Associations between Poor Sleep Quality and Repetitive Behavior among Children on Autism Spectrum Disorder (ASD): A literature Review

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Abstract. Sleep disturbance can result in heighten of challenging repetitive behavioral situation which affect the day-to-day routine among ASD children. Understanding the impact of quantity and quality of sleep are very significant for mental and physical health of children in this spectrum. Early sleep disturbance detection and the associated internal and external contributing factor should be addressed. The aim of this article is to conduct literature review on 1) the existing research on various methods in capturing sleep quantity, 2) the factors and causes that associated with sleep disturbance, 3) the related research in certain countries, 4) the relationship between the sleep disturbance and challenging repetitive behavior.

Keywords: Autism Spectrum Disorder, sleep disturbance, repetitive behavior

INTRODUCTION

Diagnosis of ASD

Based on (Cohen et al., 2016) research, these sleep difficulties commonly faced by children with ASD can produce a significant decrease in the quality of life of all family members as a consequence of sleep disturbance. As sleep is a behavioral and emotional regulator, sleep fragmentation or disturbance can worsen behavioral disturbances in children with ASD possibly triggering disruptive or inflexible behavior and anxiety. Greater variation in sleep duration and timing have been found to predict subsequent disruptive daytime behavior. Parents of children with ASD and sleep problems may, thus, have to deal with their child´s behavior problems derived from their sleep issues and the consequences of their own sleep disturbance. (Cohen et al., 2016).

DSM-5 is a clinical standard for the diagnosis of ASD, and the diagnosis must meet the following standards: Persistent deficits in social communication and social interaction (Criterion A), and restricted, repetitive patterns of behavior, interests, or activities (Criterion B) currently or by history; These symptoms are present from early childhood and limit or impair everyday functioning (Criteria C and D); These disturbances are not better explained by intellectual disability (Criteria E); according to the intensity of support required, the severity is divided into 3 levels [36]. (Chen et al., 2021)

Sleep disturbance can result in significant impairments in daytime neurobehavioral functioning in children. Neural substrates impacted by sleep disturbance include the prefrontal cortex, basal ganglia and amygdala and result in difficulties with executive functioning, reward anticipation and emotional reactivity respectively. In everyday life,

such difficulties contribute to academic struggles, challenging behaviors and public health concerns of substance abuse and suicidality. (Maski and Kothare, 2013)

Based on (Ballester et al., 2019) research sleep problems are recognized as a common comorbid condition in autism spectrum disorder (ASD) and can influence core autism symptoms and mental and physical health. SPs can be lifelong and have been reported that adults on the autistic spectrum with and without intellectual disability (ID) present SPs (longer sleep latency, frequent night awakenings, and circadian rhythm sleep–wake disorders). A prospective, objective sleep study was conducted in 41 adults with ASD and 51 typically developing adults using ambulatory circadian monitoring (ACM) recording wrist temperature, motor activity, body position, sleep, and light intensity. The findings indicated that individuals with ASD presented sleep difficulties including low sleep efficiency, prolonged sleep latency and increased number and length of night awakenings, together with daily sedentary behavior, and increased nocturnal activity. Furthermore, indications of an advanced sleep– wake phase disorder were found in these autistic adults. Examining sleep and markers of the circadian system showed significant differences between adults with ASD and ID and an age-matched, healthy adult population. The sleep disturbances described for this sample of adults with ASD, and ID are like those of already described for adults with ASD without ID; their relationship with intellectual ability should be further studied. Improving knowledge of sleep patterns in ASD adults with ID might help to designed targeted interventions to improve their functioning and reduce family stress.

Circadian Sleep and Sleep Disturbance

Sleep disturbances and circadian sleep alterations are frequent in subjects with autistic symptoms who have shown polymorphisms in clock genes expression and in genes involved in melatonin production. The impairment of circadian sleep regulation may increase the individual's vulnerability to develop symptoms of autism spectrum disorder by altering the sleep regulation in toto which play a key role in brain development. Even though controversies and “research gaps “are present in literature at this point, we may hypothesize a bidirectional relation between circadian sleep dysfunction and ASD. Circadian sleep dysrhythmic may predispose to develop ASD symptoms and vice-versa within a self-reinforcing feedback loop. By targeting sleep disturbances and circadian sleep dysrhythmic we may improve treatment strategies for both children and adults with ASD. (Carmassi et al., 2019)

Sleep disturbances may precede and worsen the behavioral outcomes in children with ASD. For example, disturbances in continuous sleep and circadian rhythms have been linked to behavioral difficulties such as high irritability as well as high stereotypic behaviors in children with ASD (Yavuz-Kodat et al. 2020). Autistic traits in toddlers were recently associated with sleep problems, particularly daytime sleepiness (Horiuchi et al. 2020). REM sleep has been postulated as an index of brain plasticity (Elia et al. 2000). Impaired REM sleep can thus be considered as a marker of abnormal brain functioning. Contextually, persistent sleep disturbance was associated with neuronal damage and impaired brain development (Jan et al. 2010;MacDuffie et al. 2020). A correlation between altered subcortical brain volumes and sleep onset problems in first two years of life may predispose infants to ASD; this further implies the neurodevelopmental connection of sleep abnormality in children with ASD (MacDuffie et al. 2020).

