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## Abstract

Studies have shown that the frequency or worsening of sleep disorders tends to increase with age and that the ability to perform circadian adjustments tends to decrease in individuals who work the night shift. This condition can cause consequences such as excessive sleepiness, which are often a factor in accidents that occur at work. The present study investigated the effects of age on the daytime and nighttime sleep patterns using polysomnography (PSG) of long-haul bus drivers working fixed night or day shifts. A total of 124 drivers, free of sleep disorders and grouped according to age (<45 years, N = 85, and ≥45 years, N = 39) and PSG timing (daytime (D) PSG, N = 60; nighttime (N) PSG, N = 64) participated in the study. We observed a significant effect of bedtime (D vs N) and found that the length of daytime sleep was shorter [D: <45 years (336.10 ± 73.75 min) vs N: <45 years (398 ± 78.79 min) and D: ≥45 years (346.57 ± 43.17 min) vs N: ≥45 years (386.44 ± 52.92 min); P ≤ 0.05]. Daytime sleep was less efficient compared to nighttime sleep [D: <45 years (78.86 ± 13.30%) vs N: <45 years (86.45 ± 9.77%) and D: ≥45 years (79.89 ± 9.45%) and N: ≥45 years (83.13 ± 9.13%); P ≤ 0.05]. An effect of age was observed for rapid eye movement sleep [D: <45 years (18.05 ± 6.12%) vs D: ≥45 years (15.48 ± 7.11%) and N: <45 years (23.88 ± 6.75%) vs N: ≥45 years (20.77 ± 5.64%); P ≤ 0.05], which was greater in younger drivers. These findings are inconsistent with the notion that older night workers are more adversely affected than younger night workers by the challenge of attempting to rest during the day.

Key words: Sleep; Shift work; Night work; Aging; Polysomnography; REM; Slow wave sleep (SWS)

## Introduction

Shift work and nighttime work have increased significantly in modern society, changing the means of production and the organization of work in industries and drastically changing the lifestyle, health and well-being of workers. Over the last decades, many studies have focused on the general health and sleep of workers who have this type of work schedule. Continuous and prolonged shift work and nighttime work predispose workers to various diseases, such as cardiovascular and gastrointestinal disorders and psychosocial stress (1-4).

It has also been observed that these workers are routinely submitted to a chronic partial sleep deprivation due to the recurrent misalignment between sleep that takes place

during the day and the external environment (5-9). A shorter and more fragmented sleep has well-known implications, such as excessive sleepiness, mental fatigue, irritability, and reduced performance, which are often the factors that cause many kinds of accidents at work (10-12).

Sleep disorders, such as periodic leg movements and sleep disorder-related breathing, are also prevalent among shift workers, and might increase the negative repercussions of sleeping during an inappropriate circadian phase (5). Indeed, some studies have demonstrated a direct relationship between sleep disturbance, sleepiness and accidents with motor vehicles. In a study with 2342 professional drivers, Howard et al. (13) observed a high frequency

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of sleep disorder-related breathing (60%) and excessive sleepiness (24%) among workers who had an increased accident risk. Furthermore, Akerstedt (14) estimated that sleepy driving caused 15-20% of the motor vehicle accidents involving professional drivers.

Another important factor is that the frequency or the worsening of sleep disorders tends to increase with age. One factor of aging is the decreased ability to perform circadian adjustments (15). The combination of these processes has been considered to play an important role in the even greater reduction in the quality and duration of daytime sleep observed among older shift workers when compared to their younger colleagues (15-19).

The relatively high rates of sleep disorder-related breathing among shift or night workers could, however, mask the extent of the effects of aging on sleep quality and duration. Expanding upon the studies developed, in our laboratory (7,8,20), using polysomnographic recordings, we compared the nighttime and daytime sleep of two groups of long-haul bus drivers who were free of sleep disorders and worked fixed day or night shifts. They were separated into two groups by age.

## Subjects and Methods

Sixty-four male licensed long-haul bus drivers operating on fixed day shifts (mean age:  $40.9 \pm 6.8$  years; range: 29-67 years) with a mean body mass index of  $26.6 \pm 3.4$ , and 60 male long-haul bus drivers on fixed night shifts (mean age:  $41.7 \pm 6.7$  years; range: 30-61 years) with a mean body mass index of  $26.7 \pm 3.6$  participated in this study. All participants underwent a medical evaluation and polysomnographic examination. They had an apnea-hypopnea index lower than or equal to 5, indicating that they were free of sleep-related breathing disorders.

The drivers were invited to come to the Sleep Laboratory for a scheduled day or night polysomnography starting within 2 h after the end of their work shift and as close as possible to their usual bedtime after a night or day shift, respectively. They were not allowed to have naps prior to the polysomnographic recordings. The number of shifts worked preceding the recordings could not be controlled.

