Sleep and Breathing (2019) 23:979–985
https://doi.org/10.1007/s11325-019-01805-7

EPIDEMIOLOGY • ORIGINAL ARTICLE

High risk of obstructive sleep apnea, insomnia, and daytime sleepiness among commercial motor vehicle drivers

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Received: 30 October 2018 / Revised: 9 February 2019 / Accepted: 14 February 2019 / Published online: 25 February 2019

Abstract

Purpose We investigated the prevalence of sleep problems, such as obstructive sleep apnea (OSA), insomnia, and daytime sleepiness in commercial motor vehicle (CMV) drivers compared with that in the general population.

Methods This is a cross-sectional study comparing sleep habits and sleep problems in 110 truck drivers with 1001 matched controls from the general population. The assessment was based on self-administered questionnaires that included the Berlin questionnaire, the insomnia severity index, and the Epworth sleepiness scale (ESS). Multivariate regression analysis was performed to determine whether CMV drivers were independently associated with these sleep problems compared with controls.

Results The prevalence of a high risk of OSA and insomnia was 35.5% and 15.2%, respectively, in CMV drivers, which was significantly higher than in controls with a prevalence of 12.2% and 4.1%, respectively ($P < 0.001$ for both). Although CMV drivers showed higher ESS scores than controls, the prevalence of daytime sleepiness did not differ between the two groups (19.1% vs. 16.8%, $P = 0.54$). After adjusting for covariates, CMV drivers had 3.68 times higher odds (95% CI 2.29–5.84) of OSA and 2.97 times higher odds (95% CI, 1.46–6.06) of insomnia compared with controls. However, the degree of daytime sleepiness was not independently associated with CMV drivers.

Conclusions The prevalence of OSA and insomnia in CMV drivers was higher than that in the general population. Daytime sleepiness was associated with increased BMI, depression, OSA, and short sleep duration, regardless of CMV driving as an occupational factor.

Keywords Obstructive sleep apnea · Insomnia · Excessive daytime sleepiness · Commercial motor vehicle drivers

Introduction

Injuries due to road traffic crashes are a leading cause of death globally, resulting in an annual death of 1.2 million people [1]. Driving is a complex process requiring coordination between various neurocognitive functions, such as attention, visual perception, and decision making, as well as sensory and motor functions [2]. Therefore, several factors may compromise the driving performance of an individual, such as sleepiness, distraction, excessive speed, intake of alcohol, and sedative drugs, which consequently increase the risk of motor vehicle crashes [3]. Among the aforementioned factors, driver sleepiness is one of the most important modifiable risk factor for motor vehicle crashes [4]. Risk factors for sleep-related

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crashes also include untreated sleep disorders, sleep loss, and working in shifts [5]. Importantly, studies have reported that commercial motor vehicle (CMV) drivers are more likely to doze at the wheel and may be involved in crashes due to drowsy driving [6]. Increased risk of drowsy driving among CMV drivers is attributed to diverse factors, including short sleep duration, disruption of circadian rhythm, high number of miles driven, and underlying sleep disorders such as obstructive sleep apnea (OSA) [5]. A previous Australian study reported that 59.6% of CMV drivers had sleep-disordered breathing and 24.1% had excessive daytime sleepiness (EDS) [7]. Based on the substantial impact of OSA on the risk of motor vehicle crashes, recommendations for OSA screening and treatment in CMV drivers have been proposed in the USA [8].

Fatal traffic collisions with CMVs have increased public awareness to drowsy driving and sleep-related crashes in CMV drivers. Although traffic conditions related to CMV crashes have been studied previously in Korea [9], relatively little information is available regarding the sleep problems in CMV drivers. Moreover, in previous studies from other countries, the prevalence of the sleep problems in CMV drivers has not been evaluated in comparison with the general population. Understanding sleep disturbances prevalent in CMV drivers is crucial for developing safety rules and guidelines for screening and treatment of such sleep problems in the CMV driving population. Therefore, the present study investigated the prevalence of sleep problems such as OSA, insomnia, and daytime sleepiness in CMV drivers compared to the general adult population. In addition, a multivariate analysis was conducted to determine the independent association of such sleep problems with CMV drivers.