(Abdul et al., 2022)

Relationship and Impact of Sleep

The relationship between ASD severity and problem behavior varied significantly depending on the degree of accompanying sleep disturbance present. For individuals with no sleep disturbance or mild sleep disturbance, ASD symptom severity and problem behavior were positively related. For these individuals, having milder ASD symptoms was associated with significantly fewer problem behaviors; it was only those with the most severe ASD symptoms who experienced problem behavior that reached clinical levels. In contrast, ASD symptom severity and problem behavior were not related in individuals with moderate-to-severe sleep disturbance; rather, these individuals exhibited clinically significant problem behavior regardless of whether they had mild, moderate, or severe ASD symptoms. This revelation is novel and emphasizes that the relationship between ASD symptom severity and problem behavior may be more nuanced than previously described. (Lindor et al., 2019)

Functions of Sleep for Behavior of ASD

According to (Cabibihan et al., 2017) the importance of properly assessing children with ASD for sleep disorders cannot be overstated, as inadequate sleep can have detrimental effects on memory, attention, cognition, daytime behavior, and even language acquisition. Reports suggest that chronic sleep disturbance increases the risk of physical health problems, including changes in cardiovascular, immune, endocrine, nervous system function, and, for children with ASD, increased weight status and poorer overall health-related quality of life. Furthermore, chronic sleep disturbances experienced by children with ASD are less likely to remit with age and continue even into adulthood. Therefore, early identification and intervention may help to offset some of the potentially detrimental effects that may occur secondary to prolonged sleep inadequacy. It is very crucial to address the relationship between sleep and behavior. There are four function of behavior which are the social attention, access to tangible items or activities, escape or avoidance of demands and activities, and seeking for sensory activities.

Behavior Challenge

The challenging behaviors in individuals with ASD persist in early adulthood and are related to core symptom severity, levels of cognitive and language impairments and medical comorbidity. The results emphasize the importance of early interventions for children with ASD to target cognitive and language abilities and to alleviate the severity of ASD symptoms. They also underscore the need to enhance opportunities for individuals with ASD to better communicate discomforts and pain in the context of medical illness. (Rattaz et al., 2018)

Sleep Assessment Among ASD

General assessment procedures to identify sleep problems in children with ASD can be categorized by subjective and objective measures. Subjective measures often utilized in the study of sleep-in children with ASD generally include parent-report questionnaires or

completion of a sleep diary record. In contrast, objective measures of sleep rely less on information from parents, and instead directly measure aspects of sleep through various technologies. Some of the most common objective approaches used to assess sleep in children with ASD include polysomnography, actigraphy, and videorecording.

Given the high rates and detrimental consequences of sleep disturbances for children with ASD, it is important to screen for these problems during routine medical care. This initial assessment may include a detailed history of the child's sleep habits and behaviors that may be associated with sleep or sleep-related activities (e.g., sleep anxiety, bedtime resistance, etc.). Once sleep is determined to be worthy of further assessment, additional steps should be considered. General assessment procedures to identify sleep problems in children with ASD can be categorized by subjective and objective measures. Subjective measures often utilized in the study of sleep-in children with ASD generally include parent-report questionnaires or completion of a sleep diary record. (Cabibihan et al., 2017)

The current study aimed to extend previous work in the area where findings thus far have been equivocal, in a well characterized sample of young children with ASD and moderate to severe disruptive behaviors. In this sample, we examine the role of age and IQ in sleep disturbances. We also test whether children with poor sleep have greater daytime behavioral problems and whether parental stress is greater in children with sleep disturbances compared to those with ASD and adequate sleep. (Johnson et al., 2018)

Basic of sleep

Sleep Calculator

It is very vital to understand basic of sleep calculator is a formula used for sleep quantity and measured based on wake-up time. In general, there are five sleep cycle with each 90 minutes which totals 450 minutes or 7.5 hours. An example is shown below.

Bedtime is equals to 10:30pm and wake up time is equals to 5:30am

Sleep calculator	=	Start time / Bedtime – End time / wake up time
	=	10:30pm – 5:30am
	=	7 hours 30 minutes

FIGURE 1. The example of sleep calculator

It is very vital to know the ideal amount of sleep for optimal health among human-being according to age group. According to Medical News Today, the amount of sleep in every 24 hours period as shown below:

TABLE 1

Age	Hours of sleep	Naps
4-12 months	12 to 16	Inclusive
1-2 years	11 to 14	Inclusive
3-5 years	10 to 13	Inclusive
6-12 years	9 to 12	-
13-18 years	8 to 10	-
18-60 years	7 or more	-

Role of Circadian Rhythms, Sleep-Wake Cycle, and Biological Clock

Circadian Rhythms

It is very vital to understand the circadian rhythms and their association to sleep. Basically, circadian rhythms are 24-hour cycles that are part of the body's internal clock which is essential for functions and processes. One of the most important and well-known circadian rhythms is the sleep-wake cycle. Different systems of the body follow circadian rhythms that are synchronized with a master clock in the brain. When properly aligned, a circadian rhythm can promote consistent and restorative sleep.

