

# Sleep in Children With Cerebral Palsy: A Review

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## Abstract

Children with neurodevelopmental disabilities, such as cerebral palsy, are considered to be a population at risk for the occurrence of sleep problems. Moreover, recent studies on children with cerebral palsy seem to indicate that this population is at higher risk for sleep disorders. The importance of the recognition and treatment of sleep problems in children with cerebral palsy cannot be overemphasized. It is well known that the consequences of sleep disorders in children are broad and affect both the child and family. This review article explores the types and possible risk factors associated with the development of sleep problems in children with cerebral palsy and the impact of this disorder on the child and family. In addition, a brief summary of current diagnostic and treatment modalities is provided. Finally, the characteristics, diagnostic techniques, and management of sleep-related breathing disorders in children with cerebral palsy are discussed.

## Keywords

sleep, cerebral palsy, obstructive sleep apnea, disorders of initiating and maintaining sleep

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Children with neurodevelopmental disabilities, such as cerebral palsy, are considered to be a population at risk for the occurrence of sleep problems.<sup>1</sup> Cerebral palsy is defined as a group of disorders of movement and posture causing activity limitations that can be attributed to nonprogressive disturbances that occur in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, behavior, and/or a concurrent seizure disorder.<sup>2</sup> Cerebral palsy is estimated to occur in 1.5 to 2.5 children per 1000 live births in developed countries and is the most common cause of childhood physical impairment.<sup>3</sup>

It is estimated that 13% to 85% of children with neurodevelopmental disabilities, including cerebral palsy, suffer from a clinically significant sleep problem.<sup>4</sup> It remains unclear whether cerebral palsy, among a population of children with neurodevelopmental disabilities, represents a risk factor for the presence of sleep problems.<sup>5-8</sup> However, more recent studies of children with cerebral palsy seem to indicate that this population is indeed at higher risk for sleep disorders. In a questionnaire-based survey published by Newman and colleagues<sup>9</sup> in 2006, 23% of the children with cerebral palsy had an abnormal total sleep score, and 44% of children had at least one clinically significant sleep disorder. Another study published by Hemmingsson and colleagues in 2009<sup>10</sup> looked at the

prevalence of sleep problems in a population of children with physical disabilities (cerebral palsy, spina bifida, muscular dystrophy, and other diagnoses) and found that as a group, 48% of children had sleep problems, of which 24% had moderate or severe difficulties. In this population of children with physical disabilities, a diagnosis of cerebral palsy was strongly associated with the presence of sleep problems.<sup>8</sup>

The importance of the recognition and treatment of sleep problems in children with cerebral palsy cannot be overemphasized. It is well known that the consequences of sleep disorders in children with cerebral palsy are broad and affect both the child and the family. For example, multiple studies have shown

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that sleep dysfunction has a negative effect on daytime behavior and on school performance of both typically developing children and children with cerebral palsy.<sup>5,6,8,11-17</sup> Some studies have shown that sleep problems may not always be appropriately addressed in clinical practice. In a study published in 2002 assessing the prevalence of severe sleep problems in a sample of 286 children with mild to profound intellectual delay, only 19% of the parents of a child with a current sleep problem had received any advice about their child's sleep disorder from a health care professional.<sup>5</sup>

Another important aspect of the recognition, prevention, and treatment of sleep problems in children with cerebral palsy is the understanding of the specific factors that render this population more at risk for a sleep disorder. Thus far, most of the studies focusing on sleep in children with neurodevelopmental disabilities have considered these children as a single group, but the specific mechanisms by which cerebral palsy disturbs sleep remain unclear.

This review article explores the types of sleep problems, their risk factors, and the consequences associated with sleep problems in children with cerebral palsy. In addition, a brief summary of current diagnostic and treatment modalities for sleep disorders is included. Finally, the characteristics, diagnostic modalities, and management of sleep-related breathing disorders in children with cerebral palsy are described.