Methods

Study sample

CMV drivers included in the present study were recruited from Samsung Electronics Logitech Corporation (Suwon-si, Korea), which is a specialized logistics company that transports products between logistics hubs and delivers products to 21 nationwide distribution centers and 3200 independent customers. The inclusion criteria were full-time commercial truck drivers who were at least 19 years of age. A total of 110 volunteers participated in the study. Although subjects included were regardless of sex, all CMV drivers recruited were men. Self-report questionnaires were used to investigate demographic information, sleep habits, and sleep-related symptoms of the participants. All subjects gave written informed consent before enrollment. Information gathered in the study was anonymized to preserve the privacy of the participants. The study protocol was approved by the institutional review board of Soonchunhyang University Cheonan Hospital (No. 2016-11-009) and conducted in accordance with the Declaration of Helsinki and the Good Clinical Practice guidelines.

Control subjects were recruited from participants in the Korean Headache-Sleep Study (KHSS) which is a questionnaire-based survey for sleep and headache in a nationwide sample of the Korean adult population. Population sampling and questionnaire survey by face-to-face interviews were performed by Gallup Korea, and the detailed protocols have been described elsewhere [10]. Briefly, the estimated population of Korean adults aged ≥ 19 years was 37,782,000 in 2009. The number of target population was 2800, which was sampled from 15 administrative districts according to the clustered, proportionate quota sampling method. Among 7615 individuals approached, 2836 completed the survey with the response rate of 37.2% and the sampling rate of 7.5 individuals per 100,000. From the 2836 individuals who responded to the survey, 1001 male subjects aged between 24 and 65 years were selected to match age and sex distribution of the CMV drivers recruited in this study. Ultimately, 110 CMV drivers and 1001 control subjects were finalized as participants in this study.

High risk of OSA, insomnia, and daytime sleepiness

The Berlin questionnaire was used to estimate the risk of OSA in the study subjects. The Korean version of the Berlin questionnaire was previously validated in the adult population; in that study, obesity was defined as body mass index (BMI) ≥ 25 kg/m^2 [11]. Subjects who reported positive symptoms in two or more categories were classified as "at high risk of OSA", whereas those who reported one or no symptom categories were designated as "at low risk of OSA". In addition, the insomnia severity index (ISI) was assessed, and a total ISI score of ≥ 15 was defined as clinical insomnia. Daytime sleepiness was evaluated by the Epworth Sleepiness Scale (ESS), and EDS was defined as an ESS score of > 10.

Other examined variables

Age, sex, body mass index (BMI), education level, alcohol drinking, smoking status, and a history of hypertension and diabetes mellitus were investigated. The BMI of the subjects was categorized as normal (< 23 kg/m^2), overweight (23–25 kg/m^2), and obesity (≥ 25 kg/m^2). Frequency of alcohol consumption was questioned as "how often do you drink alcohol?" and the responses were dichotomized into "once a week or more" and "less than once a week or never." Smoking status was classified as current smoker, ex-smoker, and never-smoker.

Sleep habits over the past month, including time to sleep, time of awakening, and night sleep duration, recorded

separately for weekdays and weekends were assessed. Average sleep duration was calculated as the weighted average of reported sleep duration during weekdays (weight, 5/7) and weekends (weight, 2/7). Sleep need duration was estimated by asking the question "How much sleep do you need to be at your best during the day?" Individuals who answered "not enough" to the question "Do you think you have had enough sleep during the past month?" were defined to have perceived insufficient sleep. Unmet sleep need was defined as when average sleep duration was less than sleep need duration. Patient Health Questionnaire-9 (PHQ-9) for depression was also used, and its Korean version was previously validated in adults. Individuals with a PHQ-9 score of ≥ 10 were defined to have depression.

