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Original Article

Ten-Year Cardiovascular Risk Estimation through the Framingham Risk Score among Commercial Motor Vehicle Drivers with High and Low Risk of Obstructive Sleep Apnea

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Abstract

Objective Obstructive sleep apnea (OSA) and cardiovascular disease (CVD) are both major medical causes of road accidents among commercial motor vehicle (CMV) drivers. The present study aimed to determine the association of the ten-year risk of developing CVD and other cardiac risk factors with the risk of developing OSA among apparently healthy CMV drivers.

Materials and Methods The present cross-sectional study was conducted on 315 male CMV drivers. Demographic characteristics were collected, and the Epworth Sleepiness Scale (ESS), the Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index (BMI) $> 35\,kg/m^2$, Age $>$ 50 Years, Neck Circumference $>$ 40 cm, and Male Gender (STOP-Bang) questionnaire, and International Physical Activity Questionnaire-Short Form (IPAQ-SF) were filled out, and the ten-year CVD risk was calculated through the Framingham Risk Score (FRS) for each individual. Laboratory tests also were performed. The participants were divided into two groups based on the STOP-Bang score and FRS, and other CVD risk factors were compared, accordingly. The Chi-squared test, the Student *t*-test, analysis of variance (ANOVA), and logistic regression were used for the analysis.

Results The mean age of the drivers was of 45.57 (range: 30 to 70) years. In the univariate analysis, the mean age, years of driving experience, FRS, vascular age, blood pressure, diabetes mellitus, metabolic syndrome, ESS score, BMI, and circumference of the waist and hip presented a significant association with STOP-Bang score $\geq$ 3 ($p < 0.05$). The metabolic equivalents of task (METs) for total physical activity and walking (min/week), time spent sitting (h/day), lipid profiles, smoking history, vehicle

Keywords
- commercial motor vehicle drivers
- obstructive sleep apnea
- Framingham risk score
- cardiovascular disease
- STOP-Bang questionnaire
- International Physical Activity Questionnaire-Short Form

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type, and shift type were statistically similar in both groups. In the multivariate analysis, a high risk of OSA was independently associated with higher FRS (odds ratio: 1.92; $p < 0.001$).

Conclusion The STOP-Bang score presented a direct correlation with the estimated ten-year CVD risk in CMV drivers. The high risk of developing OSA among CMV drivers is accompanied by higher CVD risk factors such as old age, diabetes, hypertension, BMI, and waist and hip circumference. The FRS was statistically higher in CMV drivers with high OSA risk.

Introduction

According to World Health Organization[1] (WHO) statistics, each year, 1.35 million people are killed on roadways around the world. Based on a country ranking for 2016,[1] the average mortality rate of road traffic accidents in Iran is significantly higher than the worldwide rate: 20.5 per 100 thousand inhabitants versus 18.2 per 100 thousand respectively.

In general, medical issues presented by drivers are responsible for 10% of fatal truck accidents, and 90% of these accidents are related to cardiovascular disease (CVD).[2] Sudden cardiac death (SCD) while driving has been reported as a cause of 0.4% of all road accidents in Germany;[3] SCD is often caused by coronary artery diseases (CADs), especially myocardial infarction (MI)[4] and cardiomyopathies and inherited channelopathies.[5]

Another significant medical cause of road accidents is obstructive sleep apnea (OSA), a sleep breathing disorder that is clinically known to cause repetitive episodes of partial or complete upper airway obstruction during sleep, leading to intermittent oxygen desaturation or arousal of the patient.[6] Its prevalence among professional drivers ranges from 28% to 78%, which is higher than the rate for the general population.[7] Obstructive sleep apnea may double or triple the risk of crashes for drivers.[8] Evidence shows drivers with untreated OSA have impaired psychomotor vigilance and driving simulator performance.[9,10] Moreover, OSA has a negative impact on episodic memory,[11] cognitive ability,[12] and executive functions,[13] which could be involved in driving hazards.

OSA is also directly associated with increasing cardiovascular morbidity and mortality,[14–18] as well as diabetes mellitus,[19] hypertension,[20] hyperlipidemia, obesity, and the male sex,[21] which are common risk factors of CVD.

Although the evidence confirms the relationship between untreated, severe OSA and the incidence of fatal and nonfatal cardiovascular events (MI, acute coronary syndrome, and stroke),[22] this association can also be true in the opposite direction, which means MI and heart failure (HF) may also be associated with increasing of sleep-disordered breathing.[23]

From the perspective of occupational medicine, OSA and CVD play an important role in safety-critical jobs, such as driving commercial motor vehicles (CMVs). However, it has been observed[7] many drivers do not express their symptoms, consciously or unconsciously, during the Commercial Drivers Health License (CDHL) renewal process.

