Sleep Apnea and the Brain: Neurocognitive and Emotional Considerations

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Abstract

Sleep apnea research has become increasingly relevant to the field of psychology. Although the physiological sequelae have been researched extensively, and treatment options are now available for those diagnosed, much is left to be done. Specifically, to date, the cognitive and psychological consequences of sleep apnea have received less attention. As such, this paper serves to review the current state of the literature and presents relevant neuropsychological and emotional domains. Given that sleep apnea may cause psychological dysfunction over-and-above those expected from hypersomnia alone, the role of physiological damage in relation to these impairments will also be explored. Furthermore, a brief synopsis of established and proposed treatment options is undertaken in relation to psychological symptom expression and cognitive performance improvement. Finally, this paper highlights areas for future inquiry and offers guidance regarding the inclusion of psychological domains in subsequent research.


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The authors argued that research results implicating structural changes could be attributable to comorbid conditions in the population studied, and observed that sleep apnea and daytime sleepiness may influence cognitive functioning to some extent [24,25]. A disruption in executive functioning can lead to a variety of issues spanning the cognitive processes. Findings reported by Beebe and Gozal implicated the prefrontal cortex as a link between the sleep disturbances experienced in sleep apnea and the cognitive deficits observed [15]. Specifically, they propose that the hypoxemia and repeated waking can damage the restoration process that occurs during sleep. It also appears that these findings may translate to children. Halbower et al. suggested that children (ages 6–16) with severe OSA had significant deficits in executive functioning as compared to a control group [19]. Hoth, Zimmerman, Meschede, Arnedt, & Aloia, however, found no difference in executive functioning between a group with high hypoxemia and a group with low hypoxemia [26]. These mixed results suggest that the hypoxemia-cognition relationship may not be so linear, and future research is necessary to better understanding these findings.

In addition to overall executive dysfunction, OSA patients also show abnormalities in attention and vigilance. Research has supported this hypothesis both with executive tasks that are relatively short and in studies with children suffering from sleep disordered breathing (SDB) [15]. Generally, SDB ranges in severity and includes snoring and obstructive sleep apnea, both of which have been shown to negatively impact children’s attention, concentration, and hyperactivity [27]. What makes SDBs particularly problematic for children is that tonsil and adenoid growth outpace that of their airway, thus leading to obstruction. As a result, sleep disordered breathing is a common pediatric condition, such that 30% of children snore, and 3–4% have OSA [27]. The majority of the research examining the cognitive impact that sleep disordered breathing has on children’s functioning is derive from studies assessing behavior prior to and following adenotonsillectomy surgery [28–30]. For example, Ali and colleagues (1996) compared behavioral and psychological functioning following adenotonsillectomy surgery and found that post-surgery participants in the snoring group showed reduced hyperactivity and children with SDB demonstrated diminished levels of aggression, inattention and hyperactivity [28]. Interestingly, but perhaps not surprisingly, the control group’s post-surgery performance was not significantly different compared to prior surgery [28].

Additional evidence for the cognitive toll that poor breathing quality may have amongst children can be drawn from a study by Avior and colleagues (2004) study where participants with OSA were asked to complete the Test of Variables of Attention (TOVA), a measure used in the diagnosis of ADHD, prior to and following adenotonsillectomy. Results indicated that eight out of the study’s 19 participants met TOVA’s criteria for an ADHD diagnosis prior to surgery, and did not following surgery. Similar results were found by Dillon and colleagues (2007) wherein 50% of participants initially meeting criteria for ADHD no longer did so following adenotonsillectomy as measured by the Disruptive Behavior Disorder Rating Scale (DBDRS), the ADHD Rating Scale, and the Children’s Psychiatric Rating Scale (CPRS). Given that sleep disordered breathing, including OSA, has the potential to elicit an inappropriate psychiatric diagnosis such as ADHD it is important to note that symptom remission is possible following surgery.