## Classification of Sleep Problems

It is thought that children with cerebral palsy show the same spectrum of sleep problems as children without cerebral palsy, such as disorders of initiation and maintenance of sleep and sleep-wake transition disorders.<sup>9</sup> Moreover, children with cerebral palsy are thought to be at higher risk for sleep-related breathing disorders, especially obstructive sleep apnea syndromes.<sup>9,18,19</sup> Children with cerebral palsy may be at higher risk for obstructive sleep apnea because of abnormal upper airway muscle tone or because of a primary central abnormality affecting the central control of breathing.<sup>18,20,21</sup> The International Classification of Sleep Disorders divides sleep problems into dyssomnias, parasomnias, and sleep disorders associated with mental, neurologic, or other medical disorders.<sup>22</sup> The dyssomnias are then further divided into intrinsic and extrinsic sleep disorders depending on whether the sleep abnormality is intrinsic to the child or is related to the child's external environment. Among sleep disorders associated with mental, neurologic, or medical disorders, multiple neurological diseases are included such as epilepsy, neurodegenerative disorders, and headaches; however, there is no specific mention of cerebral palsy. Overall, it is not well defined within which category children with cerebral palsy should be classified.

## Sleep-Related Breathing Disorders in Children With Cerebral Palsy

Obstructive sleep apnea is thought to be more common in children with cerebral palsy. In the general population, obstructive

sleep apnea has a prevalence of 1% to 3%, with a peak prevalence between the ages of 2 and 5 years.<sup>23</sup> In the study by Newman and colleagues,<sup>9</sup> 14.5% of the 173 children with cerebral palsy had a pathologic score for the disorders of sleep-related breathing on the Sleep Disturbance Scale for Children, suggesting that sleep-related breathing disorders are more common in children with cerebral palsy.

Obstructive sleep apnea is characterized by upper airway obstruction during sleep. This occurs when pharyngeal dilator muscles are unable to keep the airway patent against the subatmospheric pressure of inspiration. Resistance to airflow can be increased by multiple anatomic factors at sites from the nose to the larynx. In young children, adenotonsillar hypertrophy is the most common factor. In children with cerebral palsy, additional anatomic factors such as disproportionate midface anatomy or mandibular alterations and abnormality of upper airway tone (hypotonia, hypertonia or dystonia) can further contribute to the obstruction.<sup>24-26</sup> Other elements can contribute to obstructive sleep apnea in children with cerebral palsy including abnormal central control of respiration, obesity, and medications that depress upper airway maintenance musculature.<sup>26</sup>

Obstructive sleep apnea has been reported to have several potential adverse sequelae, including failure to thrive, cardiopulmonary compromise, neurobehavioral disturbances, and rarely, death.<sup>25</sup> Diagnosis and management of obstructive sleep apnea are thus important to help prevent the development of these complications. The first step in the diagnosis of obstructive sleep apnea is a detailed sleep history. Families often report noisy breathing and loud snoring during sleep, waking periods, pauses in respiration, and daytime somnolence. According to a study by Brouillette and colleagues,<sup>27</sup> the 3 most predictive symptoms associated with obstructive sleep apnea are loud snoring, difficulty breathing during sleep, and sleep-related pauses in breathing (apnea) witnessed by the parents. Physical examination in the awake child is often unremarkable, and the most common abnormality found on physical examination is tonsillar enlargement. The gold standard measurement tool for the diagnosis of obstructive sleep apnea remains polysomnography. However, this is expensive to implement and not widely accessible in all centers. In children, at least 1 obstructive apnea or hypopnea event per hour of sleep with each event lasting at least 2 respiratory cycles in duration on polysomnography study is diagnostic of obstructive sleep apnea.<sup>22</sup> Other diagnostic methods such as nocturnal pulse oximetry have been shown to be effective in detecting moderate to severe obstructive sleep apnea in otherwise healthy children, but oximetry has not been validated in patients with additional neurological comorbidities.<sup>28</sup> Thus far, studies have found that questionnaires such as the OSA-18, the Pediatric Sleep Questionnaire, and the Brouillette OSA score are helpful as screening tools but too inaccurate to serve as a definitive diagnostic test for obstructive sleep apnea.<sup>27,29,30</sup> Although not diagnostic, a lateral neck radiograph or flexible endoscopy can be performed to help assess for adenotonsillar enlargement; upper airway fluoroscopy, computed tomography, and

magnetic resonance imaging can be useful if the site of obstruction remains unclear.<sup>26</sup>