In the present study, we have calculated the risk of developing OSA through the Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index (BMI) > 35 kg/m^2, Age > 50 Years, Neck Circumference > 40 cm, and Male Gender (STOP-Bang) questionnaire, and we have also estimated the ten-year general CVD incidence through the Framingham Risk Score (FRS) for seemingly-healthy (in terms of CVDs) CMV drivers during the CDHL renewal process. The FRS can reliably assess and predict the probability of developing general CVD over the next ten years, including events of coronary, cerebrovascular, and peripheral arterial diseases, as well as HF.[24]

We performed an analysis to assess the associations involving the STOP-Bang score, the FRS, and other CVD risk factors among Iranian CMV drivers who had no history or current cardiovascular signs and symptoms.

Materials and Methods

The present was an observational cross-sectional study conducted on CMV drives who came for renewal of their CDHL at the Baharloo Occupational Medicine Clinic of Tehran University of Medical Sciences (TUMS).

The Ethical Committee of Human Research at the TUMS approved the protocol of the present study (Ethics Code: IR. TUMS.MEDICINE.REC.1398.030), and all participants signed an informed consent form before enrolling in the study.

Participants

From January 2020 to March 2021, 550 male drivers were referred to our clinic. We recruited 315 eligible participants.

The **inclusion criteria** were: male sex, age between 30 and 74 years, drivers of light and heavy urban and off- road vehicles, used for both freight and passengers, whose only job and source of income was driving, and who had at least 2 years of recent driving experience.

The **exclusion criteria** were: history of any physician-diagnosed CVD, such as MI, valvular heart disease, CAD, and HF (but not hypertension, HTN), detection of any clinically significant signs and symptoms of CVD in a physical examination, and electrocardiography (ECG) abnormalities confirmed by a cardiologist consultation, use of statins, aspirin, anticoagulants, and any medication that may influence consciousness level and circadian rhythm, and having a second job.

Steps of the Research

As a routine of our clinic for CDHL renewal, in the hospital laboratory, morning blood samples were taken for complete blood count (CBC), fasting blood sugar (FBS), serum creatinine, triglyceride (TG), total cholesterol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) after at least 12 hours of fasting. All blood biochemistry tests were performed using the Roche (Basel, Switzerland) Hitachi (Tokyo, Japan) 912 Chemistry Analyzer, and hemoglobin A1c (HbA1c), using the Agilent 1100 series HPLC system (Agilent, Santa Clara, CA, United States). Type-2 diabetes was defined as FBS $\geq$ 126 mg/dL confirmed by an HbA1c $\geq$ 6.5%[25] and/or by the use of medications to treat hyperglycemia.

All past medical history, drug history, and tobacco smoking were recorded, and general physical examinations with a focus on cardiovascular signs and symptoms were performed by an occupational medicine resident. Body weight (in kg), and height (in cm) with light clothes and without shoes were measured with a calibrated hospital mechanical scale with a height rod. The BMI was calculated as weight (in kg)/height (in m^2).

Neck circumference was measured just below the laryngeal prominence and perpendicular to the cervical spine with a plastic tape with an accuracy of 0.5 cm.[26] Waist and hip circumferences were measured using the WHO guidelines.[27]

Only current smokers were considered smokers and the pack-years (PYs) were calculated with the formula: PY = (cigarettes per day/pack size) $\times$ years; the standard pack size of 20 cigarettes was considered.

Blood pressure (BP) was measured using standard, calibrated aneroid sphygmomanometers with the appropriate cuff size and the Korotkoff acoustic method while the subjects were sitting for at least 10 minutes with their arms supported at the mid-sternal level. The ultimate recorded BP was the result of the mean blood pressure of both arms in 2 consecutive measurements at least 2 minutes apart. Hypertension was defined as having BP $\geq$ 140/90 mmHg and/or using medications for hypertension.[28] According to the Iranian CDHL guidelines, a 12-lead ECG was performed for drivers $\geq$ 40 years of age or those with suspected cardiovascular problems.

