ORIGINAL RESEARCH

The Relationship Between Sleep Efficiency and Attention-Deficit Hyperactivity Disorder

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Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is an increasingly widespread disorder associated with significant functional impairment in multiple domains, including sleep quality. Although the relationship between ADHD and sleep has been extensively studied and supported in children, it has not been similarly documented in adult patients, for whom only a few studies have been conducted in this population; thus in the current literature, there is insufficient evidence to determine a significant correlation.

Thus, the study's purpose is purpose of the study was to explore the relationship between sleep quality and the risk of ADHD diagnosis in adults. The researcher hypothesized that participants who are at risk of being more likely to be diagnosed with ADHD would score higher on the Pittsburg Sleep Quality Index (PSQI), indicating a worse sleep quality. The study investigated the sleep quality of 40 university students (20 female and 20 male) aged 18-22 in relation to their scores on the PSQI. The results were significant [$t(38) = 4.24$, $p < 0.05$] with a large effect size of $r^2=0.321$, supporting the relationship between sleep quality and ADHD risk. These results provide implications in ADHD diagnosis and treatment; however, they require further study of refinement and replication in a more representative sample of the adult population.

Lior Fusman: *AWAKE*

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is characterized as a behavioral disorder that inhibits one's ability to stay focused and consists of attributes such as short attention span, hyperactivity, inattention, restlessness, and impulsiveness. ADHD is classified into 3 subtypes: (1) ADHD of the predominantly inattentive; (2) ADHD of the predominantly hyperactive-impulsive; and (3) ADHD of the combined type consisting of both inattentive and hyperactive-impulsive behaviors (American Psychiatric Association, 2000). The disorder is often associated with functional deficits that can manifest in academic, social, and occupational settings (Dopheide & Pliszka, 2009). On average, the disorder affects 6-8% of children and 4.4% of adults (Barkley & Brown, 2008; Kessler et al., 2006). When a child is diagnosed with ADHD, there is a 60% likelihood the disorder will persist into adulthood (Yoon, Jane & Shapiro, 2013).

Of all children diagnosed with ADHD, about 70% are diagnosed with another condition. Any disorder can co-exist with ADHD; however, there are several co-occurring conditions that can alter and enhance a

patient's symptoms (Biederman, Newcomb & Sprich, 1991). A common comorbidity is sleep disorders. Generally, sleep disorders include a variety of problems with sleeping, such as falling and staying asleep, excessive daytime somnolence, and abnormal behaviors during sleep. (Dagan et al., 1997; Gruber, Sadeh & Raviv, 2000). The most common sleep disorders include sleep apnea, restless leg syndrome, and insomnia (Spira & Ancoli-Israel, 2013). Sleep apnea disorders include: snoring – the blockage of one's airway resulting in the inability to transfer air into the lungs; obstructive sleep apnea – the collapsing of one's airway causing low oxygen levels; and central sleep apnea – the desistance of breathing due to the inability of the brain to signal taking a breath. Further, insomnia, a sleeping disorder that affects 1 in 10 adults, is characterized by difficulties in falling and staying asleep, and a non-restorative sleep that results in poor sleep quality (Spira & Ancoli-Israel, 2013). Insomnia disorder also manifests during the daytime, causing symptoms that mimic classic presentations of ADHD. Such symptoms include concentration and attention difficulties, memory impairments, and daytime fatigue (Dopheide & Pliszka, 2009). Insomnia is the most common sleeping disorder, which may be attributed to its wide range of inciting factors, such as stress, worrying, arousal, chronic pain, and the use of sleep-disturbing medications (Malaffo & Espie, 2007).

