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Health Review

Attention-Deficit Hyperactivity Disorder (ADHD) and Sleep Disorders: What We Know Now and Where We are Headed

Ana Carolina Gomes de Oliveira [1], Isadora Vergamini Lamana [2], Natália Balbo Arantes Nogueira [3], Larissa Tarraf Bertazzo [1], Júlio César Claudino dos Santos [2, 3, *], Luana Stangherlin [3]

[1] Barão de Mauá University Center, CBM, Ribeirão Preto, São Paulo, Brazil.
[2] Federal University of Ceará, UFC, Fortaleza, Ceará, Brazil.
[3] Unifacvest University Center, UNIFACVEST, Lages, Santa Catarina, Brazil.

* Correspondence: julio.santos@alu.ufc.br.

Abstract: Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder observed in children and adolescents, the manifestations of which affect personal, social and academic performance. The aim of this paper is to explore the relationship between sleep disorders and ADHD symptoms, highlighting the importance of investigating the bidirectional relationship between these two conditions for the management of patients with this neurodevelopmental disorder and its comorbidities. This narrative review synthesizes the current literature to elucidate the interaction between sleep and ADHD, exploring the bidirectional communication between sleep and the comorbid symptoms of ADHD. In addition, it discussed how independent drug therapy can lead to sleep problems, showing how interaction with non-drug therapy is essential for the treatment of ADHD and sleep disorders, improving patient prognosis. Some recent research has revealed a possible link between ADHD and sleep disorders, and how they have a bidirectional relationship with each other, potentially affecting the quality of life and mental health of the individual with these disorders. As we delve deeper into the bidirectional relationship between the disorders, this review provides a comprehensive overview of current knowledge and possible implications for the diagnosis, treatment and approach of ADHD when associated with sleep disorders. Addressing the comorbid conditions of ADHD, such as sleep disorders, is fundamental as a coping strategy for the treatment of this neurodevelopmental condition, which involves both non-pharmacological and pharmacological interventions.

Keywords: Attention deficit hyperactivity disorder (ADHD); Sleep disorders; Bidirectional relationship; Mental health; Comorbid symptoms; Non-drug treatment; Drug treatment.

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1. Introduction

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder with an average prevalence of approximately 5% during childhood and adolescence, the manifestation of which impairs personal, social and academic performance [1-3]. Individuals with ADHD often have sleep disorders, daytime sleepiness and/or circadian rhythm abnormalities. Because alertness deficits and sleep disturbances have been assumed to favor ADHD, ADHD symptoms are likely to be detected in young people with sleep disturbances, evidencing a bidirectional relationship [3].

In this sense, it is interesting to highlight the importance of sleep for adults, children and adolescents with attention deficit hyperactivity disorder. Individuals with ADHD manifest sleep disorders, which can amplify or be the reason for the ADHD clinic, impacting on the quality of life of sufferers and their families [4]. A study carried out in the

United States showed that children with ADHD are more resistant to sleep and have greater difficulty initiating and maintaining sleep, as they wake up several times during the night and are more reluctant to wake up in the morning, demonstrating the impact of ADHD on the sufferer's sleep [5].

Sleep disorders have a high incidence in individuals with attention deficit hyperactivity disorder, which can result in neurobehavioral dysfunctions that resemble or amplify ADHD symptoms [4, 6]. Sleep problems are thought to contribute to the worsening of ADHD symptoms (inattention, hyperactivity and impulsivity) and ADHD can cause a worsening in sleep quality, thus showing a bidirectional relationship between the two disorders [6]. Sleep disorders are associated with worsening clinical, neurocognitive and functional outcomes, resulting in increased signs and symptoms of ADHD. Although it has not yet been proven which factors increase sleep problems in individuals with ADHD, it is possible that they do not have adequate sleep hygiene, so the first approach to intervene to improve the quality of sleep of these individuals. In addition, individuals with ADHD find it more difficult to adhere to treatment and have serious problems organizing their routine due to their difficulty in resisting immediate temptations, such as social networks. Professionals specializing in this area therefore suggest that sleep problems should be addressed in conjunction with the ADHD sufferer's functional deficiencies, because they are correlated in a communicative and bidirectional way [7].

Therefore, according to the information provided in this introduction and given the importance of ADHD in association with sleep disorders, a more in-depth study on the subject is indispensable. Therefore, this article seeks to deepen the connection between ADHD and sleep disorders and how they have a bidirectional relationship with each other, to improve the quality of life of individuals with ADHD.