Statistical analysis

Clinical characteristics between CMV drivers and controls were compared using Student's *t* test and Pearson's chi-square test, as appropriate. Multiple logistic regression analysis was then performed to determine factors independently associated with a high risk of OSA and insomnia. Furthermore, multiple linear regression analysis was performed for daytime sleepiness as measured by ESS. CMV drivers versus controls was set as an independent variable, and the multivariate model was adjusted for age, BMI, alcohol intake, smoking status, and other potential confounding factors. Statistically significant level was defined as a two-tailed *P* value of < 0.05. All statistical analyses were carried out using SPSS version 18 (SPSS Inc., Chicago, IL).

Results

The mean age of CMV drivers was 41.6 years and all participants were men. The weight of vehicles was less than 5000 kg in 70.0%, 5000 to 10,000 kg in 14.6%, and 10,000 kg or more in 15.4% instances. The average driving hours per day was 7.2 ± 2.8 h, and the mean distance driven per day was 217.0 ± 183.8 km. The BMI of CMV drivers was 24.6 ± 0.3 kg/m^2, which was marginally higher than that of controls (24.0 ± 0.1 kg/m^2, $P = 0.04$). Average sleep duration of CMV drivers was shorter than that of controls (6.7 ± 0.9 h vs. 7.2 ± 1.2 h, $P < 0.001$). In particular, CMV drivers slept less than did the controls during weekdays ($P < 0.001$), whereas sleep duration during weekends did not differ between the two groups ($P = 0.10$). The prevalence of a high risk of OSA and insomnia was 35.5% and 15.2% in CMV drivers, which was significantly higher than 12.2% and 4.1% as observed in controls ($P < 0.001$ for both). Moreover, perceived insufficient sleep, unmet sleep need, and depression were more frequently reported in CMV drivers than in controls ($P < 0.001$ for all). Although the ESS score of CMV drivers was higher than that of controls (7.0 ± 2.9 vs. 5.6 ± 4.0, $P < 0.001$), the prevalence of EDS did not differ between the two groups (19.1% vs. 16.8%, $P = 0.54$). Clinical characteristics of CMV drivers and controls are summarized in Table 1.

Multiple logistic regression analysis was performed to identify factors independently associated with a high risk of OSA. After adjusting for covariates, CMV drivers were found to have 3.68 times higher odds (95% CI 2.29–5.84) of a high risk of OSA compared with controls. In addition, high BMI (OR 1.22, 95% CI 1.15–1.30) and ex-smoking status (OR 1.36, 95% CI 1.82–2.25) were

Table 1 Characteristics between commercial motor vehicle drivers and the general population

Variables	CMV drivers ($n = 110$)	Controls ($n = 1001$)	*P*
Age, year	41.6 ± 1.0	43.6 ± 0.4	0.08
Body mass index, kg/m^2	24.6 ± 0.3	24.0 ± 0.1	0.04
< 23	34 (30.9)	374 (37.4)	
23 to 25	35 (31.8)	294 (29.4)	
≥ 25	41 (37.3)	333 (33.3)	
Alcohol consumption	88 (80.0)	565 (56.4)	< 0.001
Smoking			0.09
Never	17 (15.9)	251 (25.2)	
Ex-smoker	30 (28.0)	230 (23.0)	
Current smoker	60 (56.1)	517 (51.8)	
Sleep duration, hour			
Average	6.7 ± 0.9	7.2 ± 1.2	< 0.001
Weekday	6.2 ± 0.9	7.0 ± 1.2	< 0.001
Weekend	7.9 ± 1.6	7.7 ± 1.5	0.10
Perceived insufficient sleep	58 (53.2)	288 (28.8)	< 0.001
Unmet sleep need	91 (82.7)	285 (28.5)	< 0.001
High risk of OSA	39 (35.5)	122 (12.2)	< 0.001
Epworth Sleepiness Scale score	7.0 ± 2.9	5.6 ± 4.0	< 0.001
EDS	21 (19.1)	168 (16.8)	0.54
Insomnia severity index score	9.6 ± 5.4	3.3 ± 4.6	< 0.001
Insomnia	16 (15.2)	41 (4.1)	< 0.001
PHQ-9 score	3.6 ± 3.7	1.9 ± 3.1	< 0.001
Depression	9 (8.3)	32 (3.2)	0.01
Hypertension	19 (17.3)	119 (11.9)	0.10
Diabetes mellitus	8 (7.3)	41 (4.1)	0.10