Because obstructive sleep apnea is a multifactorial disorder in children with cerebral palsy, treatment must be individualized and depends on the underlying neurologic abnormalities and on the site of obstruction. A repeat polysomnography 3 months after treatment is recommended by some authors to assess for response.<sup>24</sup> Adenotonsillectomy remains the most common treatment in obstructive sleep apnea for all children with adenotonsillar hypertrophy, including those children with cerebral palsy. However, because of the additional and sometimes different etiologic factors of obstructive sleep apnea in children with cerebral palsy, less standard surgical approaches such as mandibular advancement and tongue–hyoid advancement sometimes are considered. Children with cerebral palsy are at increased risk of postsurgical complications and need close postoperative monitoring.<sup>24</sup> Medical therapies including continuous positive airway pressure and bilevel airway pressure have a role in selected patients, including those who have failed to improve after surgery. The control of abnormal tone can contribute to the treatment of obstructive sleep apnea in patients with cerebral palsy, as suggested by one case report that found improvement of sleep apnea in a patient with spastic quadriplegic cerebral palsy following implantation of a baclofen pump.<sup>31</sup> Finally, an important part of the treatment of obstructive sleep apnea in children with cerebral palsy is the identification and aggressive management of comorbid conditions such as gastroesophageal reflux, hypersalivation, and obesity.<sup>25</sup>

## Factors Associated With the Development of Sleep Problems

Thus far, there is no consensus on why children with cerebral palsy have more apparent sleep difficulties. One hypothesis relates to an intrinsic anomaly in sleep regulation, involving an endogenous dysfunction in hormonal release necessary for the maintenance of the circadian rhythm.<sup>1</sup> A few studies have shown abnormal melatonin secretion in children with mental retardation or intellectual disability, which frequently coexists in the context of cerebral palsy.<sup>1,32</sup> Some studies have found abnormal patterns on electroencephalogram during sleep in up to 50% of children with cerebral palsy, including the absence of rapid eye movement sleep and abnormalities in the generation of sleep spindles.<sup>9,33,34</sup> Another hypothesis is that sleep difficulties can be linked to the comorbidities often found in children with cerebral palsy, such as concurrent epilepsy, intellectual disability, or a primary sensory impairment (ie, vision or hearing). A particularly severe neuromotor impairment could be a plausible explanation.

### Intellectual Disability

It is reported that 30% to 50% of children with cerebral palsy have associated mental retardation or intellectual disability.<sup>33</sup> Contradictory results have also been found regarding the

impact of an intellectual disability on sleep. Some studies have found that the degree of intellectual disability is a predictor of a sleep problem,<sup>5,35,36</sup> whereas other studies have found that the level of intellectual disability was not associated with the frequency of either past or current sleep problems.<sup>6,11</sup> By contrast, one study done in children with abnormal development found that a more severe degree of intellectual disability was a predictor of an increased amount of nighttime sleep<sup>37</sup> and was thus considered a “protective factor” for the occurrence of sleep problems. Finally, some studies found that poor communication skills were significantly associated with the presence of sleep problems and that poor communication skills were a better predictor of sleep problems than the degree of cognitive limitations.<sup>35,6,12</sup>

### Epilepsy

The presence of comorbid epilepsy is a well-accepted risk factor for the development of sleep problems in children with neurodevelopmental disabilities.<sup>5,6,9,37,38</sup> However, it remains unclear whether it is the epileptic disorder itself through a defect in endogenous sleep regulation or rather other features of the disorder such as the presence of nocturnal seizures or antiepileptic medication that lead to the development of sleep problems. The prevalence of seizures in patients with cerebral palsy ranges between 15% and 55% and increases to 71% in patients with comorbid intellectual disability.<sup>33</sup> Some studies have found that the presence of concurrent epilepsy increases the risk of having sleep problems in a population of children with neurodevelopmental disabilities, including physical impairment.<sup>5,6,38</sup> Other studies have found that it is only the presence of the active epilepsy that is a risk factor for developing sleep problems.<sup>9,37</sup> Some authors suggest that the association between epilepsy and sleep disorders could be explained by frequent nocturnal arousals caused by subtle seizures.<sup>39</sup> Other authors argue that it is perhaps secondary to abnormal melatonin secretion, thus representing an endogenous defect in sleep regulation.<sup>40</sup> Some investigators have postulated that the use of antiepileptic medications increases the risk of having concurrent sleep problems,<sup>5</sup> whereas another study found no such association.<sup>9</sup> One study noted that the specific use of valproic acid was protective for the development of sleep problems.<sup>7</sup> More studies are needed to clarify the effects of comorbid epilepsy and its impact on sleep.