Metabolic syndrome was defined based on the Adult Treatment Panel III (ATP III) guidelines as the presence of 3 or more of the following components: waist circumference $>$ 102 cm; TG level $\geq$ 150 mg/dL and/or medication use to treat hypertriglyceridemia; HDL level $<$ 40 mg/dL; FBS $\geq$ 110 mg/dL and/or drug use to treat hyperglycemia; and BP $\geq$ 130/85 mmHg and/or use of antihypertensive drugs.[29]

At this stage, the person's health license is issued and accepted or rejected according to Iranian regulations. Then, the subjective data collection sheet, with questions on demographic and occupational information of the drivers, and the STOP-Bang and Epworth Sleepiness Scale (ESS) questionnaires were filled out under direct supervision of the researcher. For data on sleep features, we used parts of the Persian-validated Pittsburgh Sleep Quality Index (PSQI) questionnaire regarding hour of sleep onset, waking time, duration of time in bed, and duration of sleep.[30]

Finally, by combining demographics, clinical information, and laboratory tests, the mean FRS was calculated and classified into three groups: mild, moderate, and severe CVD risk. After that, all data were analyzed based on the STOP-Bang risk score.

Study Measures

Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index (BMI) $>$ 35 kg/m^2, Age $>$ 50 Years, Neck Circumference $>$ 40 cm, and Male Gender (STOP-Bang questionnaire): it consists of 8 yes/no questions; each positive answer is considered equivalent to a score, and the higher the total score, the higher the probability of developing OSA.[31]

Recently, the STOP-Bang questionnaire was validated for OSA screening in general populations and commercial drivers, and, for scores $\geq$ 3, it presents high sensitivity and negative predictive value (NPV).[32] In the present study, we used the validated Persian version of the STOP-Bang questionnaire, which performs similarly to the original version,[33] and data were analyzed using a cut-off of 3 and the enhanced STOP-Bang.

Enhanced STOP-Bang is a scoring system for the STOP-Bang questionnaire which could improve its specificity to detect moderate and severe cases. In this scoring system, after obtaining the STOP-Bang score, the individuals are designated into low ($\leq$ 2), intermediate (3 or 4), or high ($\geq$ 5) risk groups. In the next stage, patients with moderate risk (score of 3 or 4) who answered "yes" to at least 2 questions of the "STOP" section and "yes" to one of the questions regarding male gender, BMI $>$ 35 kg/m^2, or neck circumference $>$ 40 cm are considered as presenting a high risk of developing OSA.[34]

Framingham General CVD Risk Score (2008): the FRS is a sex-specific algorithm to estimate the overall risk of developing CVD (coronary, cerebrovascular, and peripheral arterial diseases, as well as HF) in the next 10 years. It is validated for use in primary care settings in populations without CVD aged 30 to 74 years. The FRS parameters comprise gender, age, systolic BP, total cholesterol, HDL level, and three yes/no questions on hypertension medication, cigarette smoking, and diabetes. In this algorithm, a CVD point is determined for each person based on the amount of cardiovascular risk factors which can become the ten-year percentage of CVD risk. The FRS algorithms can also estimate the vascular age of the individuals. Therefore, if a person has risk factors in the normal range (nonsmoker, nondiabetic, untreated systolic BP of 125 mmHg, total cholesterol of 180 mg/dL, and HDL of 45 mg/dL, for example), vascular age is defined as the chronological age of a person with the same predicted risk.[24]

We classified participants into 3 risk classes: $<$ 10% – low risk; 10% to 20% – moderate risk; and $>$ 20% – high risk, based on their FRS risk percentage.

Epworth Sleepiness Scale (ESS): it is a subjective tool to measure sleepiness in different ordinary life situations.[35] The questionnaire contains 8 questions regarding the feeling of drowsiness in different daily situations. The total score can range from 0 to 24, and a score above 10 indicates excessive daily sleepiness.[35] In the present study, we used a validated Persian version of the ESS to evaluate the drivers.[36]

International Physical Activity Questionnaire - Short Form (IPAQ-SF)

This 7-item questionnaire evaluates a person's daily sitting time, as well as vigorous or moderate physical activity, and walking time in the past week in various daily situations. Finally, it estimates a person's total physical activity in terms of metabolic equivalents of task (METs) minutes per week and time spent sitting. In the present study, we used a version of the IPAQ-SF validated and translated to Persian.[37]

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS, SPSS Inc., Chicago, IL, United States) software for Windows, version 16.0. The quantitative data were expressed as mean and standard deviation values, and the qualitative data, as the numbers and percentages. The associations involving the mean values of the quantitative variables in the STOP-Bang groups were analyzed through the Student *t*-test and analysis of variance (ANOVA). The qualitative variables were assessed through the Chi-squared test and the Pearson correlation coefficient. Logistic regression (LR) analysis was performed to adjust the confounding factors for age, BMI, HTN, FBS, TG, LDL, HDL, and STOP-Bang score with the backward LR method. Values of $p < 0.05$ were defined for significant associations.

