsy may present with brief (<2 minutes), multiple (sometimes in clusters), stereotypical events with complex motor behaviors and vocalizations. (70)(74)

NREM parasomnias are mostly benign and require no investigations, and children usually outgrow them. Parents should be advised not to interfere with the event and ensure the child's safety (eg, install barriers at stairwells, perimeter door alarms). (75)(76) Frequent, injurious, and potentially dangerous parasomnias, high parental anxiety, or suspicion of comorbid sleep disorders merit overnight PSG. Concomitant video electroencephalography is useful if suspicion for seizures is high. Treating any associated sleep disorder (eg, OSA, inadequate sleep hygiene) may benefit. Clonazepam has been used to suppress NREM parasomnia in high-risk patients. (56)

REM Parasomnias

Nightmares are defined as "extremely dysphoric, and well-remembered dreams that usually involve threats to survival, security, or physical integrity." (3) Anxiety, fear, embarrassment, or disgust are common. (3) In contrast to NREM parasomnias, nightmares tend to occur in the second half of the night, when REM sleep is common. During nightmares, children typically awaken easily with vivid recall of the experience.

The prevalence of occasional nightmares is 60% to 75%, whereas recurrent nightmares occur in 20% to 30% of children and in 4% of adults. (76)(77)(78) They may be associated with posttraumatic stress, anxiety, or other psychopathology, as well as certain medications. (3)(56) Nightmare disorder is diagnosed when recurrent nightmares result in significant effects such as mood disturbance, bedtime resistance, nighttime fears, daytime fatigue, effect on education, or familial dysfunction. (3) Reassurance and attention to good sleep hygiene are helpful (Table 2). Depending on the age of the patient, specific psychological interventions may include image rehearsal therapy, relaxation techniques, desensitization, and exposure therapy. (79)

REM sleep behavior disorder (RBD) involves "acting out of dreams" due to loss of the normal skeletal muscle atonia, which is characteristic of typical REM sleep. (3) This results in complex or even violent behaviors (punching, kicking, leaping out of bed). On awakening, the person becomes rapidly alert and coherent (in contrast to sleepwalking). (3) In adults, it is frequently associated with degenerative brain disorders. (3) RBD is very rare in childhood and may sometimes be associated with brainstem lesions, narcolepsy, and SSRI medication use. (56) Diagnostic PSG is always indicated if RBD is suspected to confirm loss of skeletal muscle atonia on limb EMG and to screen for other sleep disorders, such as OSA, which may be associated with motor activity in sleep. (3) Treatment usually involves clonazepam or melatonin and attention to any underlying precipitants. (56)

SLEEP-RELATED MOVEMENT DISORDERS

Sleep-related movements are common in young children and may occur at the transition from wakefulness to sleep, during sleep, or both. (80)(81)(82) Restless legs syndrome (RLS) and periodic limb movement disorder (PLMD) have a prevalence of 2% to 4% in children and adolescents. (83)(84) Although periodic limb movements of sleep (PLMS) are common in RLS, PLMD and RLS are distinct clinical conditions with specific diagnostic criteria. (3) Their pathogenesis is not well-understood, but genetic factors, dopaminergic dysfunction, and iron deficiency have been implicated. (84) RLS and PLMD are associated with cardiovascular, autonomic, and neurocognitive changes. (83)(84)

General symptoms may include leg discomfort, attention deficits, and absence of restful sleep. (3) A complete

neurologic examination is essential to rule out other causes of leg discomfort, such as positional discomfort, muscle/ligament/tendon sprain, positional ischemia (numbness), dermatitis, peripheral neuropathy, and fibromyalgia. PLMS are defined by specific PSG scoring criteria and comprise repetitive, stereotyped limb movements (Fig 1), with a frequency of greater than 5 per hour considered to be abnormal for children. (3)