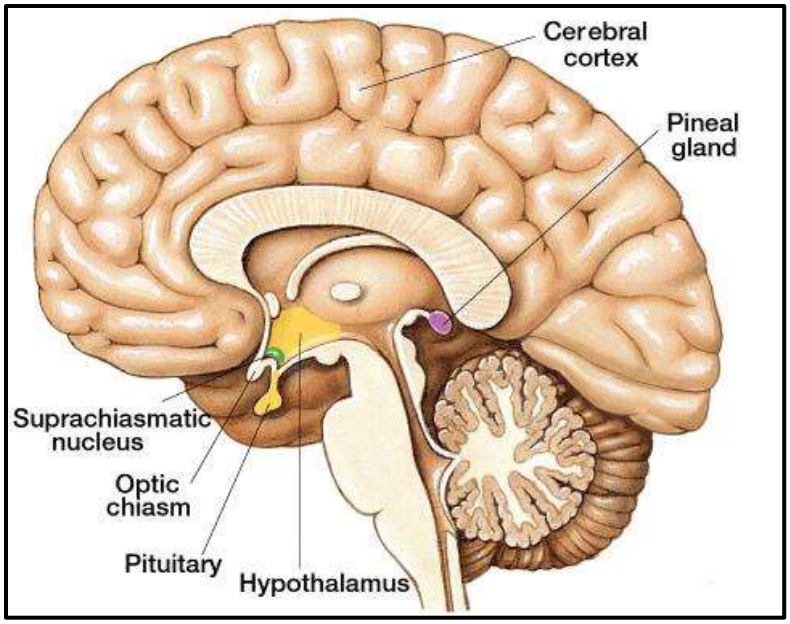

FIGURE 2

Suprachiasmatic Nucleus

As shown FIGURE 2 there is a tiny region located in the hypothalamus, situated directly above the optic chiasm. It is responsible for controlling circadian rhythms. The neuronal and hormonal activities it generates regulate many different body functions in a 24-hour cycle, using around 20,000 neurons. The SCN interacts with many other regions of the brain. It contains several cell types and several different peptides (including vasopressin and vasoactive intestinal peptide) and neurotransmitters. The basic components and the ability to generate a circadian rhythm are also characteristic of most peripheral tissues and some cell lines. (suprachiasmatic nucleus [Operative Neurosurgery], 2022)

Research is also revealing that circadian rhythms play an integral role in diverse aspects of physical and mental health. The circadian rhythms throughout the body are connected to a master clock. Specifically, it is found in the suprachiasmatic nucleus (SCN) as shown in Figure 2, which is in a part of the brain called the hypothalamus. The SCN is highly sensitive to light, which serves as a critical external cue that influences the signals sent by the SCN to coordinate internal clocks in the body. For this reason, circadian rhythms are

closely connected today and night. While other cues, like exercise, social activity, and temperature, can affect the master clock, light is the most powerful influence on circadian rhythms.

Sleep-Wake Cycle

The sleep-wake cycle is one of the most clear and critical examples of the importance of circadian rhythms. During the day, light exposure causes the master clock to send and help keep us awake and active. As night falls, the master clock initiates the production of melatonin, a hormone that promotes sleep, and then keeps transmitting signals that help us stay asleep through the night. In this way, our circadian rhythm aligns our sleep and wakefulness with day and night to create a stable cycle of restorative rest that enables increased daytime activity. (What Is Circadian Rhythm? | Sleep Foundation, 2022)

Biological Clock Among ASD

Autism spectrum disorders (ASDs) are a spectrum of neurodevelopmental disorders characterized by impaired social interaction and communication, as well as stereotyped and repetitive behaviors. ASDs affect nearly 2% of the United States child population and the worldwide prevalence has dramatically increased in recent years. The etiology is not clear but ASD is thought to be caused by a combination of intrinsic and extrinsic factors. Circadian rhythms are the ∼24 h rhythms driven by the endogenous biological clock, and they are found in a variety of physiological processes. Growing evidence from basic and clinical studies suggest that the dysfunction of the circadian timing system may be associated with ASD and its pathogenesis. (Lorsung, Karthikeyan and Cao, 2021)

Evidence linking sleep and development can come from preterm infants, who show disorganized sleep, have indeterminate states in greater proportions, poor sleep-wake cyclicity and short sleep bouts. Neonatal states are neurobehavioral variables of the maturity of nervous system. The maturation of the biological clock depends on the consolidation of clear cycles of activity and rest (Levitt, 2003). Weissman et al. (2011) show that infants whose sleep-state transitions were mainly characterized by shifts between quiet sleep and wakefulness exhibited the best development, including greater neonatal neuromaturation, less negative emotionality, better cognitive development, and better verbal, symbolic and executive competences at 5 years of age. (Geoffray et al., 2016)

Hormone and Nucleoside

Melatonin active when lights are turned off and this is connected to pineal gland. Adenosine promotes the sleep drive, or a person’s need for sleep. Research shows adenosine also plays a role in the immune system and can reduce inflammatory responses. Receptors for adenosine have also been found in the body’s circulatory, respiratory, and urinary systems.