2. Methodology

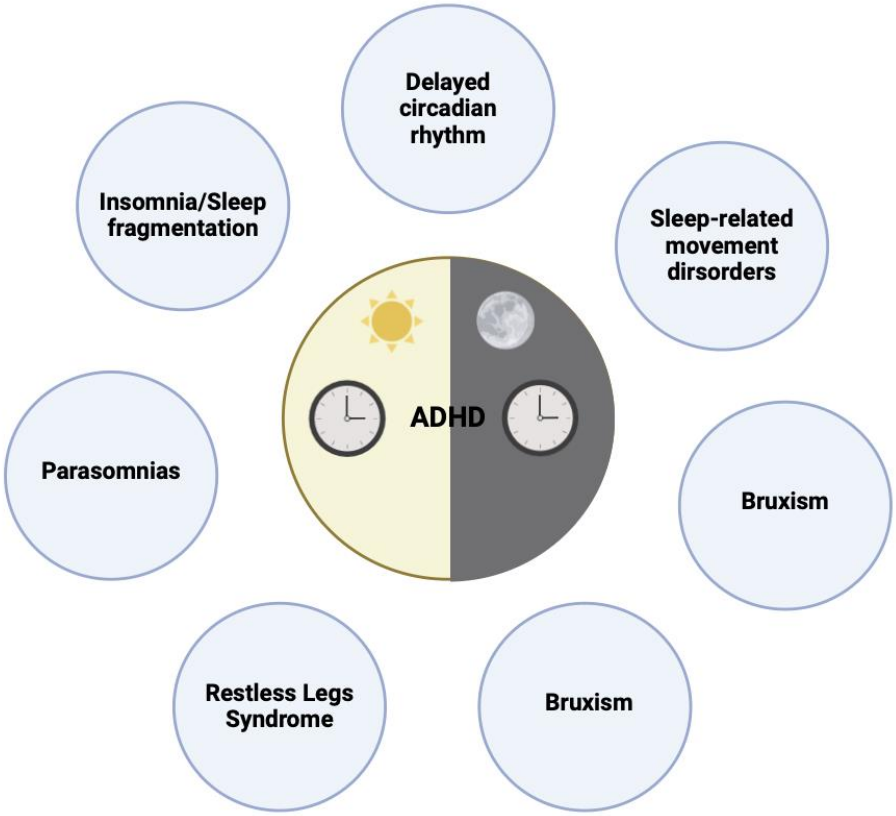
A narrative literature review was executed in the Medline database (PubMed), from 2014 to 2024, about Sleep in Attention Deficit Disorder with Hyperactivity (ADHD). In the Medline database (PubMed), 34 articles were found through the Mesh descriptor "(((Attention Deficit Disorder with Hyperactivity[Title/Abstract]) AND (Attention Deficit Disorder with Hyperactivity[Text Word])) AND (Sleep[Text Word])) AND (Sleep[Title/Abstract])" of which 23 were included, after the exclusion of articles following the first set of criteria - exclusion of titles that did not address the role of Sleep in Attention Deficit Disorder with Hyperactivity, articles not included in the research period of 2014-2024, as well as articles that were not originally in English.

After this phase, a second set of criteria was applied - exclusion of the abstracts that did not address the Sleep in Attention Deficit Disorder with Hyperactivity, which led to the exclusion of 8 articles. After the selection, 37 new articles were manually selected and added, according to their relevance to the study. Finally, aiming to enrich the discussion, 45 articles originally in English were manually selected and added according to their relevance in the synthesis of qualitative evidence.

3. Discussion

This study, which aimed to investigate the association between ADHD and sleep disorders, found a strong bidirectional relationship between sleep, ADHD and mental health. In addition, it was found that, in the long term, there is a significant worsening of the prognosis of ADHD when the patient has these disorders. In this context, it was seen that because of these relationships between the disorders, it is necessary to combine medication with non-drug treatment to improve the comorbid symptoms of ADHD. Therefore, it was concluded that an in-depth and careful investigation is necessary to give a diagnosis of ADHD, since often the individual has sleep or mental health problems and, in the end, ends up having an early and erroneous diagnosis of ADHD (Figure 1).

Figure 1. The link between ADHD and sleep disorders.