RLS is diagnosed clinically by a set of symptoms, including an irresistible urge to move the legs usually accompanied by unpleasant leg sensations that are worse during inactivity, are partially or totally relieved by movement, and occur predominantly in the evening or night. (3) A family history of RLS or PLMS on PSG may be supportive in diagnosing RLS in the child who is too young to describe the classic RLS symptom set (Fig 1). When abnormal PLMS or symptoms of restless legs cause sleep onset or maintenance problems (with or without daytime impairment), which cannot be better explained by another cause, they are deemed PLMD or RLS, respectively (Table 1). (3)

Restless sleep disorder (RSD) is a newly described sleep disorder characterized by large body movements and repositioning throughout the night, with at least 5 large body movements per hour and a significant effect on daytime behaviors. (85) Sleep-related rhythmic movements (eg, head banging, body rocking) are quite common during wake-sleep transitions in typically growing infants and toddlers but are termed *rhythmic movement disorder* if they interfere with sleep, compromise daytime functioning, or result in injuries. (3)

Tests to evaluate iron status, including complete blood cell count, serum iron level, and serum ferritin level, are indicated for RLS, PLMD and RSD. Additional tests may be indicated if neuropathy is suspected, such as thyroid function, fasting blood sugar and insulin, and serum levels of vitamins B_6, B_9, and B_{12}.

Management of Sleep-Related Movement Disorders

Similar to other sleep disorders, attention to good sleep habits is a cornerstone of RLS management (Table 2). Medications, such as SSRIs, that could aggravate RLS and PLMD should be substituted or discontinued. Caffeine should be avoided. Rhythmic movement disorder generally requires reassurance and common sense safety measures.

Pharmacotherapy is used when lifestyle modifications do not suffice. Oral iron supplemented at 3 mg of elemental iron per kilogram per day for 3 months is the first-line treatment in children with RLS, PLMD, or RSD, presenting with low serum ferritin levels (<50 ng/mL [<50 μg/L]). (85)(86)(87) Intravenous iron has been used in children who do not tolerate or fail oral iron therapy. Second-line treatment options for RLS and PLMD include α2δ-1 ligands such as gabapentin, pregabalin, and gabapentin enacarbil. (88) Clonazepam has also been tried. (89)

Summary

- Sleep disorders are common in children and may manifest as fatigue/malaise; attention, concentration, or memory impairment; impaired social, family, occupational, or academic performance; mood disturbance or irritability; daytime sleepiness; reduced motivation, energy, or initiative; and proneness to errors or accidents.
- Behavioral interventions are the first-line treatment for insomnia, but a combined psychological and pharmacologic approach may be useful for certain populations (eg, those with neurodevelopmental disorders, pervasive developmental disorders, chronic medical conditions, and psychiatric disorders). Although no medications are as yet approved by the US Food and Drug Administration (FDA) for treating pediatric insomnia, expert consensus supports a rational approach for use. (Based on expert consensus)
- Psychophysiological insomnia can be effectively treated by cognitive behavioral therapy for insomnia. (Based on research studies with evidence quality grade A)
- Children with suspected obstructive sleep apnea (OSA) should undergo nocturnal polysomnography (PSG), whereas the American Academy of Otolaryngology–Head and Neck Surgery recommends adenotonsillectomy without PSG except if at high risk for postoperative complications. (Based on practice guidelines from the American Academy of Sleep Medicine and the American Academy of Pediatrics)
- OSA treatment is indicated for an apnea-hypopnea index greater than 5 irrespective of any OSA-associated comorbidities as well as an apnea hypopnea index of 1 to 5 in the presence of OSA-associated comorbidities. (Based on practice guidelines)
- Adenotonsillectomy is generally considered the first-line treatment for OSA in otherwise healthy children with adenotonsillar hypertrophy. (Based on expert consensus)