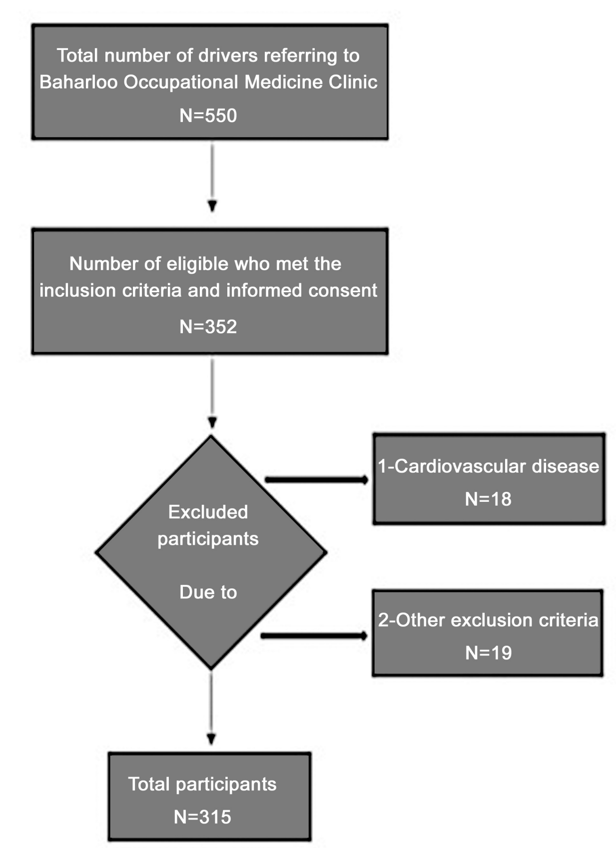

Fig. 1 Recruitment flowchart of the present study.

Results

In the present study, 315 male CMV drivers with a mean age of 45.57 (range: 30 to 70) years were recruited (►**Fig. 1**).

They were classified into 2 groups based on the STOP-Bang cutoff score ≥3. ►**Table 1** shows a comparison of the sociodemographic characteristics and health status of CMV drivers with high- and low-risk STOP-Bang scores. Mean age and years of driving experience were significantly higher in the high-risk group ($p < 0.001$). The mean age of offroad CMV drivers was higher than that of the urban CMV drivers: 46.23 ± 8.27 years versus 43.98 ± 8.65 years respectively ($p = 0.028$). The means for total physical activity (MET-mi /week) walking (MET-mi /week) and sitting (h/day) were not significantly different among high- and low-risk groups ($p > 0.05$), but walking (MET-min/week) was higher among passenger drivers (696.93 ± 604.76) than among freight drivers (509.56 ± 462.88) ($p = 0.008$).

The CVD risk factors such as diabetes, HTN, metabolic syndrome, waist circumference, hip circumference, and BMI in the high-risk group were significantly higher than in the low-risk group ($p < 0.001$). Lipid profiles (TG, total cholesterol, LDL, and HDL) as well as smoking (pack-years) and shift work were similar in both groups ($p > 0.05$). According to ►**Table 1**, The FRS and vascular age had a positive correlation with STOP-Bang score ≥ 3 ($p < 0.001$).

►**Table 2** shows that the FRS classification includes mild, moderate, and high, and that there are also yes/no questions regarding high or low risk of developing OSA risk. ►**Table 3** demonstrates the occupational characteristics of the participants.

In addition, ►**Fig. 2** shows another significant difference between the three FRS classes and the three OSA risk intensities based on the enhanced STOP-Bang ($p < 0.001$).

We performed an LR analysis adjustment for age, BMI, HTN, FBS, TG, LDL, HDL, and the STOP-Bang score with the backward LR method, with the ten-year risk of the FRS as the dependent variable. The ten-year risk of the FRS had a significant association with age, HTN, FBS, TG, LDL, and the STOP-Bang score. The STOP-Bang score was associated with the FRS, regardless of of age, BMI, HTN, FBS, TG, LDL, and HDL (►**Table 4**). Participants with HTN and higher STOP-Bang score had greater odds for the 10-year risk of the FRS.

Discussion

The current study demonstrated that ∼ 1 out of 3 (33%) referred Iranian CMV drivers were at risk of developing OSA, and the high-risk drivers were significantly older and had longer driving experience.

The overall 10-year CVD risks among this population were as follows: 61.9% – low risk; 20.6% – moderate risk; and 17.5% – high risk, as expressed by the FRS 2008 model. Moreover, the FRS and the risk intensity classes increase according to the STOP-Bang (with the cut-off ≥ 3) and enhanced STOP-Bang classifications. In other words, a STOP-Bang score ≥ 3 for drivers is a risk factor for cardiovascular disease.

Table 1 Sociodemographic characteristics and health status of participants with high and low risk of developing OSA.

