An In-depth Exploration of Sleep Disorders and Their Impact on Human Health

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ABSTRACT

The study of sleep disorders encompasses many examinations of physiological, psychological, and mental factors that influence sleep. This review article focuses on prevalent sleep issues such as insomnia, narcolepsy, sleep apnea, and, mainly, sleep paralysis. The primary objective is to identify the major contributing factors, with an emphasis on the negative impact stress has on sleep quality. Additionally, this review aims to provide strategies for managing and potentially helping with these disorders. Through the exploration of early symptoms, the many effects of irregular sleep routines on stress and academic performance, and the distinctions between different types of sleep paralysis, this research offers a thorough analysis of sleep disorders.

Introduction

The study of sleep disorders, through its physiological, psychological, and mental factors, has garnered significant attention from both researchers and health-related scientists. The main focus point of this research is diving deeper and understanding the prevalent sleep issues. This includes insomnia, narcolepsy, sleep apnea, and, the most prevalent, sleep paralysis. The primary objective of this research is to determine the major contributing factors to the development of these disorders, particularly the negative impact of stress on one's sleep quality. Additionally, this study aims to provide insights into how anyone suffering from these types of sleep disorders can adapt to or completely diminish their effects. The investigation also extends to any early symptoms one might experience when diagnosed with a sleep-related disorder. Looping back, the research will also go in-depth on how varying sleep routines influence one's stress levels and, thus, academic performance. While the research will discuss a wide range of sleep disorders listed above, the central focus is on resolving the problems and mysteries surrounding sleep paralysis. This includes many factors, including its rate of occurrence, methods for subduing its symptoms, and the direct correlations it has with anxiety and depression. Finally, the research will separate the distinctions between recurrent sleep paralysis and isolated sleep paralysis, in addition to the different types, like hypnagogic and hypnopompic sleep paralysis.

Rapidly growing evidence suggests that many Western countries are experiencing a downward trend “in the average duration of sleep and increasingly higher prevalence of insomnia and other sleep disturbances.” Taking the United States and Canada, for example, nationwide surveys prove that over 20% of the general adult population suffers from insomnia. These numbers correlate directly with the prevalence of short sleeping time and stress. In addition, these high percentages do not just affect your sleep and your activity level the next day, but “problems with falling asleep or daytime sleepiness and fatigue … impose a considerable burden in terms of morbidity and mortality outcomes.” A similar study was performed in sites in Asia and Africa, including nations like South Africa, Tanzania, Kenya, Ghana, Vietnam, Bangladesh, Indonesia, and India. The findings of this study supported “a consistent pattern of higher prevalence of sleep problems in women and older age groups.” Not to mention, associations with “lower education, not living in partnership, and poorer self-rated quality of life were” also prevalent issues that factored into the advent of sleep problems (Stranges et al., 2012).

Even in the United States, the rate of adults not getting enough rest or sleep is about one in every three, which is just a little less than the global rate. Additionally, the NIH reported that "nearly 40% of adults report falling asleep during the day without meaning to at least once a month. Also, an estimated 50 to 70 million Americans have chronic or ongoing sleep disorders." While low amounts of sleep may be normalized by now, the numerous adverse effects correlated with low sleep durations are indescribable. Furthermore, "sleep deficiency can interfere with work, school, driving, and social functioning" the next day. "You might have trouble learning, focusing, and reacting… [and] might [also] find it hard to judge other people's emotions and reactions." According to the study conducted by the NIH, around 30% of adults were reported to have symptoms of sleep paralysis, including paralysis of the limbs, inability to speak, and a sense of suffocation. Similar to sleep paralysis, 10% of the adults studied for the research reported that "having insomnia impacts their daily activities [and that] sleep apnea impacts 9%–38% of the general population" (NIH, 2022).