### Visual Impairment

The presence of a primary visual impairment, such as a cortical visual impairment, is better accepted as a risk factor for the development of sleep problems.<sup>7,9,37,41</sup> Between 20% and 50% of children with cerebral palsy have a cortical visual impairment.<sup>42</sup> Bright light, via the retinal hypothalamic tract, is the most potent stimulus of the suprachiasmatic nuclei, the primary mammalian circadian pacemaker. Melatonin, a hormone implicated in the sleep–wake cycle, is secreted by the pineal gland during darkness and suppressed by exposure to

light. Without light, most humans have a genetically influenced free-running sleep–wake cycle of around 25 hours, with a stable total sleep time spread over both “day” and “night.” This occurs despite the presence of social and other environmental cues indicative of the normal 24-hour cycle. A questionnaire-based survey done in France on a combined pediatric and adult blind population revealed that 83% of the 1073 responders had at least one sleep problem compared with 57% in the control population. In the same cohort, 59% had no light perception and 17% reported a free-running sleep–wake cycle.<sup>41</sup>

### Characteristics of Motor Impairment

The effect of the severity and type of motor disability on sleep is not yet understood. Although still controversial, it has been suggested by some that a more “total” body involvement represents a risk factor for the development of sleep problems. In the study published by Newman and colleagues<sup>9</sup> in 2006, patients with spastic quadriplegia and dyskinetic cerebral palsy were found to be more at risk for having sleep problems than those children with a more focal (ie, hemiplegic or diplegic) restricted involvement of physical impairment. Interestingly, in the same study, the presence of a sleep disorder was not associated with the severity of the motor deficit as stratified by the Gross Motor Function Classification System. In another study, performed in children with developmental delay, the coexistence of a severe locomotor disability was associated with disturbed sleep–wake behavior.<sup>37</sup> However, in a study of children with “mental impairment” (ie, cognitive disability), the level of an associated physical impairment was not associated with either the presence or the severity of sleep problems.<sup>7</sup> Finally, in a study of 374 adults who suffered from a traumatic spinal cord injury, another population with an objective motor impairment, 32% complained of a sleep disturbance, a prevalence thought to be greater than that in the general adult population.<sup>43</sup> It is not clear how the severity of motor impairment (ie, the amount and quality of body movements) can influence sleep. More studies are needed to clarify the effect of the severity and type of motor impairment on sleep, ideally with objective measures of sleep and the quantity and distribution of body movements during sleep.

### Abnormal Tone and Pain

Another particularity of children with cerebral palsy that could have a negative impact on sleep is the occurrence of pain or discomfort related to underlying abnormal tone. Some studies reported pain to be the strongest contributing factor to sleep problems in a population of children with physical disabilities.<sup>43,44</sup> Moreover, a recent study done on 35 children with bilateral cerebral palsy (ie, spastic quadriplegia or diplegia) and severe spasticity showed an improvement in the frequency of nighttime awakening along with objective severity of pain within 6 months following the implantation of an intrathecal baclofen pump.<sup>45</sup> One study done on a population of adults with spasticity of varying origins showed similar results with

improvement in sleep quality and quantity after the aggressive treatment of underlying spasticity with intrathecal baclofen.<sup>42</sup> A recent study performed on 26 children with nonambulant quadriplegic cerebral palsy reported improved sleep pattern after treatment of lower limb spasticity with Botulinum toxin type A injections. Improvements included settling more easily to sleep, having a reduction in the frequency of night-time awakening, and a decreased need for turning because of hip discomfort.<sup>46</sup>