Data are presented as mean ± standard deviation or number (%). *CMV*, commercial motor vehicle; *OSA*, obstructive sleep apnea; *EDS*, excessive daytime sleepiness; *PHQ-9*, Patient Health Questionnaire-9. Smoking status available in 107 CMV drivers and 998 controls. Perceived insufficient sleep was missing in one CMV drivers, PHQ-9 in two CMV drivers, and insomnia severity index in five CMV drivers

Table 2 Adjusted odds ratios (95% confidence interval) for high risk of obstructive sleep apnea and insomnia

Variables	High risk of OSA	Insomnia
CMV driver (vs. control)	3.68 (2.29–5.84)*	2.97 (1.46–6.06)*
Age, year	1.01 (0.99–1.03)	1.01 (0.98–1.04)
Body mass index, kg/m^2	1.22 (1.15–1.30)*	0.92 (0.82–1.03)
Alcohol consumption	1.01 (0.70–1.47)	1.56 (0.82–2.99)
Smoking (vs. never)		
Ex-smoker	1.36 (1.82–2.25)*	0.72 (0.28–1.89)
Current smoker	1.04 (0.65–1.62)	1.423 (0.67–3.06)
Depression		12.9 (5.58–29.92)*
High risk of OSA		1.23 (0.58–2.57)
Average sleep duration, hour		0.52 (0.47–0.67)*

CMV, commercial motor vehicle; *OSA*, obstructive sleep apnea. *$P < 0.05$

significantly associated with a high risk of OSA. Next, multiple logistic regression analysis was performed for insomnia. The adjusted OR for insomnia in CMV drivers was 2.97 (95% CI, 1.46–6.06) compared to controls. Insomnia was also significantly associated with depression (OR 12.9, 95% CI 5.58–29.92) and short sleep duration (OR 0.52, 95% CI 0.47–0.67; Table 2). Regarding daytime sleepiness, we conducted multivariate linear regression analysis for the ESS score. As shown in Table 3, BMI ($\beta = 0.11$, 95% CI 0.03–0.20), high risk of OSA ($\beta = 0.8$, 95% CI 0.11–1.49), depression scale ($\beta = 3.4$, 95% CI 2.13–4.67), and short average sleep duration ($\beta = -0.24$, 95% CI −0.45–− 0.04) were significantly correlated with daytime sleepiness. However, driving a CMV ($\beta = 0.73$, 95% CI −0.09–1.56) was not associated with the degree of daytime sleepiness after adjusting for the effect of average sleep duration (Table 3).

Discussion

In the present study, the prevalence of a high risk of OSA, insomnia, and EDS among CMV drivers was 35.5%, 15.2%, and 19.1%, respectively. Compared with the general population, CMV drivers had 3.68 and 2.97 times higher odds of a high risk of OSA and insomnia after adjustment for potential confounding factors. It was observed that driving a CMV did not independently affect the degree of daytime sleepiness per se, which was more significantly associated with a high BMI, depression, a high risk of OSA, and short sleep duration. A major strength of this study is that we compared CMV drivers with controls representing the general population, which allows us to identify sleep disturbances exclusively associated with CMV drivers. To the best of our knowledge, this is the first study to show that CMV drivers are significantly associated with higher risk of sleep disturbances, such as OSA and insomnia, compared with the general population in Korea.