Regarding sleep disorders in New Jersey, approximately "37.4% of adults reported sleeping, on average, fewer than seven hours in a 24-hour period," ranking as low as 35th of the 50 U.S. states (America's Health Ranking, 2023). This statistic is very concerning, considering adults' recommended daily amount of sleep is between eight and ten hours. Another study published in 2011 "discusses a survey conducted on 1,941 adolescents [from New Jersey] to explore the relationship between sleep patterns, school performance, and school start times." These subjects were selected from five medically related high school programs in New Jersey, known for their in-depth research opportunities given to students. Without surprise, the study "reveal[ed] a high prevalence of inadequate sleep and sleep health problems, especially among those with earlier school start times." Not only were poor sleep durations recorded, but there was also a decrease in school performance among those who were not getting adequate amounts of sleep. Not being nearly as emphasized as it should be, this study brings up a handful of questions regarding any "need[s] for awareness and potential adjustments in high school schedules to promote better sleep health among students" (Ming et al., 2011).

The studies on sleep disorders, focusing mainly on the prevailing issues related to sleep paralysis and insomnia, are pivotal in understanding the contributing factors and attempts to find solutions. Regarding global concerns, there has been a slight decline in the average sleep duration in Western countries, emphasizing the damaging and detrimental effects of sleep deficiency on one's daily activities. The research also reports on the higher prevalence of sleep disorders, mainly in women and older age groups, providing a direct correlation with low education and poor quality of life. In the U.S., on the other hand, one in three adults faces some type of sleep disorder, with symptoms coming from disorders like sleep paralysis, insomnia, and sleep apnea. Additionally, adolescents in New Jersey high schools push for better schedules and better sleep health due to the strenuous and time-consuming homework, never-ending extracurriculars, and an early school start time. Overall, studies on sleep disorders significantly contribute to addressing the widespread negative effects of sleep disorders and promoting needed measures for enhanced sleep health in the medical field.

Methodology

The primary goal of this research was to explore the intricacies of sleep disorders, focusing mainly on insomnia, narcolepsy, sleep apnea, and sleep paralysis. The type of research conducted in this study is a secondary literature review based on numerous primary studies and informational research articles. The methodology contains both quantitative and qualitative approaches to ensure a comprehensive understanding of the topic at hand. Quantitative data was used in this research paper through standardized surveys given to individuals affected by sleep disorders, as well as control groups. Qualitative techniques, on the other hand, were used when focusing on a group discussion to obtain information regarding individuals fighting with sleep disorders. First, the different types of sleep disorders were explained, along with the types of known treatments. Then, the leading prominent causes of these sleep disorders were examined. This was followed by the in-depth examination of the main genes and proteins that play a contributing factor in sleep-related disorders. The research wraps up as it talks about any prevention techniques for these sleep

disorders and the effectiveness and differences between therapy and medicine. No physical tools or equipment was used in this research other than online sources. Bias in this research was mitigated by analyzing multiple sources and articles and offering objective research to include various perspectives on the topic.

The Different Types of Sleep Disorders

Insomnia

There are two major types of insomnia: Short-term and long-term. Short-term insomnia, generally prevailing for just a few days to weeks, often stems from stress and tends to resolve with the mitigation of the particular stressor. Chronic insomnia, on the other hand, lasts "for at least 3 nights per week over at least 3 months". It can even be worsened by behaviors such as spending excessive time in bed or daytime napping. Many risk factors also play a role in the development of insomnia, including age, gender, mental health conditions, certain medical issues, and medication usage. When it comes to treatment, for short-term cases, "discussion with a clinician about the stressor causing sleep difficulty may be helpful." However, chronic insomnia is often managed with cognitive behavior therapy for insomnia (CBTI), "which aims to reduce fear and anxiety about sleeping and provide bedtime relaxation strategies." If CBTI proves ineffective, medications such as nonbenzodiazepine hypnotics, benzodiazepines, or melatonin receptor agonists may be prescribed, taking into account their timing and potential side effects. As of right now, there are no existing FDA-approved drugs for treating pediatric insomnia, although melatonin may be considered for children with neurodevelopmental disorders experiencing sleep-onset difficulties (Krystal et al., 2021).