All drivers were informed about the procedures and signed an informed consent form to participate in the study. The protocol was approved by the Ethics Committee of the Universidade Federal de São Paulo and was in accordance with the guidelines set forth by the Declaration of Helsinki and Tokyo. The protocol was also in agreement with the standards reported by Touitou et al. (21).

## Polysomnographic recordings

Polysomnographic recordings were performed according to the method of Rechtschaffen and Kales (22). Electrode placement was carried out according to the 10-20 system. The room used for the recordings had a large comfortable bed, acoustic isolation, and controlled temperature and light. Recordings were conducted by a trained sleep technician using the digital system Alice<sup>®</sup>4 (Philips-Respironics, USA). The following recordings were included: electroencephalogram (C3-A2, C4-A1, O2-A1), electrooculogram, chin and tibial electromyograms, electrocardiogram, airflow (thermal sensor), thoracic-abdominal movements, a microphone placed on the lateral neck to detect snoring, pulse oximetry, and body position (23). Thirty-second epochs were staged according to standard criteria and visually inspected by the sleep specialist. The following parameters were analyzed: a) total sleep time (in min), defined as the actual time spent asleep; b) sleep latency (in min), defined as the time from lights out until the onset of three consecutive epochs of stage 1 or deeper sleep; c) sleep efficiency, defined as the percentage of total recording time spent asleep; d) wake after sleep onset (in min), defined as the total time scored as wakefulness between sleep onset and final awakening; e) stages 1, 2, 3, 4, and REM sleep, as percentages of total sleep time, and f) latency to REM, defined as the time from sleep onset until the first epoch of REM sleep.

## Statistical analysis

Data from the 124 drivers, divided into two groups according to age [ $<45$  years (range: 29-44 years),  $N = 85$ , and  $\geq 45$  years (range: 45-67 years),  $N = 39$ ] and the polysomnography timing (daytime polysomnography,  $N = 60$ ; nighttime polysomnography,  $N = 64$ ) were analyzed by two-way ANOVA followed by the Tukey HSD test when appropriate, with the level of significance set at  $P \leq 0.05$ . The criterion for the cut-off in the distribution of age groups was selected as 45 years so that the drivers had worked on shift long enough to meet the proposal of this research.

## Results

Daytime sleep began at 9:00 am ( $\pm 0:47$ ) and finished at 4:24 pm ( $\pm 0:48$ ) and nighttime sleep began at 9:56 pm ( $\pm 3:08$ ) and finished at 6:40 am ( $\pm 2:32$ ).

A significant effect of bedtime (daytime vs nighttime) was observed for total sleep time, sleep efficiency, Stage 1, and REM sleep (Table 1). *Post hoc* analysis revealed that sleep during the day was significantly reduced com-

Table 1. Characteristics of daytime and nighttime sleep of day- and night-working bus drivers.

	Daytime sleep (N = 60)		Nighttime sleep (N = 64)		ANOVA F		
	<45 years (N = 41)	≥45 years (N = 19)	<45 years (N = 44)	≥45 years (N = 20)	Time	Age	Interaction
Total sleep time (min)	336.10 ± 73.75 <sup>a</sup>	346.57 ± 43.17 <sup>c</sup>	398 ± 78.79 <sup>b</sup>	386.44 ± 52.92 <sup>d</sup>	14.52*	0.002	0.680
Sleep efficiency (%)	78.86 ± 13.30 <sup>a</sup>	79.89 ± 9.45 <sup>c</sup>	86.45 ± 9.77 <sup>b</sup>	83.13 ± 9.13 <sup>d</sup>	6.56*	0.29	1.05
Sleep latency (min)	12.50 ± 11.74	14.62 ± 9.32	15.81 ± 12.30	20.76 ± 17.10	3.77	2.11	0.33
REM latency (min)	93.23 ± 49.32	101.77 ± 61.58	97.74 ± 50.40	124.39 ± 67.14	1.63	2.75	0.73
Stage 1 sleep (%)	3.26 ± 3.78 <sup>a</sup>	3.47 ± 3.65 <sup>c</sup>	1.27 ± 1.72 <sup>b</sup>	2.03 ± 2.18 <sup>d</sup>	9.15*	0.73	0.24
Stage 2 sleep (%)	48.09 ± 9.47	50.49 ± 11.85	48.11 ± 7.02	50.96 ± 9.37	0.02	2.22	0.01
Stage 3 sleep (%)	8.25 ± 3.04	6.49 ± 2.67	7.51 ± 1.61	7.83 ± 2.85	0.37	2.21	4.60*
Stage 4 sleep (%)	18.01 ± 8.02	16.41 ± 7.71	18.76 ± 7.13	18.03 ± 6.89	0.66	0.64	0.09
REM sleep (%)	18.05 ± 6.12 <sup>a,e</sup>	15.48 ± 7.11 <sup>c,f</sup>	23.88 ± 6.75 <sup>b,e</sup>	20.77 ± 5.64 <sup>d,f</sup>	19.77	5.14 <sup>#</sup>	0.04