4. Sleep and mental health

Around 60% of children with ADHD have criteria for at least one anxiety disorder, including Social, Generalized and/or Separation Disorder. In this context, individuals with ADHD who completed parameters for different anxiety disorders showed a worsening in quality of life, behavior and daily functioning, when correlated with patients with ADHD alone. Anxiety in children with ADHD has thus been found to be associated with poorer children and family development than other children [8]. Individuals with ADHD often have sleep disorders, so it is important to consider these problems experienced by children with ADHD in an individualized way and not just globally, as in most studies. In this context, the diagnostic assessment carried out by the doctors who carry out the initial analysis of these individuals should include extensive questioning about aspects of sleep, including anxiety disorders and resistance to bedtime and daytime sleepiness, and not just about difficulties in falling asleep (insomnia). The instability in sleep problems indicates that a strategic adjustment will be needed to support sleep improvement in children with ADHD, even if determining which strategies to use and the right time to introduce them is challenging. In view of this, there is a possibility that more intensive support may be needed to help the patient achieve better mental health and quality of life, such as multidisciplinary treatment [9].

Links have also been found between internalizing obstacles, including anxiety, and sleep disturbances in children with attention deficit hyperactivity disorder [8]. ADHD signs and symptoms have been linked to poorer sleep quality, increased daytime dysfunction and difficulty staying asleep. In these findings, the relevance of assessing mental health symptoms together is seen, especially since the proportions of mental health symptoms, ADHD and sleep disorders are closely associated with each other [10].

According to the study by Loram and colleagues, the results of the research examined the relationship between ADHD, sleep and mental health in adolescents. In this context,

when sleep was objectively measured, significant interactions were found between ADHD status and depressive symptoms, thus meaning that the relationship between sleep and depression varies depending on whether the adolescents had ADHD or not. Furthermore, when adolescents reported their own sleep, ADHD did not influence the relationship between sleep and mental health as markedly as it did in the objective measurement of sleep. Therefore, these results suggest that ADHD can modulate the relationship between sleep and mental health in adolescents, depending on how sleep is measured and the specific mental health variables considered [11].

Finally, according to Becker and other scholars, there is a bidirectional relationship between ADHD, comorbid mental health symptoms and sleep problems in children. Individuals with ADHD often have comorbid mental health symptoms, such as oppositional defiant disorder (ODD), mood disorders or anxiety. It is estimated that a significant percentage, between 45% and 84%, of children with ADHD have comorbid ODD, and around a third of them have a diagnosis of comorbid mood or anxiety disorder. Thus, studies have examined how comorbid mental health symptoms relate to sleep difficulties in children with ADHD [10]. Thus, Moreau and colleagues found that children with ADHD and comorbid mental health symptoms, such as elevated anxiety/depression or aggression, have greater parent-reported bedtime resistance, shorter sleep duration, more nocturnal awakenings and greater daytime sleepiness compared to children with only ADHD [12]. Therefore, among children with ADHD, those with comorbid symptoms have worse sleep functioning than children without ADHD in actigraphy sleep measurements. In addition, comorbid symptoms, as opposed to medication use, are associated with more severe sleep problems. In summary, it is concluded that these findings highlight the importance of considering comorbid mental health symptoms when assessing and treating sleep difficulties in children with ADHD, as these symptoms can have a significant impact on sleep quality and pattern [10].

5. Sleep disorders in ADHD

ADHD affects 5% of children worldwide, and they are two to three times more likely to have sleep problems compared to individuals their age with typical development. It is common for individuals with ADHD to have sleep disorders, such as delayed sleep onset, difficulty going to sleep and nocturnal awakenings [13, 14]. In addition, patients with ADHD may have less frequent sleep problems, but they are still relevant to the study, such as Obstructive Sleep Apnea Syndrome (OSAS), Restless Legs Syndrome (RLS), Narcolepsy and Bruxism [15].

Obstructive sleep apnea syndrome (OSAS) is one of the sleep disorders that can exacerbate ADHD symptoms, since the relationship between the two seems to be reciprocal. Considering that OSAS is one of the sleep phenotypes associated with ADHD, in 2018, research was carried out by Miano and his colleagues in which they looked into this hypothesis in more depth. In this study, 30 patients with ADHD without drug treatment were assessed in relation to sleep using questionnaires, actigraphy and polysomnography (PSG). This revealed that 28 of the patients had sleep comorbidities, with OSAS being identified in 15 participants. In addition, Precenzano and team found that children with OSAS scored higher than control groups in hyperactivity, ADHD index, restlessness-impulsivity and emotional instability. Thus, it appears that the duration and severity of OSAS causes greater and more evident cognitive impairment in these ADHD patients, and further research is needed on these individuals [16-18]

RLS/periodic limb movement disorder (PLMD) is known to occur in 44% of children with ADHD [19]. Various studies have shown that patients with ADHD have a high level of motor restlessness during sleep, confirmed through the use of actigraphy and based on recordings obtained from infrared cameras. Thus, one of the sleep disorders most commonly associated with ADHD is PIS, due to this physiological correlation. In addition, individuals with ADHD and PIS concomitantly presented more frequent daytime altera-

tions, such as inattention, mood variability and hyperactivity, causing poor school performance. Thus, the clinical picture of ADHD with comorbid symptoms had a higher incidence in patients with PIS, showing how the diagnosis should not be made in a limited way [20, 21].