Compared with the general population, CMV drivers were significantly associated with a high risk of OSA after adjustments for potential risk factors, such as age, BMI, and alcohol consumption. Based on the Berlin questionnaire, the prevalence of a high risk of OSA in Portuguese truck drivers was also estimated to be 29% [12], which is comparable to the results (35.5%) in our study. It has been well established that untreated OSA is a significant risk factor for motor vehicle crashes [13]. A meta-analysis reported that drivers with OSA had 2.4 times higher risk of motor vehicle crashes compared with those without OSA in the overall driving population [14]. Moreover, continuous positive airway pressure (CPAP) has been reported to significantly decrease the risk of motor vehicle crashes in

Table 3 Multivariate linear regression for the Epworth Sleepiness Scale score

Variables	Model 1	Model 2	Model 3
CMV driver (vs. control)	1.37 (0.57–2.16)*	0.84 (0.02–1.66)*	0.73 (− 0.09–1.56)
Age, year	0.002 (− 0.02–0.02)	− 0.002 (− 0.02–0.02)	− 0.005 (− 0.03–0.02)
BMI, kg/m^2	0.13 (0.04–0.21)*	0.12 (0.03–0.20)*	0.11 (0.03–0.20)*
Alcohol consumption	− 0.09 (− 0.57–0.40)	− 0.03 − 0.51–0.44)	− 0.05 (− 0.53–0.43)
Smoking (vs. never)			
Ex-smoker	0.67 (− 0.02–1.35)	0.59 (− 0.08–1.26)	0.65 (− 0.02–1.33)
Current smoker	0.15 (− 0.42–0.73)	0.01 (− 0.56–0.58)	0.07 (− 0.50–0.65)
High risk of OSA		0.88 (0.19–1.56)*	0.8 (0.11–1.49)*
ISI score		1.14 (0.05–2.23)*	0.94 (− 0.16–2.04)
PHQ-9 score		3.33 (2.06–4.61)*	3.4 (2.13–4.67)*
Average sleep duration, hour			− 0.24 (− 0.45–− 0.04)*

Data shown are beta coefficient (95% confidence interval). *CMV*, commercial motor vehicle; *OSA*, obstructive sleep apnea; *ISI*, insomnia severity index; *PHQ-9*, Patient Health Questionnaire-9. *$P < 0.05$

patients with severe OSA by 65 to 78% [15]. The crash rate after CPAP treatment was also observed to decrease to normal levels as in individuals without OSA [16]. Interplay between OSA and motor vehicle crashes has been established in CMV drivers as well as in the general driving population. Previous studies have demonstrated high prevalence of polysomnography-confirmed OSA ranging from 28.2 to 60.8% in CMV drivers when OSA was defined as an apnea-hypopnea index or respiratory distress index of at least five per hour [7, 17, 18]. Two studies using a nasal flow monitor and pulse oximetry reported that OSA was diagnosed in 42.2% and 25.6% of CMV drivers, respectively [19, 20]. In line with the present study, the vast majority of CMV drivers in previous studies were men. The prevalence of polysomnography-confirmed OSA in the general male population ranged from 17 to 27% with an apnea-hypopnea index cutoff of 5 or more [21, 22]. Collectively, these findings suggested an increased prevalence of OSA in CMV drivers compared with the general population. However, there have been limited studies comparing CMV drivers with those of other occupation categories with regard to the prevalence of OSA. In this regard, it is worth mentioning that CMV drivers were significantly associated with a higher risk of OSA compared with the general male population in the present study. The exact reason for the independent association between CMV drivers and a high risk of OSA cannot be elucidated from this study. A possible explanation is that driving CMV as an occupation might lead to a sedentary lifestyle, insufficient physical activity, and unhealthy dietary patterns. Further research will be needed to confirm the effect of lifestyle characteristics, such as physical activity and dietary habits, on the risk of OSA among CMV drivers.

