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ORIGINAL ARTICLE

Urban Bus Drivers' Sleep Problems and Crash Accidents

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Abstract Sleep problems and their direct consequence, sleepiness, results in critical effects on psychomotor skills, memory, decision making, concentration and learning; all of which may play roles in accidents and errors. Despite the importance of quality of sleep among drivers there are only few researches that deal with them. Therefore, we designed this research to better understand possible relationships. This cross-sectional study was performed between 2006 and 2007 among 175 bus drivers of a transportation company in Tehran, the capital of Iran. Participants filled out a questionnaire concerning their demographic and personal history, associated disease, the insomnia index, the Epworth sleepiness scale (ESS), and the apnea index. Then they elaborated their history of crashes. Data was analyzed with the SPSS software through χ^2, Oneway ANOVAs, and Pearson correlation tests. The mean age, and body mass index (BMI) were 43.47 ± 6.85 years and 26.35 ± 3.87 kg/m^2. The mean duration of sleep among these drivers was 6.37 ± 1.62 h per day. The mean accident rate was 2.31 ± 1.83 per year. There was a significant correlation between the insomnia index and BMI ($P = 0.014$), age (0.00), marital status (0.00), associated disease (0.005), and drug history (0.028). There was a significant relationship between marital status and the ESS, and also between age and accident rate in the past years. Sleep problems were a frequent finding among the studied group and had a significant relationship with their crash history. These results can be an alarming sign to choose bus drivers more carefully and pay more attention to treating their sleep disorders.

Keywords Sleep deprivation · Apnea syndrome · Sleep disorder · Road accident · Driver

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Introduction

Needless to say that sleep problems are one of the major human health concerns. Moreover, sleepiness results in destructive effects on psychomotor skills, memory, decision making, concentration and learning, all of which may play roles in the occurrence of accidents and errors. A reduction in sleep time and sleep interruption leads to decreased daytime vigilance, and consequently increased risk of road traffic accidents [1–3].

The US National Transportation Safety Board stated fatigue as a probable cause in 57% of accidents that result in a truck driver's death [4–7]. Sleep disorders allegedly play a large part in many motor vehicle accidents [2].

Driver sleepiness has been identified as an important contributor to motor vehicle crashes in a number of earlier studies [4–7]. Patients with clinically diagnosed sleep disordered breathing (SDB) showed poor performance on driving simulation tests and had 2–7 times higher rates of motor vehicle crashes than patients without SDB. A significant association between SDB and motor vehicle crashes was also found in a population-based sample of employed adults [8], and also there are some other reports that find sleep problems the most preventable cause of accidents in transportation (between 15 and 20% of all accidents); exceeding that of alcohol or drug-related incidents in all forms of transportation [2].

Despite the importance of quality of sleep in drivers, there are few researches concerning this issue. Therefore, this investigation was designed to improve our understanding of what factors may contribute to these risks.

Materials and Methods

In this cross-sectional study, 175 urban bus drivers employed by the Transportation Company in Tehran, Iran, were enrolled from January of 2006 to September 2007. All interviews were performed by the same person (one of the authors). First all items on the questionnaire were explained to and discussed with the participants, and their questions were answered as their filled out the forms.

The first questionnaire concerned demographic data including sleep duration, consumption of medications, and medical problems, such as diabetes or other endocrine disorders, cardiovascular problems, renal, pulmonary, gastrointestinal problems, or psychological disorders. All drivers under study also completed forms to evaluate their insomnia index [9], Epworth sleepiness scale (ESS) [10], and apnea index [11], which are able to discriminate the two categories of low and high risk for obstructive sleep apnea (OSA). For the insomnia index, participants answered five questions about their sleep on a scale of 0–4: none (0), slight (1), moderate (2), severe (3), and very severe (4), or never (0), rarely (1), occasionally (2), usually (3), and always (4) for the last two questions (Table 1).