Furthermore, with regard to narcolepsy, it is believed that there may be a genetic link between narcolepsy and ADHD [19]. In the study carried out in 2020 by Takahashi and his colleagues, it was found that the genetic risk for narcolepsy has a significant association with ADHD characteristics, that is, both hyperactivity and inattention traits were related to narcolepsy polygenic risk scores (PRS), suggesting that these comorbidities have a genetic correlation [22]. According to Wilenius and colleagues, narcolepsy is more common in individuals with ADHD than those without ADHD. Therefore, it is possible to hypothesize that these patients could benefit more from a change in drug and non-drug treatment [23].

Finally, we have Bruxism, which is a common abnormal sleep behavior that can lead to serious problems in the stomatognathic system, such as damaged and worn teeth, headaches, arthralgia and temporomandibular dysfunction (TMD) [24]. In 2020, a study was carried out by Souto-Souza and his colleagues in which it was identified that the association of the predominance of bruxism both in wakefulness and sleep among children and adolescents with ADHD is 31% and they are more likely to develop bruxism. In this context, in order to identify why ADHD and bruxism coexist, it was seen that the pathophysiological mechanism of the two disorders is similar, so it is expected that they have a relationship, since the underlying mechanism is the same. In this way, it was concluded that a strategic approach to ADHD can reduce the incidence of bruxism and maintain a better quality of life for affected individuals [6].

Table 1. Methodological description of the sleep disorders included in this review.

Reference	Study type	Sleep Disorders in ADHD	Definition
[25]	Review	Insomnia	The prevalence of insomnia in individuals with ADHD varies between 43 and 80%.
[17]	Review	Obstructive Sleep Apnea Syndrome (OSAS)	ADHD and OSAS have a reciprocal relationship, where one exacerbates the symptom of the other.
[19]	Clinical trial	Restless Legs Syndrome (RLS)	Discomfort in the lower limbs is associated with an irresistible need to move that worsens during the night, which occurs in 44% of ADHD patients.
[26]	Review	Narcolepsy	Narcolepsy is uncontrollable daytime sleepiness associated with sudden sleep attacks, which has a combined prevalence of ADHD of 25%.
[27]	Prospective Cohort	Bruxism	The unconscious act of clenching or grinding the teeth constantly and excessively, especially during sleep, with a prevalence of 40% in children with ADHD.

6. Sleep interventions for children with attention deficit hyperactivity disorder

Sleep disorders are common and more constant in children with ADHD and are related to poorer well-being in the family as a whole. Several disorders have been linked to sleep problems in young people with ADHD and it is plausible that biological sleep adversities, such as restless legs syndrome, obstructive sleep apnea (OSA) and narcolepsy, are capable of causing sleep discontinuity. Thus, some randomized clinical trial (RCT) studies have shown that sleep difficulties are subject to intervention and strategies, mainly through behavioral measures [28].

In 2015, an RCT was carried out by Hiscock and his colleagues on the impact of a behavioral sleep intervention on symptoms and sleep in children with ADHD, and in this study the intervention was carried out through sleep hygiene practices and behavioral strategies provided by psychologists and trainee pediatricians during two fortnightly consultations and a follow-up phone call, while the children in the control group only had routine clinical care. According to the RCT, the behavioral intervention showed better effects in children 3-6 months after randomization, including a good evolution of parent-reported sleep, ADHD symptom severity, quality of life, daily functioning and behavior [29]. The children also improved their classroom manners, as reported by their teachers, as well as their school attendance and working memory. In addition, there were some improvements in sleep duration for a sub-sample that completed the actigraphy. However, even though the intervention was related to continuity in the caregiver's work and mental health 3 months later, these benefits were not observed at 6 months [28].

ADHD is a neurodevelopmental disorder with altered melatonin secretion leading to sleep disturbances. As sleep disturbances can worsen ADHD symptoms, especially in the morning, exogenous melatonin (ELM) has been proposed as a form of treatment to reduce the comorbid symptoms of ADHD. Thus, the effects of exogenous MLT therapy on children with ADHD and chronic insomnia have been demonstrated, resulting in improvements in sleep, behavior and mood. However, the influence of exogenous melatonin treatment on cognitive impairments has not been confirmed [30-32].