### Other

Finally, a potential contributor to sleep problems in children with cerebral palsy is the postural equipment sometimes worn at night. However, this association was not found to be significant in either the study by Newman and colleagues<sup>9</sup> or a more recent pilot study in which sleep was measured using polysomnography.<sup>34</sup> Moreover, some patients with a severe motor deficit need for their caregiver to change their body position during sleep to prevent bed sores, which could also have a negative effect on sleep patterns and quality.<sup>12</sup> In the study by Hemmingsson and colleagues,<sup>43</sup> 56% of children with cerebral palsy needed parental nighttime attention at least once each night. However, it is interesting to note that parental nighttime attention and sleep problems were not consistently correlated.

### Consequences of Sleep Problems on the Child and the Family

The consequences of sleep disorders are broad and affect both the child and the family. We know that sleep dysfunction has a negative effect on daytime behavior and that both typically developing children and children with neurodevelopmental disabilities suffering from sleep disorders have been found to have higher scores on behavioral scales indicating more irritability, hyperactivity, aggression, screaming, and impulsivity.<sup>5,6,8,11-13</sup> A study performed in a population of healthy school-aged children found a significant association between decreased sleep time and a higher rate of psychiatric symptoms as reported by the child’s teacher.<sup>14</sup> Multiple studies have explored the relationship between sleep problems and school performance. A study done with 449 healthy school-aged children found a direct relation between the self-rating of the quality of sleep and objective school functioning.<sup>15</sup> The presence of sleep-disordered breathing has been linked by multiple studies with poorer school performance.<sup>16</sup> Moreover, the Québec Longitudinal Study of Child Development recently published data showing that children who were sleeping less at a young age were more likely to score lower on various cognitive scales such as the Peabody Picture Vocabulary Test and the Wechsler Block Design test.<sup>17</sup>

Sleep problems can have a significant impact on the child’s family. In studies done with families of children suffering from both a neurodevelopmental disability (including cerebral palsy) and a clinically significant sleep problem, it has been shown

that parents often complain that they themselves are not getting enough sleep.<sup>5,6,8,12,43</sup> In the same population, previous studies have shown that parents of children with sleep problems feel more stressed and irritable and relate that their child's sleep problems affect their own daytime lives and represent an extra demand on already limited personal time and energy.<sup>5,11,12,44</sup> In one study, parents also believed that as a result they had a relatively impoverished social life.<sup>5</sup> Conversely, family stressors may negatively affect a child's sleep pattern.<sup>48</sup>

## Clinical Recognition and Diagnosis of Sleep Disorders

The first step in the management of sleep problems is its recognition on a clinical basis. In a study published in 2002 assessing the prevalence of severe sleep problems in a sample of 286 children with mild to profound intellectual delay, only 19% of the parents had received any advice about their child's current sleep problem.<sup>5</sup> Multiple tools are available to the clinician working in an outpatient clinic to screen for the presence of sleep problems in children. One such tool, the BEARS sleep screening tool, was found to increase the amount of sleep information recorded in charts in a pilot study performed in a pediatric residents' continuity clinic.<sup>48</sup> The mnemonic BEARS stands for Bedtime issues, Excessive daytime somnolence, night Awakenings, Regularity and duration of sleep, and Snoring. In this study, BEARS forms were placed in the chart of every patient who had a medical appointment, and the amount of sleep-related information was recorded before and after BEARS implementation. Regardless of the way sleep-related information is obtained, a sleep history has to be developmentally oriented. For example, daytime naps are expected in toddlers but are usually pathologic in teenagers. In the specific population of children with cerebral palsy, questions should be asked to address the multiple comorbidities with a potential effect on the child's sleep pattern, such as the presence of nocturnal seizures, abnormal tone or cramps, evening medication use, and the use of nocturnal postural equipment. Finally, the clinician should always inquire about the effect of the child's sleep problem, if present, on the family.