Narcolepsy

Narcolepsy is a sleep disorder "characterized by excessive daytime sleepiness (EDS), frequent uncontrollable sleep attacks as well as sleep fragmentation and can be associated with cataplexy, sleep paralysis, and hypnagogic hallucinations." Similar to insomnia, there are two main types of narcolepsy as well: narcolepsy type 1, which includes cataplexy, and narcolepsy type 2, which lacks cataplexy. The loss of most orexin-containing neurons characterizes narcolepsy type 1. This might occur due to an autoimmune process triggered by infection. "HLA haplotype DQB1*0602 is present in 95% of narcolepsy type 1 patients, but [it] is also present in about 20% of the general population without narcolepsy as well. While the specific cause of Narcolepsy type 2 may not be clear, research suggests it involves "less severe loss of orexin neurons or impaired orexin receptor signaling." In some cases, narcolepsy type 2 patients may progress to develop cataplexy, the sudden loss of muscular tension while one is awake. In all, narcolepsy "is a rare sleep disorder that has no cure and is difficult to manage." Nevertheless, the effects of this disorder can be mitigated through various medications and modifications to healthcare and lifestyle (Slowik et al., 2023).

Sleep Apnea

Sleep apnea is a common sleep disorder distinguished by frequent pauses in breathing during sleep. This often leads to loud snoring and daytime sleepiness. The two main types of sleep apnea are obstructive sleep apnea (OSA) and central sleep apnea (CSA). OSA occurs when the airway becomes blocked during sleep, causing excess snoring and sudden and sharp gasps for breath. It affects approximately 10% to 30% of adults in the United States, while many other cases go undiagnosed. CSA, on the other hand, involves "disruption in the communication between the brain and the muscles that control breathing," resulting in shallower breathing and pauses. It is less common, only affecting less than 1% of people. Treatment for OSA often involves positive airway pressure (PAP) therapy, which keeps the airway open during sleep. Other options include mouthpieces and surgical procedures. For CSA, treatment focuses on

addressing underlying medical issues or oxygen therapy to promote steady breathing during one's sleep (Suni et al., 2024).

Sleep Paralysis

Only prevalent in 1.7% of the population, sleep paralysis is defined as "a temporary sense of paralysis that occurs between stages of wakefulness and sleep." One main difference between sleep paralysis and dreams and nightmares is that one is awake during an episode of sleep paralysis. Like most of the other main sleep disorders, sleep paralysis also has two different types: isolated sleep paralysis and recurrent sleep paralysis. "Sleep paralysis is isolated when it appears without any other signs of narcolepsy or other sleep disorders," whereas recurrent sleep paralysis is characterized by multiple episodes over time. In relation to sleep paralysis, there are also two other types, including hypnagogic and hypnopompic sleep paralysis. These hallucinations are fairly simple: hypnagogic hallucinations occur as one is falling asleep, and hypnopompic hallucinations take place as one is waking up from sleep. An episode of sleep paralysis can last from as short as a few seconds to as long as a few minutes. During these episodes, one might experience a sense of evil or a disturbing presence in the room, chest pressure, or even a feeling of movement or flying (Restivo, 2023).

Prominent Causes of Sleep Disorders

Sleep disorders, whether it is as mild as insomnia or as severe as sleep apnea, are prevailing challenges affecting millions of people globally. These conditions stem from a variety of different, diverse factors and significantly disrupt individuals' sleep patterns, emphasizing the importance of understanding and addressing them for healthier well-being.

Researchers at a large state university in the southeastern United States set up an experiment to examine the prevalence of risk for sleep disorders among college students by age, gender, and academic success. Utilizing the SLEEP-50 survey, administered to over 1,800 students, many different sleep disorders, such as Obstructive Sleep Apnea (OSA), Insomnia, and Narcolepsy, were levied. Results indicated a significant association between sleep disorders and academic performance, highlighting the need to address these issues among college students. The study found that around 27% of college students "were at risk for at least one sleep disorder," with narcolepsy and insomnia being the most common. On average, students rated their sleep satisfaction at 6.50 and slept 6.79 hours on nights they had school or work the next day, with a discrepancy of 2.49 hours on weekends. Better sleep quality was also linked to higher academic performance (Gaultney, 2010).

Overall, physical exercise also has a major correlation to sleep quality. A study conducted by researchers at Xuzhou City, China, "analyze[d] the factors influencing [undergraduate students'] sleep quality to promote their health education and psychological well-being." Participants were diverse, with different demographics and gender, grade, and economic status. The main way exercise levels and sleep quality were assessed in this study was through "The Physical Activity Rating Scale-3 (PARS-3) and the Pittsburgh Sleep Quality Index (PSQI)." Over 3,300 students were surveyed, and the results showed that "the detection rate of exercise varied among universities[, with] higher rates of large exercise detected at Xuzhou Medical University." However, sleep disorders were more prevalent among students at Jiangsu Normal University. This study not only encourages physical activity in adolescents but also promotes healthy habits as crucial in enhancing sleep quality among college students (Wu et al., 2022).