Melatonin (N-acetyl-5-methoxytryptamine) is a hormone synthesized primarily in the pineal gland. The major role of melatonin is to organize circadian physiology the sleep–wake and core body temperature rhythms. Environmental light perceived by the photosensitive ganglion cells of the retina synchronize pineal melatonin secretion with the 24-h day/night cycle is the main phenomena. A distinct circadian rhythm of melatonin is

demonstrated with low levels secreted during the day and high levels at night, which is reflective of the human sleep–wake cycle.

According to (Baker et al., 2017) sleep problems frequently occur in individuals with Autism Spectrum Disorder (ASD) with prevalence rates estimated to be between 50 and 80%. To date the etiology of such sleep disturbances is relatively unknown. One theory postulates a disturbance of the underlying melatonin circadian rhythm, with low levels of melatonin argued to be the cause of lengthy sleep onset latency (Sol) and increased wake after sleep onset (WASO) episodes. While there is some evidence to support atypical levels of melatonin in individuals with ASD. these findings are conflicting and any associations with sleep remain under researched. (Baker et al., 2017)

Gamma-aminobutyric acid (GABA) is the type of an amino acid which plays a major role in hormone secretion. Besides it is also does controlling anxiety, stress, and fear. Decreased GABA levels are associated with several neurological and mental health and medical conditions. Increasing GABA levels may help treat high blood pressure, diabetes, and insomnia. (Gamma-Aminobutyric Acid (GABA): What It Is, Function & Benefits, 2022)

According to (Ballester et al., 2020), the circadian system provides timing information for the sleep-wake cycle that is regulated by the interaction of an endogenous processes (circadian - Process C, and homeostatic - Process S) and synchronizing agents (neurohormones and neurotransmitters), which produce homogenic activity. A clinical priority in ASD is understanding the cause of these sleep problems to improve treatment outcomes. It was stated that, sleep-wake mechanisms and problems, and brain areas and molecules controlling sleep (e.g., GABA and melatonin) and wake maintenance (e.g., serotonin, acetylcholine, and glutamate). Therefore, the articles proposed on how altered sleep structure could be related to neurobiological alterations or genetic mutations and the implications this may have for potential pharmacological treatments in individuals with ASD. (Ballester et al., 2020)

Sleep Architecture

According to (Mazzone et al., 2018) sleep architecture represents the cyclical pattern of sleep as it shifts between the different sleep stages. It may change with age and can have an impact on the quality of life. For example, it is known that that during the physiological development, NREM sleep gradually increase while REM sleep decrease, resulting in a lighter sleep; thereby, it might become easier to awaken throughout the night and harder to fall and stay asleep at night. Disrupted sleep architecture, including increased REM density, reduction of REM sleep, or longer sleep latency, has been also described in individuals with ASD.

Based on (Shrivastava et al., 2014) a sleep study report describes the percentages of various sleep stages. The normal percentage of each stage is reported with the number of total REM Stage sleep cycles recorded overnight. In adults, approximately 5% of the total sleep time is Stage N1; 50% Stage N2; and 20% is Stage N3 sleep. The remaining 25% is REM stage sleep. (Shrivastava et al., 2014)

Sleep stage	Type of sleep	Functions	Length
1	NREM (N1)	Light sleep during this stage muscles started to relax; activities slow down. This is the most very light sleeping stage, quickly can wake up	1 to 7 minutes
2	NREM (N2)	Intermediate sleep last for 25 minutes. Like stage 1, breathing slows down	25 minutes
3	NREM (N3)	This is the most important stage; this is the deep sleeping stage. Immune system strength, growing and recovering	20 -40 minutes
4	REM	Heart beats go up. Legs are paralyzed. No physical movement. Vivid dreams happen here	1-5 minutes

TABLE 2

The table above shows the stages and the length. There are two types of sleep pattern which is monophasic sleep pattern and biphasic sleep feels natural and works great for them, while others feel better on a monophasic sleep schedule. There is historical evidence that humans used to naturally follow a biphasic sleep schedule. Research has also proven the benefits of a short, midday nap.

Sleep Pattern Among ASD

Sleep patterns in children with autism spectrum disorder (ASD) appear to diverge from typical development in the second or third year of life. Little is known, however, about the occurrence of sleep problems in infants who later develop ASD and possible effects on early brain development. In a longitudinal neuroimaging study of infants at familial high or low risk for ASD, parent-reported sleep onset problems were examined in relation to subcortical brain volumes in the first 2 years of life. Sleep onset problems were more common at 6–12 months among infants who later developed ASD. Infant sleep onset problems were related to hippocampal volume trajectories from 6 to 24 months only for infants at high risk who developed ASD. Brain-sleep relationships were specific to the hippocampus; no significant relationships were found with volume trajectories of other subcortical structures examined (the amygdala, caudate, globus pallidus, putamen, and thalamus). (MacDuffie et al., 2020)

Sleep Assessment

The researchers (Shrivastava et al., 2014), clearly stated benefits of sleep assessment and the restorative effect of our sleep. By improving our understanding of how lifestyle and personal decisions affect our sleep, we can make better, more informed decisions in support of our health and well-being. To serve that purpose, First beat has developed a comprehensive method for credibly estimating sleep quantity, structure, and the restorative effect of sleep using wearable data. This white paper describes the factors behind the method and presents its validation results.