Studies of sleep disorders in children with ADHD have provided overwhelming evidence indicating a significantly more impaired sleep compared to children without ADHD (Cortese et al., 2009; Cohen-Zion & Ancoli-Israel, 2004; Golan et al., 2004; Sadeh & Bar-Haim, 2006; Yoon, Jain & Shapiro, 2013). Excessive daytime sleepiness, defined as sleepiness that occurs during a time where an individual would be expected to be awake and alert, is the primary symptom of patients who suffer from sleep disorders (Littner et al., 2005). Studies indicate that children with ADHD exhibit greater excessive daytime sleepiness in comparison to healthy controls. (Golan et al., 2004; Lecendreux et al., 2000). Thus, current literature demonstrates an interaction between ADHD and excessive daytime sleepiness in children.

Dopamine is a neurotransmitter that carries out motor control and hormone release tasks. Studies suggest that dopamine plays an important role in both excessive daytime sleepiness and ADHD development (Maher et al., 2002). Patients with ADHD often exhibit specific polymorphisms of D4 (DRD4) a dopamine transporter (DAT1) that seem to decrease brain dopamine levels (Albrecht et al., 2014; El-Faddagh et al., 2004; Langley et al., 2006). These dopamine D4 receptors are known to modulate melatonin synthesis in the pineal gland, a small endocrine gland in the brain that is central to the regulation of circadian rhythms. Dopamine inhibits the effects of norepinephrine, a neurotransmitter in the pineal gland that synthesizes and releases melatonin hormones – hormones that prepare the body for sleep. Thus, a decrease in dopamine levels results in insufficient inhibition of norepinephrine, which could lead to irregular sleep patterns and aggravated circadian rhythms (González et al., 2012). Overproduction of melatonin and a lesser capability for the brain to "wake up" explains many typical ADHD symptoms such as difficulty getting out of bed, extensive irritability in the morning, and the overall excessive daytime sleepiness seen in patients with ADHD and sleeping disorders (Owens et al., 2009). This evidence supports the theory that

Key Points: What is Attention Deficit Hyperactivity Disorder (ADHD)?

- A common neuropsychiatric disorder that manifests in childhood and adolescence that can persist into adulthood[1]
- The most noticeable deficits of ADHD surround frontal and subcortical dysfunction, particularly executive function[2]
- Examples of executive functions include multitasking, problem solving, reasoning, and inhibiting responses[2]

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excessive daytime sleepiness is directly associated with ADHD in both children and adults.

In 2006, studies revealed that 70% of ADHD patients suffered from sleeping disorders and 37% of these patients met the criteria for subjective excessive daytime sleepiness (Oosterloo et al., 2006; Sadeh, Pergamin & Bar-Haim, 2006). The most common cause of excessive daytime sleepiness is a disturbance in sleep quality (Slater & Steier, 2012). Thus, a measure of poor sleep quality indicates increased excessive daytime sleepiness. When compared to the pediatric population with ADHD, adults with ADHD are more likely to complain of sleep problems (Philipsen, Hornyak, & Reimann, 2006) and indicate lower sleep efficiency, longer latency, and more interrupted sleep than healthy controls (Boonstra et al., 2007; Sobaski et al., 2008). However, the interaction between sleep quality and ADHD has scarcely been researched and the interaction of sleep disorders and ADHD in adults has yet to be determined (Yoon, Jain & Shapiro, 2013). If adults with ADHD demonstrate a worse sleep quality, this information would provide evidence about the interaction between sleep disorders and ADHD in the adult population, therefore suggesting that adults with ADHD may have sleep problems that exacerbate or contribute to their ADHD symptoms.

The Present Study

The aim of the present study is to investigate the interactions of sleep disorders and ADHD symptoms in the adult population, as research in this group is relatively scarce. This study will also examine the direct relationship between sleep quality and ADHD symptoms, whereas previous research focused on a broader range of sleeping variables that are both quantitative and qualitative. Only a qualitative sleep measure will be used, as it is the most accurate predictor of excessive daytime sleepiness.