Multiple questionnaires are available to the clinician to screen for the presence of the most common sleep problems in children. Some questionnaires have to be completed by the parents and others by the child. For example, the Sleep Disturbance Scale for Children is a validated parent-report questionnaire designed for children ages 3 to 18 years that contains 26 items related to the most common sleep problems found in this population. It is grouped into 6 subscales: (1) disorders of initiation and maintenance of sleep, (2) sleep breathing disorders, (3) disorders of arousal, (4) sleep-wake transition disorders, (5) disorders of excessive somnolence, and (6) sleep hyperhydrosis.<sup>49</sup> Parents are asked to recall sleep behaviors occurring in the past 6 months. Items are rated on a 5-point scale: *always* if the sleep behavior occurs daily, *often* for 3 to 5 times per week, *sometimes* for 1 to 2 times per week,

*occasionally* for 1 to 2 times per month or less, and *never*. The questionnaire yields both a total score and 6 subscale scores.<sup>49</sup>

The Children's Sleep Habits Questionnaire is a validated, retrospective, parent-report questionnaire designed for children ages 4 to 10 years. It contains 35 items related to the most common sleep problems found in this population and is grouped into 8 subscales: (1) bedtime resistance, (2) sleep onset delay, (3) sleep duration, (4) sleep anxiety, (5) night waking, (6) parasomnias, (7) sleep-disordered breathing, and (8) daytime sleepiness.<sup>19</sup> Parents are asked to recall sleep behaviors occurring over a typical recent week. Items are rated on a 3-point scale: *usually* if the sleep behavior occurred 5 to 7 times per week; *sometimes* for 2 to 4 times per week; and *rarely* for 0 to 1 time per week. The questionnaire yields both a total score and 8 subscale scores. For this questionnaire, data obtained in a community sample of 469 healthy children ages 4 to 10 years are available for comparison.<sup>50</sup> A total score of 41 or higher has been reported to be a good clinical indicator of the presence of a sleep problem with a sensitivity of 0.80 and a specificity of 0.72.<sup>19</sup> In addition to answering questionnaires, parents can be requested to keep a sleep log or diary of their child's sleep pattern over a certain period of time, typically 2 weeks.

If a clinician suspects a sleep problem or specific sleep disorder, the child is usually referred to a specialized sleep clinic and/or sleep laboratory where objective measurements are obtained to establish a diagnosis. Indeed, some studies have shown that parents tend to overestimate or underestimate their child's sleep problem.<sup>5,51</sup> Polysomnography remains the gold standard for the diagnosis of sleep problems in the pediatric population. This technique records a wide range of electrophysiological measures to assess sleep and breathing, including sleep continuity, rapid eye movement sleep, and non-rapid eye movement sleep as well as cardiorespiratory measures for diagnosis of sleep-related breathing disorders. However, for the family caring for a child with cerebral palsy, this means spending at least 1 night in the hospital, which may be impractical in this specific population. Actigraphy represents a good alternative to obtain objective sleep measurements at home in the child's usual sleep environment. The actigraph, a portable device with a highly sensitive accelerometer, can continuously record movements of body parts over extended periods of time. Based on the high correlation between movement and wakefulness and absence of movement during sleep, actigraphy has been shown to distinguish between sleep and wakefulness with high accuracy in healthy individuals. The 2007 version of the practice parameter for the use of actigraphy from the American Academy of Sleep Medicine states that "actigraphy is indicated for delineating sleep patterns and to document treatment responses in healthy infants and children and in special pediatric populations."<sup>53(p525-526)</sup> However, as also stated by the American Academy of Sleep Medicine, "further work is needed to clarify the relative and unique contributions of actigraphy, polysomnography and sleep logs in the diagnosis of sleep disorders and measurement of treatment effects."<sup>52</sup>