Additionally, a cross-sectional study performed by researchers in Sakarya, Turkey, set out to find the main "contributing factors to poor sleep experiences in university students." To do this, "a descriptive survey was conducted randomly on 256 university students in Turkey." When the results came back, it shocked the researchers, not only on the number of students experiencing poor sleep but also on the factors that cause them. In relation to the self-reported university students, the most frequent causes were "exposure [to] psychological problems (67.2%), stress (64.8%),

exposure to tobacco smoke in the sleeping room (63.7%), pain (62.9%), having family problems (62.5%).” just to name a few. This research revealed high rates of poor sleep experiences among university students. (Altun et al., 2012)

Genes Related to Increased Risk of Sleep Disorders

Recent genome-wide association (GWA) studies have discovered additional susceptibility loci for narcolepsy, “a chronic neurological disorder that affects the brain's ability to control sleep-wake cycles.” One such locus, identified in a Japanese sample, is located between the carnitine palmitoyltransferase 1B (CPT1B) and Choline Kinase B (CHKB) genes. Both CPT1B and CHKB are “plausible candidates” for regulating REM sleep. On one hand, “CHKB metabolizes choline, the precursor of acetylcholine, a regulator of REM sleep.” On the other hand, CPT1B plays a role in transporting fatty acids into mitochondria and is crucial in the beta-oxidation pathway, associated with theta oscillations during REM sleep regulation. Notably, this polymorphism has been linked to Essential Hypersomnia, exhibiting its direct influence on REM sleep independent of hypocretin deficiency. The association also suggests a direct correlation between decreased mitochondrial beta-oxidation and increased REM sleep, linking REM sleep with energy homeostasis (Sehgal et al., 2012).

Familial Advanced Sleep Phase Syndrome (FASPS) “is characterized by persistent advanced sleep onsets and awakenings that are earlier than desired” and represents a rare yet fascinating circadian disorder distinguished by a notable advance in sleep-wake timing (Reid et al., 2001). This syndrome, with unique circadian abnormality, has been closely tied to mutations in the Period circadian clock (PER2) gene, which plays a pivotal role in regulating circadian rhythms in humans. Specifically, the PER2 gene acts as a positive regulator within the feedback loop involving the CLOCK-BMAL1 complex. In that, mutations within the PER2 gene, particularly those affecting the phosphorylation site within the casein kinase I epsilon (CKIε) binding domain, have been identified in individuals and families affected by FASPS. These mutations are thought to significantly disrupt the normal function of the endogenous circadian clock, leading to visible alterations in sleep timing characteristic of FASPS. This identification process of mutations in the PER2 gene and other circadian-related genes not only underscores the significance of genetic factors in shaping circadian rhythms and sleep patterns in humans but also “clearly indicate[s] that single gene mutations in circadian genes might be involved in the etiology of human circadian disorders as repeatedly reported in several animal models” (Tafti et al., 2009).

The serotonin transporter gene-linked polymorphic region (5-HTTLPR) has been extensively studied in terms of its uncertain correlation to gene-environment interaction in depression. The S allele of this polymorphism is closely associated with reduced serotonin transporter expression and has been involved in increased susceptibility to depression. Recent research suggests that insomnia and poor sleep quality may play a significant role in “the interplay between 5-HTTLPR, stress, and depression” (Wray et al., 2012). Insomnia has been identified as a primary risk factor for depression, and numerous genetic studies have revealed a genetic overlap between depression and insomnia. Investigating the involvement of sleep disturbances in the gene-environment interaction in depression could provide valuable insights into this complex relationship (Dalfsen, 2019).