For the purposes of this study, ADHD patient diagnoses will not be necessary; rather, a rating of ADHD symptoms will be utilized. If sleep quality is significantly different for participants who demonstrate more ADHD-like symptoms, there will be a better understanding of the interaction between sleep and ADHD in the adult population. A positive relationship suggests that poor sleep quality can manifest as ADHD symptoms and subsequently increase the risk of being diagnosed with this disorder. Participants who are at risk of being diagnosed with ADHD will be defined as those who have indicated 4 or more symptoms consistent with the disorder.

Based on findings discussed in this paper's introduction, it is hypothesized that adults at risk of being diagnosed with ADHD will exhibit significantly worse sleep quality than those who are not at risk of haviong this disorder. This hypothesis is based on current literature, which reveals a strong relationship between sleep quality and ADHD for children.

Methods

Participants

The sample was composed of 40 university students aged 18 to 22 years (M=20 years, SD=1.24), enrolled at Western University. The sample consisted of 20 males and 20 females, all unknown to the researcher. Participants were selected via convenience sampling, and a systematic selection plan was used to increase randomization within the sample. Every 5th person who walked into the University Community Center was approached and verbally asked to participate in a study concerning the interaction between attention and sleeping habits. Fifty people were invited to participate, with 4 refusing and 6 who were unqualified. The remaining 40 consented and completed the study. All participants were exposed to the same experimental conditions and were asked to complete 2 types of surveys. Due to the use of a convenience sampling procedure, the results of this study are subject to potential sources of sampling bias and may not be generalizable to the entire population. Since the sample only consisted of university students, it may be comprised of unique characteristics (such as high average IQ) that are not generalizable to the entire population. No compensation or credit was given as reward for participation in this study.

Materials

Pittsburgh Sleep Quality Index. Participants completed a short version of the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), consisting of the first 9 9-items (see Appendix A). Item 10 and 5j were not used, as they were not relevant for the purposes of this study. This self-report survey was used to differentiate between "poor sleep" and

"good sleep" by measuring the following divisions: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of medication, and daytime dysfunction. Scoring of the answers was based on a 0 to 3 scale, where 3 reflected the negative extreme. The first four 4 PSQI items were open-ended questions that required the participant to report an accurate number response to the items. For example, Iitem 2 stated "How long does it take you fall asleep each night?" Responses to items 1 and 3 were not scored individually but instead used to derive a component score for the "sleep efficiency" whereby the following equation was used: Sleep efficiency= (#hours slept/ #hours in bed) X 100%; the number of hours slept was derived from Iitem 4, and the number of hours in bed was derived from the sum of Iitems 1 and 3. Sleep efficiency was then scored according to the following scale: 0: more than 85%; 1: 75-84%; 2: 65-74%; or 3: less than 65%. Item 2 was scored using the following 3-point scale: 0: 0-15 minutes or less; 1: 16-30 minutes; 2: 31-60 minutes; or 3: 60 minutes or more. Item four 4 was scored on a 3-point scale such that: 0: more than 7 hours; 1: 6-7 hours; 2: 5-6 hours; or 3: less than 5 hours, scored 0, 1, 2, and 3, respectively. Items 5-8 were rated on a 3-point scale: 0: not during the past month; 1: less than once a week; 2: once or twice a week; or 3: three or more times a week. For example, item 6 asked, "During the past month, how often have you taken medicine (prescribed or over the counter) to help you sleep?" Item 9 was also reported on a 3-point scale: 0: very good; 1: fairly good; 2: fairly bad; or 3: very bad. These were scored 0, 1, 2, and 3, respectively. The nine items were allocated to the seven components that were added up in order to derive a global PSQI score.

The Pittsburgh Sleep Quality Index was deemed a valid and reliable measure, with a Cronbach's alpha of 0.83, and was supported internationally through a variety of several studies that employed it as a means of measuring sleep efficiency (Smyth, 2012). The survey was distributed in a paper and pencil format, and it took approximately five minutes to complete.