Research regarding the effects of OSA on intelligence remains inconclusive. According to Beebe et al., OSA does not typically affect core intellectual and verbal abilities [31]. However, research has shown that individuals at higher risk for OSA had significantly lower cognitive scores [32]. It has been proposed that OSA may negatively impact the developing brain and thus could cause long-term scholastic underachievement in children [33] allower et al. supported this hypothesis finding that children with severe OSA had significant deficits in IQ [19] however, Kielb, Ancoli-Israel, Rebok, & Spiro did not find this same effect on intelligence, and proposed pre-morbid intelligence may serve as a protective factor against decline, in line
Aβ protein is associated with high concentrations in wakefulness and amyloid-β (Aβ), which possibly has a role in sleep regulation [41,42]. The growing body of research supports a link between OSA and dementia, centers, that monitor breathing. The second model is similar to other components of AD impact areas of the brain, such as the medullary model proposes that AD leads to sleep apnea as the destructive OSA and Alzheimer’s disease (AD) could be related [40]. The first needed before confidentiality establishing the casual relationship cognitive impairment and increased risk of developing dementia. In comparison to controls, those with sleep-disordered breathing or used a longitudinal model to track cognitive impairment in a group continues to grow. In fact, a study conducted by Yaffe and colleagues decrease in cognition functioning related to sleep disturbance in an older population [10,37,38]. Although these studies do not present a function of sleepiness, and that hypoxemia independently predicts both declarative memory and working memory [24]. However, Hoth et al. found that a high hypoxemia group performed significantly better on immediate recall than a low hypoxemia group, suggesting the memory deficits may be more related to long-term memory than short-term or working memory [26]. An MRI study by Torelli et al. showed decreased hippocampal volume and caudate nuclei volume, as well as general reduction in cortical grey matter in individuals with OSA [36]. These findings are consistent with a structural damage cause for memory impairment, as these are areas implicated in memory. These results also concluded that brains of individuals with OSA are more susceptible to the effects of aging, introducing the possibility that normal, expected memory loss due to aging may be potentiated by OSA. Torelli et al. also found evidence that OSA patients have reduced volume of a variety of brain areas, most notably the hippocampus [36]. In this study, age was correlated with these results, suggesting that OSA may mediate and accelerate the process of brain deterioration due to aging. These results warrant advocacy for early treatment to attenuate these deleterious effects.

As dementia and OSA increase in prevalence with advancing age, researchers have implemented several investigations to explore the relationship between these two conditions [10,37,38]. Current literature supports the relationship between sleep-related issues, including OSA, and dementia. Specifically, reports demonstrate that individuals with comorbid OSA and dementia experience more sleep apnea episodes than age-matched controls and severity of dementia is linked to severity of OSA symptomology also found a significant decrease in cognition functioning related to sleep disturbance in an older population [10,37,38]. Although these studies do not present causal evidence enabling investigators to understand how dementia and OSA interact in those with both conditions, research in this area continues to grow. In fact, a study conducted by Yaffe and colleagues used a longitudinal model to track cognitive impairment in a group diagnosed with sleep-disordered breathing without dementia [39]. In comparison to controls, those with sleep-disordered breathing or experiencing elevated oxygen desaturation via apnea showed mild cognitive impairment and increased risk of developing dementia. Moving forward, more studies investigating longitudinal cases are needed before confidentiality establishing the casual relationship between dementia and OSA.

In line with this goal, Blwise has proposed two models by which OSA and Alzheimer’s disease (AD) could be related [40]. The first model proposes that AD leads to sleep apnea as the destructive components of AD impact areas of the brain, such as the medullary centers, that monitor breathing. The second model is similar to other hypoxic outcomes in that sleep apnea causes AD as hypoxic events disrupt higher cortical functions. In addition to these models, a growing body of research supports a link between OSA and dementia, specifically AD, is a possible shared genetic predisposition on the apolipoprotein E gene (APOE). The presence of the allele epsilon 4 (E4) has been identified in clinical groups with AD and sleep apnea [38,40]. The APOE gene is associated with production of the protein amyloid-β (Aβ), which possibly has a role in sleep regulation [41,42]. Lucey and Bateman investigated the function of Aβ in apnea as the Aβ protein is associated with high concentrations in wakefulness and lower concentrations during sleep in normal populations [41]. The researchers found that Aβ alternations from AD pathogenesis impact sleep regulation, which is possible from the presence of Aβ plaques caused by these maladaptive proteins. In addition, chronic hypoxia is also thought to proliferate the presence of Aβ proteins by causing a cascade of B-secretase activity that increases Aβ proteins [43]. However, the link between APOE and sleep apnea is not definitive as many other variables, including cerebrovascular events, could be attributed to dementia and sleep apnea co-morbidity [40]. Therefore, more research is needed to isolate various biological processes that underlie the presence of dementia and OSA.