The sleep study reports are typically arranged into sections containing patient information, which includes their sleep related symptoms, the technical details, quantitative data regarding distribution of different stages of sleep called sleep architecture and sleep staging. The technical details document the number of electroencephalographic (EEG), electro-oculogram, chin and leg electromyogram, electrocardiogram, and air flow at the nose and mouth. The chest and abdominal wall movements are recorded by plethysmography strain belts. The oxygen saturation is sampled by continuous pulse oximetry and the snoring microphone is used for recording the snoring and its intensity. (Shrivastava et al., 2014)

Technique Used for Sleep Assessment

Polysomnography

Sleep assessment done with various methods, firstly polysomnography. Polysomnography is a comprehensive measure of sleep. It is based on the simultaneous recording of cortical electroencephalogram (EEG), submental muscle (electromyogram), and elect ocular activity via the standardized positioning of scalp surface electrodes. Furthermore, during the procedure a few additional physiological signals (e.g., ECG, respiration, leg movements, nasal pressure, oxygen desaturation and body position) are routinely assessed and help to characterize the complex nature of sleep and potential presence of sleep disorders. Sleep studies, such as a polysomnography conducted in a specialized lab, are necessary for the formal diagnosis of some sleep disorders. Because of the detail it provides, a polysomnography is the gold standard for identifying many sleep disorders, but it is expensive and requires spending at least one night in a sleep clinic.

Polysomnography (PSG), popularly known as a ‘sleep study’, has been used for decades to diagnose and evaluate the severity of sleep-disordered breathing. There is a significant increase in the demand for sleep-related evaluations and sleep studies, due to the heightened public awareness of sleep disorders.

Sleep Diary

Secondly, sleep diaries method which contains daily record of important sleep-related information and called sleep journals or sleep logs. According to sleepfoundation.org, the common details include bedtime, wake-up time, how long it takes to fall asleep, the number and duration of sleep interruptions. The number and duration of daytime naps. It also includes perceived sleep quality, consumption of alcohol, caffeine, and/or tobacco, daily medications, and daily exercise. This method is highly recommended for its simplicity, low-cost, and broad insight into sleeping habits that may be used at a doctor’s request or on one’s own. Sleep questionnaires involve subjective evaluations of sleep without the detailed recordings made in a sleep diary. Though potentially useful, sleep questionnaires are typically less precise than a sleep log. (Sleep Diary: How and Why You Should Keep One | Sleep Foundation, 2022)

Actigraphy

Thirdly, actigraphy method which uses a special device worn on the wrist to monitor movement, including sleep. Actigraphy is often recommended when doctors are trying to identify a sleep problem because it offers more objective data 7 than a sleep diary. That said, results from sleep logs and actigraphy are often similar, and sleep diaries are simpler and less expensive. In many situations, doctors may request that patients use both at the same time to get a subjective and objective assessment of sleep.

Wearable Sleep-Trackers

Fourthly, wearable sleep-trackers (e.g., wristbands, armbands, smartwatches, headbands, rings, sensor clips) are part of a larger consumer sleep technology (CST) family. Consumer sleep technology includes smartphones, in-bed sensors, and contactless sensors, as well as other devices designed to enhance sleep and/or improve sleep behaviors, such as neurostimulators, biofeedback devices, and brainwave entrainment systems. (De Zambotti et al., 2019)

Factors that Influence Sleep

In between year 2010 to 2014, researchers have examined actigraphy in relation to subtypes of anxiety symptoms in healthy school-aged children. The current study therefore combined parent-report and objective sleep assessment with a validated anxiety measure in a community-recruited group of healthy school-aged children (6–12 years). Prior to examining the role of anxiety, the first aim of the study was to comprehensively assess sleep profiles by combining the Children's Sleep Habits Questionnaire (CSHQ) and actigraphy; specifically, examining the effect of age and gender. They hypothesized increasing age to be mostly associated with shorter sleep duration with no effect of gender on parent-reported or objective sleep profiles (Gruber et al., 2014; Holley et al., 2010).