The identification of low and high risk for OSA is based on three symptom categories. The ESS is an 8-item questionnaire where each question is answered on a scale of 0 (would never dose) to 3 (high chance of dosing), yielding a total between 0 (minimum) and 24 (maximum sleepiness) which is then classified into three groups: minimum (0–8), moderate (9–16), and high risk (17–24).

Sleep apnea was assessed through the apnea index scores by asking 4 questions about snoring and daily symptoms, and then categorized the severity into 5 groups: never (0), rarely (1), about half of the time (2), almost always (3), and always (4).

For each driver, the body weight and height were registered to calculate their body mass index (BMI). We used the BMI as a surrogate indicator of nutritional status. According to the standards established by the World Health Organization (WHO, 1997), a BMI of 30 kg/m2 or greater signifies obesity [6].

The participants' occupational history was completely reviewed and data such as qualification, job experiences, and crash records were analyzed. Injury rates were calculated and compared among levels of sleep variables and potential confounding variables. Potential confounding variables included in the analysis were age, sex, general health status, current alcohol use, and depression status.

This research was approved by the Ethical Committee of Tehran University of Medical Sciences. All participants signed informed consents to participate in this research.

Data analysis was done with the SPSS software. We used χ^2 tests to compare categorical variables, and also one-way ANOVAs and Pearson correlation tests. Factors that had a significant univariate association with accident rates were included as potential predictors in a stepwise ordered multiple logistic regression analysis with reported accidents in 3 categories as the dependent variable. The significance level for all of the statistical analyses was P value ≤ 0.05 and statistical significance was accepted at $P < 0.5$ in two-tailed tests. The results for continuous variables are expressed as mean $\pm$ standard deviation.

Results

All participants were male and their mean age was 43.47 $\pm$ 6.85 (range 27–58) years. Their mean weight was 77.42 $\pm$ 11.74 (range 55–106) kg. In terms of marital status, 9 (5.1%) were single, 139 (79.4%) were married, and 10 (5.7%) were widowed or divorced. The mean BMI of the drivers was 26.35 $\pm$ 3.87 kg/m2.In their history of medication, 13 (7.4%) had a history of taking sleeping

Table 1 Insomnia index

	None	Slight	Moderate	Severe	Very severe
Difficulty in falling asleep	55(33.1%)	49(28%)	35(20%)	17(9.7%)	6(3.4%)
The effect of sleep problems on daily effectiveness	13(7.4%)	35(20%)	63(36%)	33(19%)	21(12%)
Other's attitude about the effect of sleepiness on daily life	21(12%)	42(24%)	40(22%)	25(14.3%)	36(20.6%)
Satisfaction with quality of sleep	19(10.9%)	19(10.9%)	67(38.3%)	41(21.4%)	17(9.7%)
	Never	**Rarely**	**Occasionally**	**Usually**	**Always**
Recurrent wake up during sleep	45(25.7%)	62(35.4%)	33(18.9%)	16(9.1%)	8(4.6%)
Difficulty in continuing of sleep	44(25.1%)	54(30.9%)	33(18.9%)	19(10.9%)	14(8%)

Table 2 Other problems related to sleep difficulties

	0	1	2
Physical problem	13(7.4%)	107(61.1%)	29(16.6%)
False habit before sleep[a]	42(24%)	63(36%)	38(27.7%)
Aging	57(32.6%)	69(39.4%)	14(8%)

[a] Irregular sleep, (alcohol or coffee or tea consumption before sleep), night life activities, reading in bed, eating heavy meals before sleep and etc

pills, 4 (2.3%) took awakening pills, and 9 (5.1%) had a history of drug abuse. The self report of associated diseases indicated psychological disorder in 4 (2.3%) participants, heart disease in 2 (1.1%), hypertension in 19 (10.9%), COPD in 5 (2.9%), diabetes in 2 (1.1%), other endocrine disease (including thyroid problems) in 2 (1.1%), and chronic renal failure in 3 (1.7%). Finally, 48 (27.4%) drivers had history of leg movement in bed.

Their experience in driving was 10.52 ± 2.27 years on average; which had no significant relationship with their crash history and was not found a confounding factor in this series.