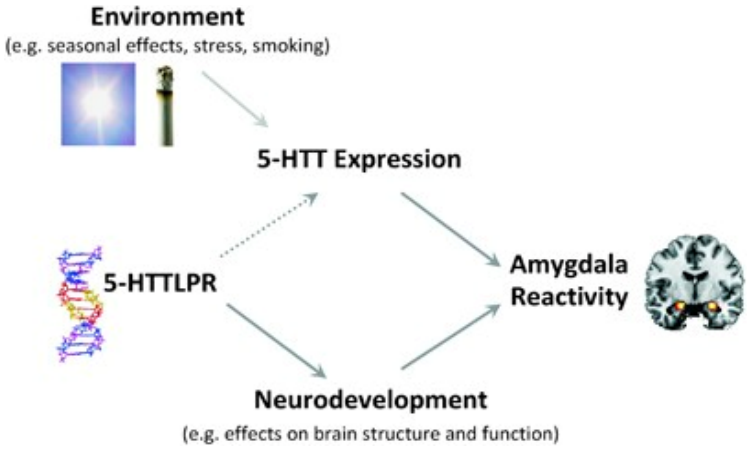

Figure 1: How the serotonin transporter 5-HTTLPR polymorphism influences amygdala function. Source: Kobiella et al., 2011

The serotonin transporter-linked promoter region (5-HTTLPR) polymorphism of the serotonin transporter gene is associated with amygdala response during negative emotion.

The Paired Box 8 (PAX8) gene, as recent as 2023, emerged in the scientific world as a significant gene relating to sleep disorders in the realm of sleep genetics, particularly concerning sleep duration. Large-scale genome-wide association studies (GWAS) have consistently implicated PAX8, among other loci, in regulating sleep patterns. Initial studies with modest sample sizes failed to detect significant variants associated with sleep duration, but as sample sizes increased, more genetic variants were identified in many different studies. Studies involving thousands of individuals have identified multiple loci linked to usual sleep duration, with the PAX8 gene being one of the most replicated loci. In some cases, sample sizes exceeded well over 100,000 individuals, "identifying numerous loci associated with habitual sleep duration, with replication in PAX8." While GWAS studies have primarily focused on sleep duration, there is also evidence of genetic contributions to other sleep phenotypes, such as "sleep quality, napping behavior, and chronotype." Significant SNP-based heritability estimates have been reported for sleep quality, with identified loci influencing various aspects of sleep, including sleep efficiency and latency. Overall, despite some variability, the consistent identification of genetic loci like PAX8 highlights the genetic reinforcements of sleep regulation (Madrid-Valero et al., 2023).

The paired-like homeobox 2B (PHOX2B) gene has been implicated in the regulation of sleep disorders as well, particularly in relation to congenital central hypoventilation syndrome (CCHS), a condition characterized by impaired control of breathing during sleep. Studies have identified mutations in the PHOX2B gene as a key genetic factor contributing to CCHS. This gene plays "a crucial role in the development and function of the autonomic nervous system," including the control of breathing. Research has shown that mutations in the PHOX2B gene "disrupt the normal development of neural pathways involved in breathing regulation, leading to abnormalities in respiratory control during sleep." Individuals with CCHS often experience hypoventilation and inadequate breathing during sleep, resulting in low levels of oxygen and high levels of carbon dioxide in their blood. This can lead to various complications, including respiratory failure and possibly even sudden death if not properly subsidized. In addition, studies have also suggested a potential link between PHOX2B mutations and other sleep-related disorders, such as sleep-disordered breathing and sleep apnea. While researchers and scientists are still investigating the exact mechanisms underlying this association, it is believed that disruptions in the autonomic nervous system caused by PHOX2B mutations contribute to abnormalities in sleep patterns and respiratory functions (Mainieri et al., 2021).