Another important finding of the present study was the association of CMV drivers with insomnia. After controlling for covariates, CMV drivers were found to have approximately three times higher odds of insomnia than did the controls. Insomnia, particularly accompanied by short sleep duration, is associated with deficits in neurocognitive functioning, such as processing speed, attention switching, and short-term visual memory [23]. In line with this, a meta-analysis demonstrated that insomnia was associated with a 2.87-fold increased risk of workplace accidents [24]. Furthermore, patients with primary insomnia showed impaired driving performances than did controls in simulated driving tests [25]. Although the aforementioned data supported the idea that insomnia is an important factor in traffic safety, most previous studies conducted regarding sleep problems in general or commercial drivers have focused on OSA, EDS, and sleep deprivation rather than insomnia. Among French highway drivers, insomnia was found in 9.3% and was significantly associated with a high risk of drowsy driving accidents [26]. Notably, Garbarino et al. reported that 28.5% of Italian truck drivers had insomnia, and they had a 1.82-fold increased risk of motor vehicle crashes compared with non-insomniac truck drivers [27]. Taken together with the results of this study, it may be suggested that insomnia should be considered a significant sleep problem in CMV drivers.

EDS is another risk factor of motor vehicle crashes in the general and commercial driving population [7, 12, 26, 28]. Among CMV drivers, the prevalence of EDS has been estimated to be between 13.4 and 24.1% [7, 12, 28], which is consistent with the percentage reported (19.1%) in the present study. Compared to controls, CMV drivers reported shorter average sleep duration with a higher rate of perceived insufficient sleep and high risk of OSA, which are closely associated with increased risk of EDS. However, the prevalence of EDS did not significantly differ between the two groups in the present study, although CMV drivers had higher ESS scores than controls. This result may seem counterintuitive. A possible explanation for this result is selection bias that CMV drivers with EDS might have refused to participate in this study. Alternatively, the ESS questionnaire may not have optimally reflected the degree of daytime sleepiness in this population of Korean CMV drivers. Although the ESS is a widely used and validated instrument to identify those with EDS, it is not always predictive in special populations. For instance, among moderate to severe OSA patients in Korea, the mean ESS score was only 5 although daytime sleepiness symptoms were frequently reported by questionnaires other than ESS [29]. The inverse correlation between the ESS score and the OSA severity was also found in CMV drivers [30], indicating that the reliability of the ESS for screening symptomatic patients can be limited in this particular occupational setting. In summary, the results of the present study for the lack of independent association between ESS and CMV drivers may be interpreted as CMV driving itself, as an occupational factor, is not a direct cause of EDS. Other EDS-related factors, such as obesity, OSA, depression, and chronic sleep deprivation, should be evaluated and managed if CMV drivers are found to have EDS.

This study has several limitations. Because sleep characteristics of the study subjects were assessed by self-administered questionnaires, the risk of OSA was measured by the Berlin questionnaire instead of polysomnography. Although the Berlin questionnaire is a useful screening tool for OSA, objective measurements, such as apnea-hypopnea index, would have more accurately represented the presence and severity of OSA. Considering that the number of Korean truck drivers is estimated to be approximately 200,000 [31], the number of CMV drivers investigated in this study is too small to represent the CMV driver population. Furthermore, CMV drivers were recruited from a single company, which would also preclude generalization of our results to the general population of CMV drivers. Additionally, selection bias might have occurred because CMV drivers having sleep disturbances, such

as EDS, may be reluctant to participate in this study compared to CMV drivers without sleep disturbances. Although multivariate analyses for sleep problems were adjusted for BMI, the fact that CMV drivers and controls were not matched for BMI is another potential limitation. Finally, because this is a cross-sectional study, the causal relationship between the sleep disturbances and CMV driving cannot be determined. Therefore, the findings of the present study should be cautiously interpreted.

In summary, the prevalence of a high risk of OSA and insomnia in CMV drivers was higher than that in the general population. Daytime sleepiness was associated with increased BMI, depression, a high risk of OSA, and short sleep duration, regardless of CMV driving as an occupational factor. For improving CMV safety, a multidisciplinary approach involving the government, industry, and general public will be needed to identify undiagnosed sleep disorders and improve sleep health of CMV drivers.

Funding This work was supported by a National Research Foundation of Korea (NRF) grant funded by the Ministry of Education (No. NRF-2017R1D1A1B04035931) and a grant from the Soonchunhyang University Research Fund.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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