Low Functioning ASD

To date, most of the studies exploring sleep in ASD have focused on individuals with high functioning autism, those individuals who have an ability to communicate and cooperate during actigraphy and polysomnography sleep studies. Currently, there is an inconsistent understanding of the nature and prevalence of sleep difficulties in low-functioning autism. One study has suggested that the severity of sleep problems (such as sleep-onset delay and sleep duration) increases with the severity of autism symptoms (such as communication deficits) [8]. Another study has suggested that increased autism severity predicts an increased likelihood of sleep problems [23]; however, these links are still speculative, and sleep profiles in low-functioning autism are yet to be elucidated. To date, it is still unclear what specific sleep problems and symptom relationships are unique to individuals with low-functioning autism. (Cohen et al., 2016)

Understanding the relationship between the physiology of sleep and neurobehavior in children is critical. In the last 20 years, the role of sleep has been elucidated in memory and learning in both adults and children; however, the influence of sleep on neurobehavioral functioning and contribution to core symptoms present in common neurodevelopmental

disabilities is an emerging area of research. Most data on neural changes with sleep disturbance have been in adults with the prefrontal lobe, striatum and amygdala shown to be highly affected. These areas are of great importance in considering the effects of sleep disturbance on children as there are potential critical periods in childhood where damage to these structures may result in both immediate and long-term behavioral dysfunction. (Maski and Kothare, 2013)

Contributing Factors

Cross-Sectional Studies

Cross-sectional studies only capture an ASD profile at one specific age presentation, and most studies have combined both children and adolescents. Little is known about how sleep changes over time in ASD and what factors might be associated with this change, for example, age and stages of development. In ASD, one study found no relation between sleep difficulties and developmental stage. (Cohen et al., 2016)

Correlation Between Sleep and Anxiety

Linkages between frequently co-occurring psychiatric conditions in ASD such as anxiety or attention problem and sleep patterns should be explored in longitudinal studies to move beyond correlation. The role of other family characteristics in sleep disturbances in children such as socioeconomic status and family composition, which have studied in other pediatric populations have not been examined in ASD. Learning more about these complex interactions of biological and environmental factors will promote development of more tailored interventions to improve sleep quality in children with ASD. (Johnson et al., 2018)

Environment

The role of other family characteristics in sleep disturbances in children such as socioeconomic status and family composition, which have studied in other pediatric populations have not been examined in ASD. Learning more about these complex interactions of biological and environmental factors will promote development of more tailored interventions to improve sleep quality in children with ASD. With improved sleep, better outcome for children with ASD could be expected.

Challenging Behavior

Autism and its associated challenging behaviors, the effects of sleep disruption in this disorder are potentially serious. Sleep problems have been found to exacerbate ASD symptoms. Fewer hours of sleep have been shown to correlate with and predict greater ASD severity stereotypic behaviors and non-functional routines. Sleep difficulties have been shown to be associated with increased rates of overactivity, disruption, non-compliance, aggression, irritability, and affective problems.

In typical development, sleep disruption is associated with emotional and behavioral problems. Moreover, a growing body of evidence shows that childhood sleep disturbances may widely impact children's health, behavior, attention, cognition, and school activities.

Given the nature of autism and its associated challenging behaviors, the effects of sleep disruption in this disorder are potentially serious. Sleep problems have been found to exacerbate ASD symptoms. (Cohen et al., 2016)

Sleep Disturbance and Sensory

Children with autism exhibited more severe sensory abnormalities and sleep disturbances than age-matched controls. The sleep disturbance scores were moderately associated with touch and oral sensitivities in the autism group and with touch and vestibular sensitivities in the control group. Hypersensitivity towards touch exhibited the strongest relationship with sleep disturbances in the autism group and single-handedly explained 24% of the variance in total sleep disturbance scores. In contrast, sensitivity in other sensory domains such as vision and audition were not associated with sleep quality in either group. While it is often assumed that sensitivities in all sensory domains are similarly associated with sleep problems, our results suggest that hypersensitivity towards touch exhibits the strongest relationship with sleep disturbances when examining children autism. This may indicate the existence of a specific sleep disturbance mechanism that is associated with sensitivity to touch, which may be important to consider in future scientific and clinical studies. (Tzischinsky et al., 2018)

Use of Algorithm

In year 2014, system detects heartbeats, breathing, snoring, sleeping positions and movements using a special electret microphone and an inertial measurement unit (IMU). The system first analyses the sleep using the acoustic information provided by the electret microphone. Early results show that the system can be used to detect the occurrence of obstructive sleep apnea syndrome (OSAS). OSAS is traditionally diagnosed using polysomnography, which requires a whole night stay at the sleep laboratory of a hospital, where the patient is attached to multiple electrodes and sensors.

First beat algorithm is light and highly efficient, making it possible to implement the algorithm in various wearable devices such as smart- and fitness watches and trackers having limited data processing resources. It also means that it’s possible to analyze sleep and offer insight without needing to transfer data and rely on the processing power of a paired smartphone or cloud-based computational solution.