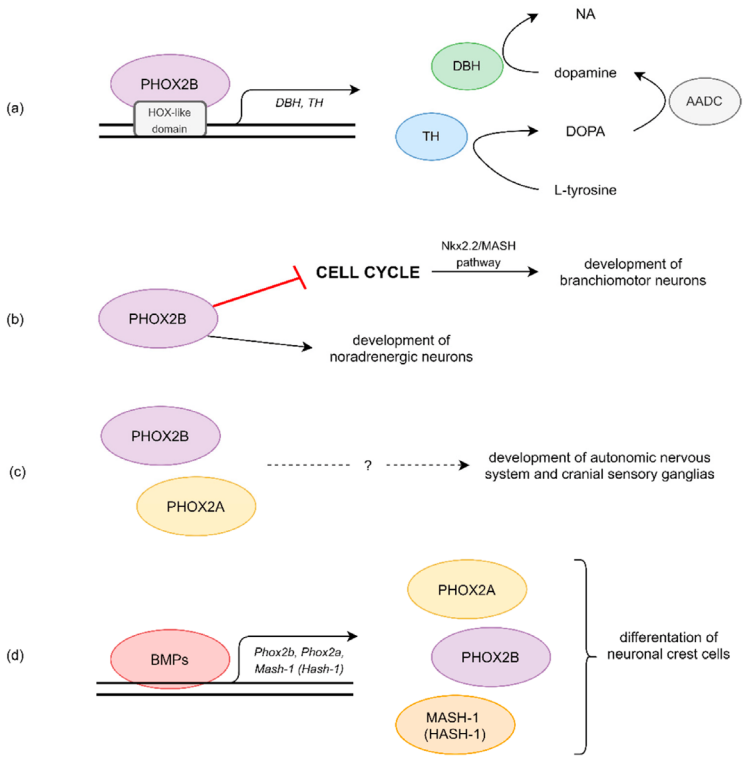

Figure 2: Possible pathomechanisms of CCHS. Source: Ditmer et al., 2021

Description: (a): The domain of PHOX2B binds to promotors of NA synthesis genes, (b): PHOX2B arrests some cell cycles in the brain, which enables proper development of branchiomotor neurons, (c): PHOX2A and PHOX2B expression was detected in the autonomic nervous system, (d): BMPs promotes expression of neuronal crest cells differentiation factors.

Sleep Disorder Prevention

Light Therapy

In short, light therapy, or phototherapy, is the direct exposure to sunlight or artificial light. The significance of light therapy lies in "adjust[ing] the amount of melatonin your body needs to make to reset your sleep-wake cycle." There are two uses for a patient to use a lightbox: to move your sleep and wake time earlier and to move your sleep and wake time later. To move their sleep and wake time to an earlier time, patients must use the lightbox when they wake up in the morning. Using a lightbox in the morning can also reduce daytime sleepiness. To move their sleep and wake time to a later time, patients must "use the lightbox late in the afternoon or early in the evening." This situation mainly occurs due to a shift work disorder or any case of jet lag (NIH, 2022).

Orofacial Myofunctional Therapy

Orofacial myofunctional disorders (OMDs) are "patterns involving oral and orofacial musculature that interfere with normal growth, development, or function of orofacial structures or call attention to themselves." Examples of this disorder include tongue thrusts, mouth breathing, and jaw malocclusions and may stem from genetics, orthodontic issues, finger sucking, or neurological disorders. To treat this, orofacial myofunctional therapy was introduced, implementing techniques such as oral muscle exercises, creating a lips-together mouth posture, and helping with swallowing. Oral muscle exercises are exercises that "improve the strength, positioning, and coordination of the mouth

and throat muscles." For example, a patient can be asked to hold their tongue tip behind their top teeth as an exercise. Speech therapists using OMT can also improve their patient's ability to keep their lips together and "help modify the textures or thickness or foods and drinks to help a child with an Orofacial Myofunctional Disorder to be able to properly swallow" (Vollmer, 2022).

Cognitive behavioral therapy for insomnia (CBT-I)

Cognitive behavioral therapy for insomnia, or CBT-I, is an extensive 6- to 8-week treatment plan to help patients learn how to both fall asleep faster and stay asleep for a longer period of time. This treatment is mainly used by healthcare providers, nurses, or therapists for long-term insomnia. There are many different types of CBT-I therapies that fit the patients' needs. Cognitive therapy, for example, helps one feel less nervous about not being able to sleep. Medication therapy, on the other hand, "teaches [one] how to relax and fall asleep faster." To add on, "sleep education helps you learn good sleep habits," and sleep restriction therapy gives you a specific amount of time to spend in bed, even if you are not able to sleep during the given amount of time. This type of therapy is widely accepted as you sleep better when your sleep time increases (NIH, 2022).