## Treatment of Sleep Problems

As previously described, sleep problems in children with cerebral palsy are often complex and treatment is often challenging. The first step in the treatment of dyssomnia in children with cerebral palsy should always be behavioral interventions, such as graduated extinction, faded bedtime, parent education, and positive bedtime routines. For example, graduated extinction helps the child to fall asleep independently. The child is placed in his bed or crib while still awake, and over several days the parent waits an increasing amount of time before reentering the room if the child cries. In the faded bedtime method, the child is initially put to bed when he or she is more likely to fall asleep. Subsequently, bedtime is moved 15 minutes earlier every 2 to 3 days until the desired bedtime is achieved.<sup>53</sup> These techniques have been found highly effective for treatment of insomnia in typically developing infants and young children as published in the American Academy of Sleep Medicine review.<sup>54</sup> Another review of the treatment of sleep problems in individuals with severe intellectual disability or multiple handicaps also found that behavioral interventions were effective.<sup>55</sup>

Even though behavioral and environmental modifications have a definite place in the treatment plan, the effect can be limited in certain subtypes of children with cerebral palsy. Sedatives, such as  $\alpha$ -agonists, antihistamines, chloral hydrate, and benzodiazepines, are prescribed for sleep problems in this specific population but can be associated with enhanced daytime sedation, an increased risk of sleep-related breathing disorders, and increased behavioral problems, in addition to possible interactions with other medications taken by the child.<sup>56</sup> Exogenous supplements of melatonin have been used with success in typically developing children and in certain populations of children with neurodevelopmental disabilities. A recent review on the effect of melatonin on sleep disorders in children with intellectual disability of varying origins identified 6 randomized controlled trials with a total of 82 patients. The conclusion of the review was that melatonin is probably effective in reducing sleep onset latency and increasing total sleep time. No effect was found on nighttime awakenings.<sup>57</sup>

Since publication of the review by Sajith and Clarke,<sup>57</sup> a randomized placebo-controlled trial of melatonin treatment in individuals with intellectual disability and chronic insomnia was published. In this study, 51 individuals of various age groups (2-78 years) were given a 4-week trial with either melatonin or placebo following 1 week of baseline sleep observation. Nine patients had a diagnosis of cerebral palsy in this cohort. The study demonstrated a significant improvement in sleep onset time, sleep latency, number of nighttime awakenings, duration of wake episodes, and total sleep time. Parental observation was used to measure sleep in children.<sup>58</sup> Another randomized placebo-controlled study of melatonin treatment in children with neurodevelopmental disabilities was published in 2008. The study had a crossover design in which the patients were receiving a 10-day course of melatonin or placebo followed by 3 to 5 days of washout period and then 10 days

of the alternative treatment. In this study, a controlled-release form of melatonin was used. Fifty-one children, including 26 children with a diagnosis of cerebral palsy, completed the trial. A significant improvement in total nighttime sleep and sleep latency was documented both by direct observation and by actigraph recordings.<sup>59</sup> Possible adverse effects of exogenous melatonin included enuresis, depression, and excessive daytime somnolence, with one report of increased seizures in a child with severe intellectual disability.<sup>60</sup> More recent studies have found no serious adverse effects associated with melatonin treatment and no apparent effect on seizure control.<sup>61,62</sup>

A recent consensus statement published in 2006 on the pharmacologic management of insomnia in children and adolescents concluded that further studies on the safety and efficacy of pharmacological treatments of insomnia are urgently needed.<sup>63</sup> Of all children and adolescents, those with a neurodevelopmental disability and comorbid insomnia were identified as the specific group with the highest priority for such studies because of their higher rate of sleep problems and poorer response to usual available treatment options.<sup>63</sup>

## Conclusion

Much remains unknown regarding the specific risk factors for the development of sleep problems in children with cerebral palsy. It is also unclear as to what is the best strategy to successfully treat this broad group of sleep disorders in children with cerebral palsy. However, the consequences of sleep problems on the child and family are extensive and well established, affecting various aspects of the child's development and behavior. In children with neurodevelopmental disabilities such as cerebral palsy, great effort should be made to recognize and manage sleep problems to help the child maximize his or her developmental potential. Further studies on diagnosis and management of sleep disorders in this population are greatly needed to provide evidence-based guidelines useful to health care providers, parents, and children.

## Author Contributions

ES-T did the review of literature and wrote the first version of the paper under the supervision of MS. All authors discussed and commented on the manuscript at all stages.

## Declaration of Conflicting Interest

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Not applicable.

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