Model Predicting the Sleep Problem

Sleep difficulties in children with autism spectrum disorders (ASD) have been well established. A sample of children in the Autism Speaks-Autism Treatment Network (ATN) registry without parent-reported sleep problems at baseline and with sleep problem (yes/ no) data at first annual follow up was randomly split into training (n = 527) and test (n = 518) samples. Model predictors were selected using the training sample, and a threshold for classifying children at risk was determined. Comparison of the predicted and true sleep problem status of the test sample yielded model performance measures. Outcomes and results: In a multivariable model aggressive behavior among children with no sleep problems reported at baseline was associated with having more sleep problems at the first annual follow-up visit. This model performed in the test sample with high sensitivity and

accurate prediction of low risk. Conclusions and implications: Among children with ASD aggressive behavior independently predicts sleep problems. The model's high sensitivity for identifying children at risk and its accurate prediction of low risk can help with treatment and prevention of sleep problems. Further data collection may provide better prediction through methods requiring larger samples. (Shui et al., 2018)

Correlation Between Cognitive and Sleep

The high prevalence of sleep problems in ASD is thought to be due to a complex interaction between dysregulated melatonin and comorbid medical conditions. For some individuals, the presence of mood-related internal stimuli can prevent sleep can heighten unhelpful cognitive activity, producing a state antithetical to initiating and maintaining sleep. Autism-specific characteristics, such as cognitive inflexibility, can compound anxiety and depressive, thus increasing their risk of sleep disturbance, and warranting the use of targeted cognitive treatments.(van Deurs et al., 2021)

The impact of poor sleep on cognitive performance in ASD children is not well-established. The fact that a significant correlation was observed between markers of poor sleep and typical performance (speed) but not with atypical performance (working memory and sustained attention) does not support an association between slow non-verbal processing and poor sleep in ASD. Differences between correlations in the ASD suggest that the relationship between sleep and daytime cognitive functioning takes different brain routes or altered connectivity substrates in these two populations. The present results disclose that objective signs of poor sleep-in persons with ASD are associated with some limitations in performance.(Backer et al., 2018)

Sleep Improvement

Need for Sensory Skill

Bedtime settling is associated with a series of environmental shifts, for example a reduction in ambient light and noise. These changes are external time cues that entrain the biological rhythms. According to the bidirectional theoretical framework intolerance to changes, insistence on sameness, and social communication difficulties – three hallmarks of autism – lead children with ASD to perceive external cues as environmental stressors. To face these stressors, they adopt maladaptive coping strategies, such as internalizing behaviors, as evidenced by increased anxiety around bedtime, and externalizing behaviors, with tantrums and oppositional behaviors in response to change, or restricted interests and repetitive behaviors to ensure some sameness in the day/night transition period. These coping mechanisms result in somatic and cognitive hyperarousal states that entail difficulties in falling asleep and sleep maintenance. (Deliens and Peigneux, 2019)

Parenting

Regarding the relationship between maternal sleep and psychological wellness, findings have supported the hypothesis that more frequent sleep problems are significantly positively correlated to a greater severity of depressive symptoms, particularly in the areas of overall sleep, subjective sleep quality, sleep latency and daytime dysfunction. These

effects persisted even after controlling for maternal age, the child's ASD severity measured by CARS-2 and the child's sleep quality measured by CSHQ. These findings add more evidence in support of several previous studies that suggested that mothers of children with ASD are chronically sleep deprived and have higher rates of poor psychological function and depression. The mothers in this sample appear to have undiagnosed sleep onset insomnia, when considering this data within the sleep disorders criteria, although this claim is yet to be verified by professional health practitioners. Nonetheless, the present findings have elucidated the relationship between sleep and mental health within the context of caring for a child with ASD, which gives renewed impetus for healthcare professionals to consider more comprehensive support to caregivers in terms of their psychological needs and to screen for potential mental health issues among parents of children with ASD. (Eid et al., 2022)

Sleep Habit

The disturbed sleep among children with ASD negatively affect the sleep quality of parents and family. Schreck and Mulick (2000) have reported that early morning waking, unusual bedtime routines, and night walking are common among children with ASD. Most of the studies examining sleep problems among children had emerged from Euro-American populations which in general have populations with a smaller number of children compared to developing countries. Therefore, studies are needed to examine the sleep problems among children in developing countries. These studies will be expected to provide a better understanding of sleep problems among children and will enhance development of national policies and protocols of clinical practice in these countries. (Al-Farsi et al., 2019)

Worldwide Research

Research in Saudi Arabia and UK

A cross-cultural study is conducted, involving typically developing children and children with ASD aged 5–12 across two countries: Saudi Arabia and the United Kingdom. Methods and procedures: Using a combination of questionnaires measuring ASD severity (CARS-2), sleep quality (CSHQ), sociodemographic and lifestyle variables and sleep diaries, 244 children were sampled using a mixture of snowball and convenience sampling methods. Outcomes and results: Children with ASD experience more sleep problems compared to typically developing children in Saudi Arabia, and these problems similarly persist across time. Specifically, it was found that children with ASD in Saudi Arabia experience greater sleep onset latency and a greater number of night awakenings. Additionally, across the ASD groups, it was found that children from Saudi Arabia generally experienced poorer sleep than children in the United Kingdom in terms of shorter sleep duration, although children in the United Kingdom tended to report more instances of sleep anxiety and parasomnias. Several reasons such as parental education about sleep hygiene, cultural influences and social hours were put forward as potential explanations for cross-cultural differences. Findings served to emphasize the importance of culturally-appropriate interventions and public education regarding child sleep. (Bin Eid et al., 2022)

Research in China

Sleep disturbances in preschool-aged children with ASD and their associations with daily behavior in children have been widely researched in the West; however, research on these topics is still lacking in China. This was the first cross-sectional study to compare sleep problems between TD children and Chinese preschool-aged children with ASD with sleep problems who were not taking any medications.