Medicines

Unlike cognitive behavioral therapy for insomnia, prescription medicine is widely discredited by the public due to the possible side effects of each medication. Benzodiazepine receptor agonists, for example, are medications given to patients to treat their sleep disorder that may include side effects such as anxiety and severe allergic reactions. Similarly, side effects of melatonin receptor agonists include dizziness, fatigue, and even doing activities like walking or talking while asleep. "Benzodiazepines may be prescribed for [patients with] insomnia if other treatments and medicines have not worked" but are reported to induce dizziness, confusion, and muscle weakness in patients (NIH, 2022).

For those not comfortable taking prescription medicine, however, "healthcare providers may prescribe medicines that are commonly used for other health conditions but are not approved by the U.S. Food and Drug Administration (FDA) to treat insomnia." This type of medicine is called off-label medicine and includes antidepressants, antipsychotics, and anticonvulsants (NIH, 2022).

When it comes to over-the-counter (OTC) medicines and supplements, "antihistamines are sold as sleep aids." Patients should also talk to their providers before any actions involving over-the-counter medicine. Another commonly used OTC medicine by patients suffering from sleep disorders is melatonin supplements, which are "lab-made versions of the sleep hormone melatonin." While this medication is not regulated by the U.S. Food and Drug Administration, "the dose and purity of these supplements can vary between brands." Thus, it is always recommended for a patient to talk to their provider about the safety of any given medication before using it. Side effects of melatonin supplements include "excess sleepiness, headaches, high blood pressure, low blood pressure, stomach upsets, and worsening symptoms of depression" (NIH, 2022).

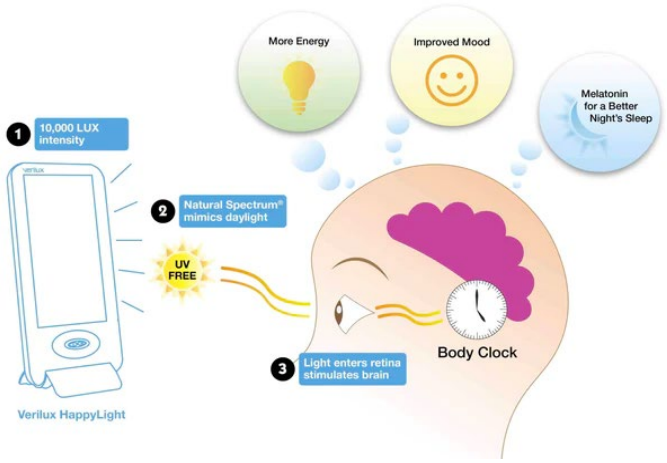

Figure 3: The different factors that play into factor when regulating one's circadian rhythm and sleeping better with light. Source: Verilux, 2024

Description: Through exposure to UV-free light with high LUX intensity, one can gain more energy, improve mood, and use the provided melatonin for a better night's sleep. This is done through natural light, stimulating the brain to release chemicals in one's body.

Conclusion

In conclusion, this review article uses secondary articles and literature works to emphasize the intricate relationship between stress and sleep disorders, particularly focusing on sleep paralysis. As the evidence suggests, stress plays a significant role in the onset and worsening of sleep disorders, highlighting the importance of effective stress management strategies. While pharmaceutical treatments and changes in one's lifestyle are promising methods, the most effective appear to be psychological support and behavioral therapies in order to improve sleep quality and reduce the occurrence of sleep disorders like sleep paralysis.

Limitations

This review of sleep disorders, while extensive and comprehensive, is also subject to several limitations. Firstly, due to the reliance on numerous secondary sources and works of literature, the findings of the review are restrained by the quality of the original studies. Many studies on sleep disorders implemented in this review article may suffer from smaller sample sizes, especially those that focus on population studies like college students or specific geographic regions. This, in turn, may limit the accuracy of the results. On top of that, this review primarily covers works of English literature, disregarding other relevant studies in other languages, which might have provided different perspectives on the topic. Additionally, this review's primary focus is on the relation stress has on sleep disorders, particularly sleep paralysis, which may neglect other factors such as genetic predispositions, environmental influences, and the lifestyle choices one chooses to make. Thus, future research should aim to address these limitations by incorporating larger and more diverse samples and exploring a broader range of contributing factors to provide a more in-depth understanding of sleep disorders.

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