The impact of how sleep apnea impacts an individual’s mood remains unclear due to the current state of scientific literature in this area. One of the main reasons is the common misconception that hypoxemia is the toll of OSA as most research to date has focused on the physical ramifications of the disorder. In fact comprehensive research surrounding anxiety and OSA has yet to be conducted. Preliminary results suggest that anxiety severity seems to depend more on daytime sleepiness rather than on degree of nighttime hypoxemia [25]. In fact, Macey et al. did not find a strong relationship between AHl and anxiety, supporting the earlier research by Naimsmith et al. [25,50]. However, more recent literature has suggested otherwise, finding evidence that anxiety may be more common in severe OSA than depression [51]. Anger is another domain lacking research amongst individuals with OSA. Bardwell, Berry, Ancoli-Israel, andDimsdale reported that, unlike anxiety, anger appears to be more related to hypoxemia [52]. While it is uncertain as to why this is the case, frontal lobe damage has been frequently implicated in OSA patients, and damage to the prefrontal cortex can drastically change temperament (e.g. Phineas Gage). However, further research on
comorbid conditions is needed to make confident conclusions in these and other domains.

Conclusion

It has been well established that OSA has a significant biological and physiological impact on physical health. Yet, as apparent through this review, to date research supporting the significant and severe effects of OSA mental health and cognitive functioning continues to contain many gaps. Moving forward, given the mixed findings of the impact of OSA on neuropsychological and psychological functioning, it is important the future research work to standardized methodology clearly states condition severity and controls for confounding variables such as affective states [11]. It is also imperative to expand the body of OSA research in order to better understand the causes of neuropsychological impairment and how psychological dysfunction should be addressed in people with OSA. Currently the most prominent treatment for OSA is CPAP. Little is known about whether or not CPAP alone is effective in treating not only hypoxia, but also the psychological and cognitive side effects of OSA. Conducting research on the effectiveness of CPAP in addressing symptoms outside of hypoxia and sleep disruption is crucial to identify if additional interventions, such as therapy or medication, are necessary to fully restore mental health to a baseline level.

Psychotherapy has been thoroughly researched in its effectiveness in treating various disorders, including helping individuals cope with various medical conditions, however, OSA has yet to be targeted specifically and thus should be included as a future area of study, especially given the recent research documenting the psychological impact OSA takes on individuals living with the disorder. Prior research has concluded that when sleep is restored or normalized in individuals with psychiatric conditions, symptoms of the disorders either improved or remitted. As such, OSA-affected individuals may see a great reduction in psychological distress and improvement in mood, mental health and other psychological areas. Thus is the recommendation of the authors that future research explore the effects of sleep normalization or improvement on OSA.

Research into sleep apnea is also imperative due to the number of comorbid conditions and ill effects of misdiagnosis. Undiagnosed and untreated sleep apnea can be mistaken for ADHD in children or exacerbate Alzheimer’s and other dementias in older adults thus prolonging or preventing necessary treatment and resulting in deleterious effects. Understanding how OSA is diagnosed, making certain it is diagnosed properly, and better understanding of available treatments is essential in the progression of how professionals view the challenges and consequences of sleep apnea.

The prefrontal model of Beebe and Gozal provides a theoretical connection between brain dysfunction due to OSA-specific symptomatology and the psychological dysfunction observed in the literature [13]. Whether the theory holds true depends on future research projects investigating the always-evolving field of brain-behavior relationships. Including psychological outcome measures in research projects investigating the always-evolving field of brain-literature [13]. Whether the theory holds true depends on future symptomatology and the psychological dysfunction observed in the challenges and consequences of sleep apnea.

References