ADHD Self Report Scale. Participants proceeded to complete part A of the adult ADHD Self Report Scale (ASRS-v1.1; Kessler et al., 2005), which contained six items to assess symptoms of Attention-deficit Deficit Hyperactivity Disorder (see Appendix B). Only part A of the ASRS-v1.1 questionnaire was used, since part B is only useful in providing insight about specific ADHD symptoms, which is beyond the scope of this study. The items were rated on a 5-category frequency scale that consisted of the following divisions: Never, Rarely, Sometimes, Often, and Very often. For example, item Item 1 stated, "How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?" ARSR scores in the shaded boxes of the questionnaire indicated symptoms that are consistent with adult ADHD. These boxes were used to divide the participants into two categories: "at risk" or "not at risk" of ADHD. If four or more marks appeared in the shaded boxes of the surveywere shaded, the participants were placed in the "at risk" category. However, if fewer than four marks were recorded in the shaded boxes, the participants were categorized as being "not at risk."

The ASRS v1.1 was deemed to have high internal consistency and reliability with a measure of 0.63-0.72. The measure has been observed to yield test-retest correlations (using Pearson correlations) of 0.58-0.77 (Kessler et al., 2007). The survey was distributed in a pencil and paper format, and it took approximately three minutes to complete.

		Sex	
Age (years)	% of Participants	Male	Female
18	17.5	3	4
19	20	5	3
20	27.5	2	9
21	22.5	7	2
22	12.5	3	2

Table 1. Description of Participants

Procedure

Participants were recruited individually at Western University between the hours of 1:30pm-3:00pm from Monday-Friday. It was crucial to survey the participants around the same time each day at a consistent hour, as perceived wakefulness varies with time of day. Each participant was given a letter of information and a document of informed consent prior to their participation in the study (see Appendix C). Individually, they filled out the PSQI questionnaire and then completed the ASRS. The study was described verbally to each participant as "a survey that measures the interactions between attention and sleep." Upon completion of the surveys, the participants were given a debriefing letter (see Appendix D) and an opportunity to ask questions and express concerns.

Results

To explore the relationship between sleep quality and ADHD, an independent t-test was conducted (see Table 1 for description of participants). The analysis revealed that students who were at risk of being diagnosed with ADHD had a significantly worse sleep quality (M = 7.82, SD = 1.83) than those who were not at risk of having ADHD (M = 5.14, SD = 1.77), t(38) = 4. 24, p < 0.05. Mean sleep quality scores are presented in Figure 2. There was a moderate relationship (r^2= 0.321). With 95% confidence, the difference in average sleep quality for the groups is between 1.40 and 3.96.