The mean duration of sleep was 6.37 ± 1.62 h per day. The mean rate of accident was 2.31 ± 1.83 per year. Distributions of responses to the insomnia index evaluation are summarized in Table 1. The mean insomnia index was 13.02 ± 4.38. The ANOVA level (2-tailed) showed a significant correlation between the insomnia index and BMI (0.014), age (0.00), marital status (0.00), associated diseases (0.005), and drug history (0.028), but there was no significant correlation with history of crash in past years.

The distribution of participants' responses to the questions concerning related problems, and the ESS are presented in Tables 2 and 3, respectively. The mean ESS was 12.66 ± 5.35. There was a significant linear correlation between age and the ESS (Pearson correlation, $P = 0$). There was also a significant relationship between their marital status and ESS (ANOVA test, $P = 0$) with minimum for single and maximum for the divorced. Grouping the participants based on their ESS showed 30 (17.1%) fell in the minimum category and 92 (52.6%) in the moderate, while 40 (22.9%) were high risk. Age had a significant correlation (ANOVAs, $F = 6.26$, $P = 0.002$) with these different groups and also with rate of accidents in the past years (Pearson χ^2; value 7.27, DF = 2, $P = 0.026$), but we could not find any significant correlation with BMI.

Table 4 contains the distribution of responses to the apnea index questionnaire. The mean apnea scoring index was 5.84 ± 2.9 and it was significantly correlated (Oneway ANOVA) with age ($P = 0.02$), BMI ($P = 0$), education status ($P = 0.023$), marital status ($P = 0.001$), and drug history ($P = 0.00$). Although there was no significant correlation between the apnea index and history of crashes in the past 5 years, when we divided the crashes into financial and life threatening, there was a correlation between the financial type of crashes and apnea index score (0.011), and also with the duration of work at night (0.004).

Thirty-three (18.9%) drivers had a history of crash, 12 (6.9%) did not answer this item, and the rest stated they had no history of any accidents in their career. The mean driving time was 6.3 ± 1.62 h per day per person and the mean number of nights out of home was 8.27 ± 1.31 per

Table 3 Epworth sleepiness scale

	0	1	2	3
Sitting and studying	44(25.1%)	25(14.3%)	44(25.1%)	48(27.4%)
Watching television	25(14.3%)	27(15.4%)	63(36%)	49(28%)
Sitting immotile in a public place	22(12.6%)	30(17.1%)	51(29.1%)	56(32%)
Sitting immotile as a passenger in a car	21(12%)	23(13.1%)	44(25.1%)	70(40%)
Lying down to rest	17(9.7%)	35(20%)	20(11.4%)	89(51%)
Sitting and speaking	96(55%)	23(13%)	32(18.3%)	6(3.4%)
Sitting after having lunch	10(5.7%)	21(12%)	52(29.7%)	73(41.7%)
In a car after stopping in traffic jam	83(47.4%)	48(27.4%)	25(14.3%)	4(2.3%)

Table 4 Apnea index score distribution

	Never = 0	Rarely = 1	About half the time = 2	Almost always = 3	Always = 4
Frequency of snoring	26(14.9%)	62(35.4%)	14(8%)	41(23.4%)	17(2.3%)
Fatigue feeling during a day	2(1.1%)	55(31.4%)	69(39.4%)	26(14.9%)	7(4%)
Headache after wake up	53(30.3%)	56(32%)	43(24.6%)	7(4%)	1(0.6%)
Dry mouth after wake up	65(37.1%)	41(23.4%)	29(16.6%)	13(7.4%)	11(6.3%)

month. Both factors were significantly correlated with the crash occurrence in the past years (Pearson correlation, $P = 0.00$ and $P = 0004$, respectively).

Discussion

The effects of bad quality of sleep on daily activities are well-known [12, 13]. But the direct effect of quality of sleep and sleep disorders on increased risk of automobile accidents is a topic under research [2–5, 14–18]. Recent neuroimaging studies have shown the range of effects of sleep deprivation from cognitive performance to distorted patterns of cerebral metabolism and blood flow in humans. Sleep deprivation induced impairments in concentration and vigilance have been found to be accompanied by prominent decreases in metabolic activity in the thalamus and prefrontal and posterior parietal cortices, as measured by PET scan [2, 13]. OSA is associated with an increased risk of sleep-related motor vehicle accidents [7, 8, 16, 17].

