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The deterioration of driving performance over time in drivers with untreated sleep apnea

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ABSTRACT

Sleep apnea increases risk of driving crashes when left untreated. This study examined the driving performance decrements of untreated, undiagnosed sleep apnea drivers compared with healthy controls in a monotonous highway driving simulator task. It was hypothesized that the sleep apnea group would perform worse during a driving simulator test compared with the control group. A significant group by time interaction occurred indicating that sleep apnea participants' performance degraded more quickly over the course of the drive. In contrast with previous studies, this sleep apnea group did not include sleep disorder center patients, but rather community volunteers whose screening indicated a significant apnea/hypopnea index of 15 or greater. There may be inherent differences between patients and nonpatients with sleep apnea, as patients may have a more significant impact on their quality of life, causing them to seek treatment. Still, the results are clear that although the sleep apnea group drove similarly to the control group at the start of the drive, they are sensitive to time on task effects. These results support the need to diagnose and treat sleep apnea.

1. Introduction

Drivers with untreated sleep apnea are at high risk for sleep-related crashes. Sleep apnea is a common sleep disorder in which a person stops breathing repetitively during sleep. In evaluating how sleep apnea affects drivers, it is important to obtain an objective measure of driving performance on which to base recommendations for patients' fitness to drive. A safe choice for evaluation is the use of a driving simulator. The goal of this study was to evaluate driving performance of community volunteers with sleep apnea compared to a control group using a driving simulator test.

Apnea is defined by the American Academy of Sleep Medicine (AASM) as a period of at least 10 seconds where a person stops breathing (Berry et al., 2012). This can be a period of non-breathing where the person is still exerting effort to breathe (obstructive sleep apnea) or when effort to breathe has also ceased (central sleep apnea). Hypopnea events are defined as a 30% reduction in airflow instead of a complete cessation of breath, with a corresponding 3% oxygen desaturation or arousal (Berry et al., 2012). When evaluating sleep apnea during a polysomnogram, the apnea/hypopnea index (AHI) is calculated and used to determine the severity of the apnea. This index is derived by counting the number of apnea and hypopnea events and dividing this number by the number of hours the patient slept during the test. An AHI between 5 and 15 is considered mild, 15–30 considered moderate and greater than 30 considered severe (Kushida et al., 2006; Epstein et al., 2009). Sleep apnea can occur across all age groups and races (Vorona and Ware, 2002). Sixty to 70% of obstructive sleep apnea (OSA) patients are obese (Guilleminault, 1994). OSA is associated with an increased risk of hypertension, coronary heart disease, stroke and death (Vorona and Ware, 2002).

Night-time symptoms of OSAS include snoring, restlessness, sleep disruption, choking sensations during sleep, reflux and nocturia (Guilleminault, 1994). Day-time symptoms include excessive daytime sleepiness, performance decrements, inability to concentrate, deterioration of memory and concentration, changes in personality (moodiness or depression), sexual problems and morning headaches (Guilleminault, 1994). One study illustrated the vigilance and attention impairments in OSA patients on a sustained attention, divided attention and maintenance of wakefulness tests (Mazza et al., 2005). Many of these symptoms can impact driving performance in drivers with untreated sleep apnea.

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One benefit of the driving simulator test is to safely determine performance decrements in high-risk populations. Studies have shown that driving performance is worse for sleep disorder patients and participants undergoing sleep deprivation compared to control participants (Risser et al., 2000; Vakulin et al., 2009). Other studies have shown that treatment for sleep disorders improves driving performance in these patients and that when withdrawn from treatment, performance declines (Filtness et al., 2011, 2012; Hack et al., 2001; Mazza et al., 2006; Orth et al., 2005; Turkington et al., 2004). For many of these studies, untreated sleep apnea patients, or sleep deprived participants demonstrated a more pronounced performance decrement over time (Filtness et al., 2011, 2012; Risser et al., 2000; Vakulin et al., 2009). A few of these studies are highlighted below.

Risser et al. (2000) compared driving simulator performance of sleep center apnea patients with performance of normal, healthy control participants. They found that the sleep apnea patients had increased lane position variability, steering rate variability, speed variability and crash frequency. Lane position variability and crash frequency increased over the 60-min drive in the sleep apnea group, suggesting a vigilance decrement over the drive. The sleep apnea patients overall had greater lane position variability and crash frequency compared to controls.