Sleep disturbances are normal in preschool-aged children with ASD; however, symptoms of insomnia are often neglected by their parents. Many clinical doctors have limited knowledge of sleep problems and the US Food and Drug Administration (FDA) did not approve sleep medications for children until 2017.The Autism Treatment Network (ATN) sleep committee experts presented a consensus statement that all children with ASD should be screened for insomnia, that treatment should begin with the parents, and that behavioral interventions should be the first-line approach. Thus, China should screen for sleep problems in all children with ASD regardless of cognitive level and age. Additionally, we should encourage the establishment of a special sleep routine for preschool-aged children with ASD based on the Chinese social context. (Kang et al., 2020)

Research in India

Based on study was conducted in a tertiary care teaching hospital in north India over a two-year period. Children diagnosed with ASD and normally developing children (controls) aged 3 to 10 years were enrolled in the study. Both groups underwent sleep evaluation based on CSHQ (Children's Sleep Habit Questionnaire). Children with ASD also underwent PSG (Polysomnography), CARS (Childhood Autism Rating Scale), CBCL(Childhood Behavioral Checklist) and DP-3(Developmental Profile-3). (Aathira et al., 2017)

Research in Malaysia

According to (Koo et al., 2021) based in Malaysia stated that generalized disturbance in sleep may be attributed to a multitude of internal and external factors. Higher prevalence of these problems can be explained by the different circadian cycle in relation to the neurotransmitters such as melatonin, GABA, and serotonin, which in turn can affect sleep cycles in children with ASD. All the six subtypes of sleep disorders were present in different percentages in our children with ASD. Sleep disturbances are common in Malaysian children with ASD, the most frequent indicators include disorders of initiating and maintaining sleep (DIMS), sleep breathing disorders (SBD) and disorders of excessive somnolence (DOES). We found an association between female gender, older age group, shorter sleep length, and longer sleep latency with the child's sleep problems. Clinicians who work with children with ASD should include evaluation of sleep problems as part of their comprehensive care. Affected children could then be directed to appropriate avenues for intervention.

Research in Turki

Studies on sleep are frequently from western countries. There is only one recent study from the Turkish population, reporting that children with ASD had more sleep problems than typically developed children (TCD). Research found that difficulty in falling asleep (73.4%), difficulty in sleeping after waking up in the night (79.7%), frequent changes in falling asleep (76.6%) and tiredness after sleeping (75%) were the most reported problems in the ASD group, along with bedtime rituals (65.6%), restless sleep (51.6%), daytime sleepiness (45.3%), bedwetting (45.3%), body, and/or head shaking while falling asleep (31.3%), and frequent wakening (28.1%). (Köse et al., 2017)

Chinese and Japanese Preschool

Based on the researchers(Wang et al., 2020) sleep disturbances are often associated with emotional or behavioral problems in young children, but whether the association differs among Asian countries remains unknown. The association between sleep disturbances and emotional or behavioral problems in Chinese and Japanese preschoolers and to explore potential differences. Participants were 1,020 Chinese preschoolers from 10 cities and 438 Japanese preschoolers from 1 city aged 4 to 5 years. Parents filled out the Children's Sleep Habits Questionnaire (CSHQ) and the Strengths and Difficulties Questionnaire (SDQ). The result shows, Chinese children with sleep disturbances (defined as total CSHQ score >41) demonstrated more peer problems than children without, while there was no such difference in Japanese preschoolers. Domains of sleep disturbances associated with emotional or behavioral problems in Chinese children were sleep disordered breathing and daytime sleepiness, yet in Japanese children were sleep anxiety and night waking. Children with a higher score of sleep anxiety showed more emotional problems in Japan, but fewer conduct problems in China. In conclusion, sleep disturbances were associated with emotional or behavioral problems in preschoolers with differences between China and Japan, indicating subcultural differences in preschoolers' sleep within Asian countries.

CONCLUSION

This literature review has given clarity and motivation for better implementation of sleep strategies as mentioned by the researcher (Williams Buckley et al., 2020) has mentioned that for children and adolescents with ASD and sleep disturbance, clinicians should assess for medications and coexisting conditions that could contribute to the sleep disturbance and should address identified issues. Clinicians should counsel parents regarding strategies for improved sleep habits with behavioral strategies as a first-line treatment approach for sleep disturbance either alone or in combination with pharmacologic or nutraceutical approaches. Clinicians should offer melatonin if behavioral strategies have not been helpful and contributing coexisting conditions and use of concomitant medications have been addressed, starting with a low dose. Clinicians should recommend using pharmaceutical-grade melatonin if available. Clinicians should counsel children, adolescents, and parents regarding potential adverse effects of melatonin use and the lack of long-term safety data.

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