The primary goal of the current study was to assess the relation between sleep characteristics and accidents by using different methods of sleep evaluation.

Measuring the prevalence of daytime sleepiness is a tough task. Although the objective methods are considered the gold standard, it is difficult and cannot be administered to a large scale of subjects. Thus, subjective methods are a better way to estimate the prevalence of sleepiness [9, 14, 19], but like any questionnaire-based method, all chosen systems are limited by the subject's ability to read and understand the content of the questionnaire and to answer the question correctly and honestly. Among subjective scales, the ESS is well accepted and currently the most commonly used [10, 14, 20], and in order to compare its results to other subjective methods, we used the insomnia index and the apnea index score that are used to evaluate different aspects of sleep [10, 11]. In addition, subjective sleepiness measured by these methods correlate significantly with objective sleepiness measured by the multiple sleep latency test, albeit imperfectly [10, 21].

Another problem in evaluating the relationship between sleep problems and car accidents is the difficulty to quantify the role of different suspected factors. In this survey we tried to cover most of the reasons and lessen their effects on final results.

All participants in this study were male, so inter-gender comparisons were not possible [18, 23]. This is because women are not engaged in this occupation in Iran.

There are many factors that contribute to sleep among people. BMI is a thoroughly investigated one. In spite of former studies [6, 23], BMI has a significant correlation only with the insomnia index, but we found no significant relationship between other sleep problem scale and BMI in our series. This may be because of normal or near normal BMI in most of our participants. Our age results were relatively different, because it was found significantly correlated with all sleep quality scales; this is compatible with other researches [1, 24, 25].

Marital problems were seen in 5.7% of the drivers and significantly correlated with sleep problems; this is also in agreement with previous reports [22, 26]. In general, the mean duration of sleep was 6.37 ± 1.62 h per day showing that most of our drivers had less than normal sleep that could predispose them to having accidents [1, 2, 8].

Another variable that proved to affect sleep problems was taking drug and drug abuse; a result similar to that reported by other researchers [2].

Associated disease affected the insomnia index but there was no significant correlation with other methods of sleep evaluation.

Twenty-three percent of drivers had an ESS higher than 17, this shows a larger number of participants in the high risk group compared to other reports. For example, in Nelson's series only 6% of participants scored 15 or higher, and this prompts us to pay more attention to our drivers' health problems [20].

Because the cutoffs in the ESS values are arbitrary [20], we repeated the analysis in crude number, as there are no accepted values of the ESS that define pathologic sleepiness.

Because daytime sleepiness is known to be a key factor in motor vehicle accidents, we used different methods to find correlations, but ESS is probably a better indicator.

There is an important need to increase public awareness about the potential consequences of various sleep disorders such as, sleep apnea, shift-work-related sleep loss, excessive daytime sleepiness, and it relationship to accidents in order to reduce the number of sleep-related traffic accidents [7, 8, 15, 16, 20, 27, 28].

There were some limitations in performing this study; first, since it was a cross-sectional study, a direct cause-effect relationship could not be made. The survey was based on self report, so the accuracy of responses could not be assured. To better evaluate the accuracy of reports, we had one author supervise the drivers as they filled out the forms. Another drawback of this research was that reports of accidents were based on the drivers' recollection which might have been incorrect. It is recommended that future studies use larger sample sizes and objective methods of sleep disorder assessment.

Conclusion

Sleep problems were prevalent among the studied group of urban bus drivers, and the significant relationship with history of crashes is an alarming sign to pay more attention to in choosing bus drivers and treating their sleep diseases. Moreover, adequate sleep time is an important factor that requires more attention in the area of occupational hygiene of bus drivers. Also, consulting with a physician to diagnose sleep disorders may be an important step in injury prevention.

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