- Unexplained excessive daytime sleepiness in a school-age child is unusual and should be investigated. Narcolepsy comprises a tetrad of symptoms, including excessive daytime sleepiness for longer than 3 months, cataplexy, sleep paralysis, and hypnagogic hallucinations.
- A multiple sleep latency test preceded by nocturnal PSG is indicated if narcolepsy is suspected. (Based on practice guidelines)
- Frequent, injurious, and potentially dangerous parasomnias; high parental anxiety; or suspicion of comorbid sleep disorders merit overnight PSG. Concomitant video electroencephalography is useful if suspicion for seizures is high. (Based on expert consensus)
- Oral iron is the first-line treatment in children with restless legs syndrome, periodic limb movement disorder, or restless sleep disorder presenting with low serum ferritin levels (<50 ng/mL [<50 μg/L]). (Based on expert consensus and research studies with evidence quality C)

References and teaching slides for this article can be found at https://doi.org/10.1542/pir.2022-005521.

PIR QUIZ

1. A 4-year-old boy is brought to the clinic by his parents for a health maintenance visit. The parents report that the child is displaying behavioral problems during the day and sleep difficulty at night. The parents state that they must stay with the child until he falls asleep, and the child comes into their bed when he awakens in the middle of the night and will not fall back asleep unless they stay with him. Which of the following is the most likely explanation for this child's nighttime behavior?

   A. Attention-deficit/hyperactivity disorder.
   B. Psychological insomnia.
   C. Separation anxiety.
   D. Sleep-onset association disorder.
   E. The child's temperament.

2. The parents of a 9-month-old boy are at their wit's end and exhausted from the effort of getting their son to sleep. The parents hold the baby until he falls asleep, then lay him down in his crib, and repeat this each time the child awakens, which occurs an average of 4 times per night. You explain behavioral techniques and agree on implementing a modified extinction plan. You warn the parents that in the first few days, they may see "extinction bursts" of excessive crying. Which of the following best describes the average expected duration of these extinction bursts in the first few days?

   A. 5 minutes.
   B. 15 minutes.
   C. 25 minutes.
   D. 35 minutes.
   E. 45 minutes.

3. A 6-year-old is brought to the clinic by his parents for an annual health maintenance visit with no specific parental concerns. The physical examination is notable for a BMI of 32 and mild tonsillar hypertrophy. On pursuing physical activity and diet history, you learn that he is "too tired" to play outside. The mother works the night shift and cannot comment on his sleep hygiene or snoring. A polysomnogram shows moderate to severe obstructive sleep apnea. Recommendations for which of the following interventions is the most appropriate next step in management?

   A. Adenotonsillectomy.
   B. Monitoring.
   C. Prone sleep positioning.
   D. Supplemental oxygen.
   E. Weight loss program.

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4. A 10-year-old boy presents with his mother, who is concerned about his psychological well-being. In recent weeks he has been found wandering around the house at night after he has gone to bed and fallen asleep. Mom reports that he is "zombie-like" and does not respond to her in these wanderings. Your patient does not believe his mother's report and calls her "hysterical." There is a very high level of anxiety and conflict around this topic. Which of the following is the most appropriate first recommendation and measure that should be taken by the clinician for this patient?

    A. Educate the family on parasomnias, their benign nature, and safety measures.
    B. Order a polysomnogram with an electroencephalogram.
    C. Prescribe clonidine to optimize more successful sleep.
    D. Recommend that mom videotape an event to reduce conflict.
    E. Refer to psychiatry to rule out dissociative disorder.

5. A 15-year-old girl who is a sprinter on the high school track team is brought to the clinic for a routine health visit. On inquiry about diet and sleep, she reports that she has a very hard time falling asleep because her "legs are jumpy." She reports that this has been distressing, especially when it occurs the night before a track meet or an examination. The laboratory evaluation for the suspected diagnosis should include which of the following studies?

    A. Blood toxicology screen.
    B. Serum creatinine kinase.
    C. Serum electrolytes.
    D. Serum iron, ferritin, and complete blood cell count.
    E. Urine specific gravity.