P ≤ 0.05 comparing groups for the \*time factor, #age factor and +interaction (two-way ANOVA followed by the Tukey test). Comparison of groups by the *post hoc* test for the <sup>a-b,c,d</sup>time factor and the <sup>e-f</sup>age factor.

pared to nocturnal sleep, and was characterized by lower sleep efficiency and a greater amount of Stage 1 sleep. There was no significant effect of age (<45 vs ≥45 years) for most variables, with the exception of the proportion of REM sleep. A higher amount of REM sleep was observed during nocturnal sleep and among the younger drivers. Finally, a significant effect of time on age was observed for Stage 3 sleep due to a slight increase of daytime sleep observed in the younger drivers.

## Discussion

Many studies have investigated the effects of aging on the quality of sleep of shift or night workers, but few of them have used objective measures, such as polysomnography. Since it is recognized that sleep disorders increase with aging, we conducted a laboratory-based study to explore the effects of aging on the sleep of night workers without sleep disturbances, such as sleep disorder-related breathing problems.

Consistent with previous studies (5,7), daytime sleep was shorter and less efficient, and was composed of longer Stage 1 and fewer REM sleep periods. There were age-related differences only in REM sleep, which was higher among the younger drivers.

There was a significant interaction between age and time in relation to Stage 3 sleep. The younger drivers who sleep during the day had significantly more Stage 3 sleep than their counterparts. No difference in Stage 3 sleep between the two groups was observed in those who slept at night. This suggests that older workers have more difficulty in obtaining deep restorative Stage 3 sleep when attempting to sleep during the day.

We also failed to observe a difference in some of the

sleep variables for age. It is possible that these results stem from the fact that night workers are already adapted to working at night, since, as suggested by Harma (24) and Costa (3), there is a kind of natural selection in which those who face serious health problems and difficulty to adapt to this kind of work schedule tend to be referred to daytime work.

Even though there is evidence that aging is associated with certain circumstances that might impair the adaptation to night work or shift work (17,19,25), one should also consider an overlap between aging and the accumulation of experiences, as stressed by Costa (15). For some individuals, the passing of time certainly comes along with the learning of personal strategies that enable them to better cope with night work. Work commitment, regular life style, more satisfactory job positions, and fewer household chores are among the positive and protective factors. Similarly, in older night workers, learning personal habits that favor sleep, primarily in potentially adverse situations such as sleeping during the day, could be connected to their work experience.

Although learning good sleeping habits could have provided the older individuals with a sleep duration and efficiency similar to those of the younger individuals, the effects of circadian misalignment were not overcome. We found that both groups showed a reduction in sleep duration and sleep efficiency when sleeping occurred during the day.

Sleep curtailment and reduced sleep quality represent risk factors for sleepiness and errors, and traffic accidents are one of the leading causes of death and injuries in Brazil. Although researchers cannot precisely calculate to what extent sleepiness contributed to the alarming fatality rate of 6.3 per 10,000 vehicles in Brazil (26,409

fatalities) and 18,778 accidents involving buses in 2005 (26), some national studies point to the association of sleep deprivation. In a recent cross-sectional study with 300 truck drivers using questionnaires regarding sleep quality and sleepiness, de Pinho et al. (12) showed that approximately 46% of professional drivers reported low-quality sleep as well as excessive sleepiness, factors that they associated with accidents. Furthermore, Mello et al. (20) had shown that 16% of the 400 interstate bus drivers interviewed admitted to falling asleep while driving.

In general, the counter-measures to sleepiness most routinely adopted by drivers, such as opening the window or playing the radio loudly, provide little benefit. Getting enough sleep prior to night work is still a potentially safer strategy. In this context, educational campaigns may play an important role (27), especially if the experiences of those who better cope with the challenges of aging and night work are taken into account and shared.

Some studies suggest that occupational medicine should consider that several factors (psychobiological,

general health, social, and economics) can influence the tolerance and adaptation to night work (2,3). Among these factors, sleep pattern and age were addressed in this study using polysomnography to evaluate night employees on their daily routine of work.

As in the study of Santos et al. (7), we observed a decrease in total time and efficiency of sleep in night workers who sleep during the day compared with daytime workers who sleep during the night. However, in the study of Santos et al. (7), the workers were not distributed according to age, and some had sleep disorders that were controlled in our study. Thus, the present study found that even in workers without sleep disorders, the influence of night workers' bedtime (during the day) was important to reduce the total time and efficiency of sleep, regardless of age.

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