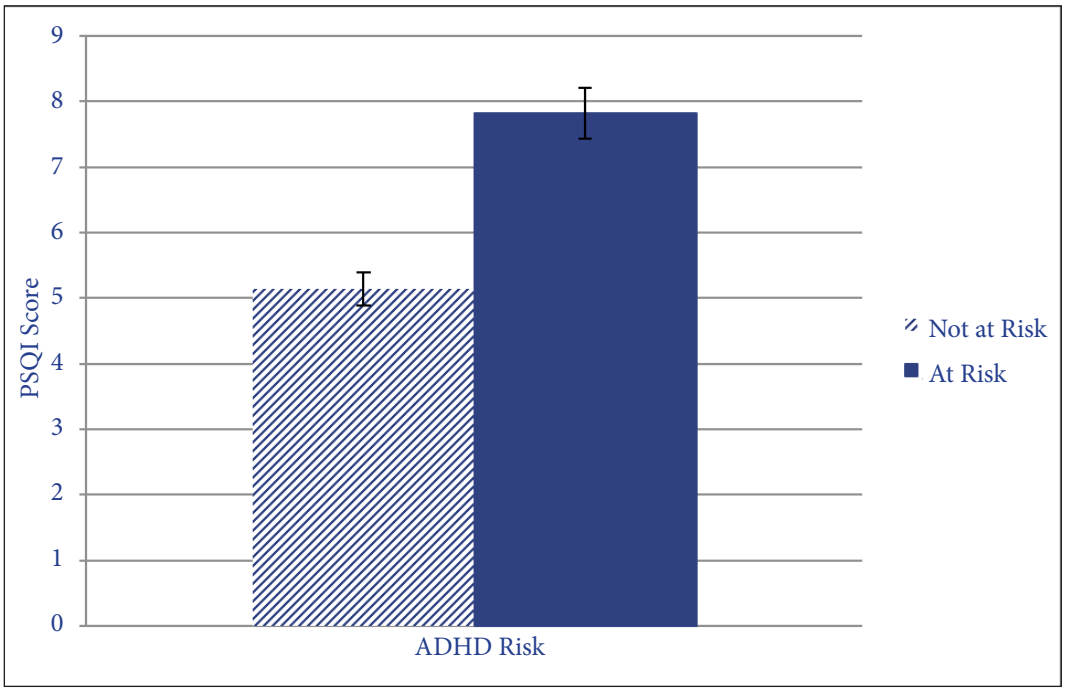

Figure 2. Mean and Standard Deviation values of (PSQI) for both at risk and not at risk of ADHD groups.

Note. Higher scores indicate worse sleep quality.

Discussion

The study investigating the relationship of sleep quality and Attention-Deficit/Hyperactivity disorder in adults supports the hypothesis that individuals at risk of ADHD have worse sleep qualities than those not at risk of ADHD. Results show a considerable relation between students who are at risk of being diagnosed with the disorder and their scores on the Pittsburgh Sleep Quality measure. Specifically, reporting 4 or more hyperactive-impulsive symptoms (the criterion for ADHD risk) was significantly correlated with an increase in the global PSQI score, indicating worse sleep quality. The results of this study are consistent with Neha et al. (2010), which found a significant relationship between ADHD risk and the global PSQI score, indicating worse sleep quality in children who are at risk of the disorder.

As previously outlined, dopamine dysfunction is implicated in sleep disorders and also in ADHD. These results might establish a stronger understanding of the dopamine system's workings and dopamine's proposed role as the underlying mechanism for this relationship. For example, if dopamine functions improperly, melatonin production may be disturbed, thus affecting the body's circadian rhythms and causing abnormal sleep patterns. Additionally, it might decrease daytime alertness, which is seen in both ADHD and sleep disorders (Owens et al., 2009).

The significant relationship between sleep quality and ADHD further suggests a correlation between

excessive daytime sleepiness and ADHD. Such a relationship might reframe many hyperactive symptoms as coping mechanisms to counteract daytime sleepiness. Furthermore, it could explain the difficulty in concentration and attentional tasks since the brain is not "fully awake" yet during the day. This analysis would be consistent with findings from Palm et al. (1992) in which there was increasing excessive daytime sleepiness in children with ADHD. Children were described as more "sleepy" and exhibited more extreme deficits in hyperactivity, attention, restlessness, and impulsivity.

The overlap between sleep disorders and ADHD symptoms has prompted several case studies about the misdiagnoses of ADHD in children. For example, Picchietti and Walters (1994) found that 34% of pediatric ADHD patients in their study had sufficient symptoms to be diagnosed with periodic leg movement disorder. Hickey et al. (1992) discussed three case studies of children with restless leg syndrome who had been misdiagnosed with ADHD. Likewise, Brooks (1993) reported that sleep apnea is often misdiagnosed as ADHD since many children with sleep apnea exhibit hyperactive symptoms. Since the present study documents a relationship between ADHD and sleep in the adult population, it may provide further evidence for common pathophysiological mechanisms between the two disorders that has been hypothesized in previous studies. Further, it might address the process of ADHD diagnosis by suggesting the possibility of a sleep measurement component during the time of diagnosis in order to eliminate sleep disorders as the cause of ADHD symptoms. Ultimately, the elimination of sleep variables may increase the certainty of ADHD diagnosis and avoid the possibility of misdiagnosis.