In 2018, studies were carried out to investigate the signs and symptoms of individuals with ADHD when they participated in a strategy using cognitive behavioral therapy (CBT). This prepares patients to understand their emotions, impulsivity and inattention, which are part of their daily routine. In this way, CBT was compared with supportive psychotherapy techniques, revealing more positive aspects of the ADHD symptoms reported by the doctor through the CBT method. In addition, CBT associated with pharmacotherapy, compared to pharmacotherapy alone, was shown to improve symptoms, especially symptoms of depression and anxiety [33-34].

In addition, delayed sleep onset, also called insomnia, typically defined as greater than 30 minutes, is an adverse effect associated with the use of stimulant medications for the treatment of ADHD, such as methylphenidate (MPH) and amphetamines (AMP) [35]. These drugs have been the most widely used to treat ADHD in children for over 60 years, where 75% to 80% of children with ADHD benefit from these psychostimulants [35, 36]. However, more recent studies have shown that treatment with stimulants has been linked to a change in sleep latency, worse sleep efficiency and shorter sleep duration [35]. Thus, new analyses and research have shown that non-pharmacological measures also improve ADHD symptoms as much as pharmacological measures, concluding that the best form of treatment for ADHD is the combination of drug and non-drug treatment [37].

7. Future perspectives

The occurrence of ADHD and sleep disorders concomitantly has always been a long-standing issue, but studies into these two disorders have only intensified in recent years [38]. It is known that the symptoms of ADHD are similar to the signs and symptoms of sleep deprivation. In this context, sleep disorders with ADHD in adults can cause memory

problems and attention/concentration deficits during the day. On the other hand, in children and adolescents, fatigue is usually demonstrated through hyperactivity and impulsivity. In this way, it can be difficult to conclude where the problems come from, whether they are caused by ADHD or lack of sleep, which is why we have many misdiagnoses allowing sleep problems to go unnoticed. Therefore, sleep screening is recommended before starting drug treatment for ADHD [39].

Due to this association between sleep and ADHD, scholars are looking for new forms of interventions to not only improve sleep, but also the adverse effects of psychostimulants used in ADHD and comorbid ADHD symptoms, since they have a bidirectional relationship. Thus, sleep hygiene strategies have been found to improve both disorders, leading to an improvement in daily functioning, behavior and memory, in other words, improving the quality of life of this patient [40]. When it comes to sleep hygiene, you need a persistent bedtime routine and healthy practices to help you fall asleep better. Some of the practices that help is avoiding sugar, caffeine and alcohol, reducing screen time before bed, not doing stimulating activities before falling asleep, exercising, leaving the bed as a place only for sleep and sex, developing a routine of waking up and going to sleep at the same time, dimming lights and reducing noise before bed [41].

In 2017, a study was carried out by Morash and his colleagues, in which participants were assessed in relation to sleep through polysomnography and cognitive performance. In this study, it was found that long-acting psychostimulants are a suitable form of treatment for improving the comorbid symptoms of ADHD, but it is a treatment that has led to a worsening of sleep quality. The results of this article showed the relevance of investigating and observing sleep when stimulant medications are prescribed, as is done in the treatment of ADHD in children [42].

In theory, it can be concluded that the doctors and pediatricians involved in the evaluation of these children with suspected ADHD are no longer prepared to prescribe only a pharmacological treatment for the child, since these psychostimulants when prescribed can cause harm such as sleep problems. Thus, both pediatricians and child psychiatrists prefer to prescribe a combined treatment of medication and non-pharmacological measures such as CBT, sleep hygiene, acupuncture and others [37]. Finally, it is known that there is a significant impact of sleep problems on the long-term prognosis of ADHD. It is therefore necessary that, just as ADHD is carefully investigated and treated, sleep disorders should also be considered as a complicating comorbidity and that this should be well diagnosed and monitored to improve the quality of sleep and life of the patient in question [43].

The relationship between sleep and ADHD was thus clear and prevalent, and how it affects the quality of life of these sufferers. In addition, given the results, it was noted that it is important to carry out a precise, detailed and in-depth assessment, in order to be able to give a diagnosis of ADHD when the patient also has sleep problems, since it was often noted that a diagnosis of ADHD was given when it was only a sleep disorder. In addition, it has been seen that the pharmacological therapy used to treat ADHD can itself cause sleep problems, which is why it needs to be combined with non-pharmacological treatment to reduce both sleep disturbances and the comorbid symptoms of ADHD. Finally, it is of the utmost importance to increase research into this area, as it is a subject with few large, long-term studies, so that the results of these show greater precision between the disorders.

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