In comparing sleep restriction and alcohol consumption in untreated sleep apnea patients and controls, Vakulin et al. (2009) also demonstrated group differences and a time on task effect. Each group was exposed to 3 different conditions, a normal night's sleep, a night of 4 h sleep (or less) and consumption of vodka to equate to a blood alcohol level of .05. During the normal night's sleep, sleep apnea patients had greater steering deviations and more deviations over time. This result was exacerbated both by the sleep restriction and the alcohol consumption. The sleep apnea patients also had more crashes than controls in all three conditions.

One treatment for sleep apnea, continuous positive airway pressure (CPAP), improves driving simulator performance. Turkington et al. (2004) compared sleep apnea patients undergoing treatment with those not yet receiving treatment over a period of seven days. The driving test was given at the same time each day and was a 20-min drive using their divided attention driving simulator. This driving simulator also integrated a reaction time task where patients pressed a button every time a "2" appeared on the screen. A baseline driving simulator test was performed before treatment for both groups of patients. Driving simulator tests were performed three additional times throughout the seven days of the study. There was no significant difference in driving performance measures at baseline between the two groups. The treatment group showed significantly lower tracking error (lane position variability), faster reaction time and fewer off-road events post-treatment as compared to the non-treatment group.

Mazza et al. (2006) found sleep apnea patients prior to CPAP treatment had longer reaction time, and twice the number of collisions as compared to controls in an on-road safety platform. This was an instrumented test track which monitored the car's speed and sent up a spout of water the driver had to stop for. Collisions were counted when the car hit the spout of water. CPAP treatment eliminated performance differences between the sleep apnea patients and controls.

Filtness et al. (2011) compared treated sleep apnea patients (using CPAP) and control participants after a night of normal sleep and a night of sleep restriction. Treated patients after sleep restriction had significantly greater lane crossings and shorter time to first major incident (crossing out of lane with all 4 wheels). There was also a significant time effect where the longer the drive, the more line crossings for this sleep deprived treated apnea patient group. These results indicate that although CPAP is effective, these patients are more sensitive to the effects of sleep restriction as compared to their healthy counterparts.

One study compared driving simulator performance in untreated sleep disorder patients, sleep deprived participants, treated sleep disordered patients, participants consuming alcohol and normal, healthy controls (Hack et al., 2001). Driving performance measures included lane position variability, number of off-road events and length of drive completed. Sleep deprived participants had significantly poorer driving performance compared to non-sleep-deprived controls. Participants consuming alcohol performed significantly worse, compared to their driving performance when sober. Untreated sleep apnea patients experienced greater lane position variability than participants who consumed alcohol, but better lane position variability than sleep deprived participants.

These studies stress the driving performance decrements in driving simulation tasks for sleep apnea patients, highlighting the time on task effects of performance decrements. In addition, these studies stress the ability of driving performance measures to capture the effects of sleep apnea, the improvement with treatment and the susceptibility of these patients for performance decrements during sleep restriction while on treatment.

The purpose of this study was to confirm performance decrements in participants with sleep apnea as compared to controls. The unique difference in this study versus previous studies was that these apnea participants were not patients in a sleep disorders center; they had not sought help or treatment for sleepiness or potential sleep disorders. These participants were not clinically diagnosed, but identified as having apnea via the home sleep test results obtained during the study. There may be fundamental differences between apneics who have sought out treatment and those who have not. However, it is believed that having sleep apnea, having sought treatment or not, impacts performance. It was hypothesized that the performance decrements in sleep apnea patients would be robust and present even with undiagnosed community participants screening positive for sleep apnea. Based on the previous literature, we predicted that the sleep apnea group, at risk for sleepiness and crashes, would perform worse compared to a non-apnea/non-sleepy control group. Additionally, performance of sleep apnea patients would degrade more significantly over the course of the drive.

2. Method

2.1. Design

This study utilized a quasi-experimental 2 (group) by 6 (time epoch) ANOVA design. We controlled for length of drive, excluded untreated sleep disorders for control participants and documented caffeine and nicotine use. Tests for outliers, normality and linearity were performed prior to hypothesis testing. The dependent variable was standard deviation of lane position variability (transformed to reduce the effect of outliers). The independent variable was condition (sleep apnea versus no sleep apnea).

2.2. Participants

There were 57 participants (25 males, 32 females) who completed the study. Of these, 45 met the criteria for one of the two groups, having an AHI $\geq$ 15 (APNEA group) or <10 (normal, NORM group). Participants having an AHI between 10 and 15 were excluded from analysis. Demographics reported are from the 45 participants included in the analysis.

Of the participants, 31 participants self-identified as Caucasian, 10 as African American, 2 as Hispanic, 1 as Asian and 1 as multiracial. Ages ranged from 18 to 74 (M = 40.4, SD = 17.11). Participants