This study of sleep and ADHD allows for the opportunity to advance ADHD treatments. A case study by Dahl et al. (1991) reported that a ten-year-old girl with ADHD and insomnia showed significant improvements in sleep and daytime behaviors after co-treatment with behavioral modification for her ADHD and chronotherapy (circadian rhythms regulation therapy) for her insomnia. Specifically, she demonstrated progress in concentration, task completion, arithmetic proficiency, and social interactions. A report by Bergman (1976) documented the attenuation of sleep difficulties and hyperactivity symptoms after therapy for insomnia in the case of a seven-year-old boy diagnosed with both ADHD and insomnia. Thus, these findings suggest that ADHD interventions should incorporate sleep therapy to reduce or even eliminate symptoms. The results of the current study may also suggest a similar pattern in the adult population.

Limitations of the Current Study

The current study has many limitations, resulting from the generalizability of the sample to the entire adult population, the sample size of the study, and possible measurement reactivity as a result of the non-blind nature of the study. An in-depth discussion of each limitation follows.

Generalizability of Findings to the Adult Population. The population of the study was limited to the university population, aged 18-22 years. The older adult population may be different than the young adult population that was surveyed, possibly resulting in statistical results that are not representative of the entire adult population.

Sample Size. The sample size of the study was limited to 40 participants, 20 males and 20 females. This is a relatively small sample, limiting the generalizability to a large population. Further, there were only 7 participants who met the criteria for "At Risk of ADHD" category, whereas the "Not At Risk of ADHD" category consisted of 33 respondents.

Measurement Reactivity. Students were not blind to the study; thus, measurement reactivity may have played a role in its results. For example, a participant may have adjusted their responses according to the experimenter's expectations. Particularly, if the participant were to assume that the researcher is expecting to find certain results about their sleep quality, based on their demonstration of ADHD symptoms, they would score their questionnaires accordingly.

Future Directions and Practical Implications

The current study contains various limitations that can be addressed in order to facilitate further research in this field. First, a larger sample size that encompasses a wider age range should be utilized to improve the generalizability of the results to the adult population. Additionally, the researcher should

conduct a blind experiment in order to eliminate all sources of measurement reactivity. This study provides major implications in the field of ADHD diagnosis, highlighting the necessity of disqualifying alternative causes of symptoms prior to propounding an ADHD diagnosis. Since sleep disorders and ADHD have corresponding symptoms, one should consider sleep variables at the time of ADHD diagnosis to ensure that behaviors are solely congruent with ADHD. This measure would minimize misdiagnoses, ultimately increasing the certainty of an ADHD diagnosis. These results provide possible implications in interventions for both sleep disorders and ADHD. A sleep quality component may be incorporated into ADHD therapy to enhance the overall treatment for ADHD. Likewise, sleep disorder treatments can be augmented by incorporating a behavioral therapy component that targets ADHD symptoms. These treatments would require further study to determine their effectiveness.

Additional research regarding the correlation between the number of hyperactive-impulsive symptoms and global PSQI score should be conducted in order to further validate the relationship between ADHD and sleep quality. Likewise, it might be useful to study gender differences in sleep quality for individuals at risk of ADHD in order to determine gender's role in the prevalence of this disorder. Should gender-associated research be conducted, implications in future diagnosis and treatments of ADHD may be established. In particular, if research yields significant differences in gendered sleep quality scores, then a varying sleep quality criteria for ADHD diagnosis should be incorporated, along with diversifying the degree of sleep-targeting mechanisms in ADHD treatments.

Concluding Remarks

This study's purpose was to determine if a relationship exists between ADHD and sleep quality. The present study's results were consistent with previous research regarding pediatric patients in that a significant relationship was found between sleep quality and ADHD. Future directions should include adjustments to the sampling methodology of the current study by creating a more representative sample of the adult population and increasing control over extraneous variables like measurement reactivity. The study provides implications in ADHD diagnosis and treatment for both sleep disorders and ADHD.

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