Characteristics	Total (*N* = 315)	STOP-Bang < 3 (*N* = 209)	STOP-Bang ≥ 3 (*N* = 106)	*p*-value
Demographic and Anthropometric data	Mean	Mean(± SD)	Mean(± SD)	
Age (years)	45.5	43.8(± 8.0)	49.0(± 8.7)	< 0.001
BMI (kg/m^2)	28.2	26.9(± 3.2)	30.7(± 4.3)	< 0.001
Waist circumference (cm)	98.7	95.5(± 8.6)	104.8(± 11.4)	< 0.001
Hip circumference (cm)	102.4	100.6(± 5.9)	105.8(± 8.6)	< 0.001
Sleep features				
Nightly sleep duration (hours)	6.59	6.59(± 1.15)	6.59(± 1.39)	0.983
Sleep efficiency (%)	94.65	94.27(± 6.11)	95.39(± 4.94)	0.685
ESS	2.68	2.46(± 2.41)	3.10(± 2.78)	0.036
Physical activity				
Total physical activity (MET-min/week)	1290.73 (1383.26)	1284.55(± 1000.29)	1302.85(± 1931.57)	0.912
Walking (MET-min/week)	561.07	600.11(± 554.34)	484.10(± 403.56)	0.057
Sitting time (h/day)		12.45(± 2.14)	12.81(± 2.13)	0.171
Health status and laboratory data	Mean(± SD)	Mean(± SD)	Mean(± SD)	*p*-value
SBP (mmHg)	119.6	115.1(± 11.5)	128.5(± 15.5)	< 0.001
DBP (mmHg)	77.0	74.8(± 8.0)	81.4(± 8.6)	< 0.001
FBS (mg/dL)	110.5	106.1(± 19.1)	119.0(± 38.2)	0.001
Triglycerides (mg/dL)	195.1	187.7(± 149.4)	209.7(± 131.1)	0.201
Total cholesterol (mg/dL)	187.4	186.7(± 33.9)	188.7(± 39.0)	0.647
LDL cholesterol (mg/dL)	109.7	108.9(± 25.7)	111.2(± 29.4)	0.496
HDL cholesterol (mg/dL)	45.4	46.1(± 11.5)	44.1(± 8.9)	0.128
Smoking (pack-years)	8.71(± 9.09)	7.56(± 8.79)	10.48(± 9.34)	0.072
FRS	9.9	7.4(± 5.9)	14.7(± 8.9)	< 0.001
Vascular age (years)	51.24	46.90(± 12.08)	59.80(± 14.22)	< 0.001
	Number (%)	Number (%)	Number (%)	*p*-value
Metabolic syndrome (yes)	128 (40.6%)	62 (29.7%)	66 (62.3%)	< 0.001

Abbreviations: BMI, body mass index; ESS, Epworth Sleepiness Scale; DBP, diastolic blood pressure; FBS, fasting blood sugar; FRS, Framingham Risk Score; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MET, metabolic equivalent of task, OSA, obstructive sleep apnea; SBP, systolic blood pressure; SD, standard deviation; STOP-Bang, Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index (BMI) > 35 kg/m^2, Age > 50 Years, Neck Circumference > 40 cm, and Male Gender.

Table 2 Association of the FRS 10-year CVD risk classes and its "yes/no questions with OSA risk among participants.

	Total (*N* = 315)	STOP-Bang < 3 (*N* = 209)	STOP-Bang ≥ 3 (*N* = 106)	*p*-value
*FRS component**	Number (%)	Number (%)	Number (%)	
Smoking (yes)	131 (41.6%)	79 (37.8%)	52 (49.1%)	0.055
On HTN medication (yes)	13 (4.1%)	1 (0.5%)	12 (11.3%)	< 0.001
Diabetes mellitus (yes)	30 (9.5%)	11 (5.3%)	19 (17.9%)	< 0.001
FRS class				< 0.001
Low	195 (61.9%)	158 (75.6%)	37 (34.9%)	
Moderate	65 (20.6%)	33 (15.8%)	32 (30.2%)	
High	55 (17.5%)	18 (8.6%)	37 (34.9%)	

Abbreviations: FRS, Framingham Risk Score; HTN, hypertension; OSA, obstructive sleep apnea; STOP-Bang, Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index (BMI) > 35 kg/m^2, Age > 50 Years, Neck Circumference > 40 cm, and Male Gender.
Note: *Due to the unisexual nature of the study, gender was removed from the table. The other four components are shown in ►**Table 1**.

Table 3 Occupational characteristics of the study population according to OSA risk.

	STOP-Bang <3 (*N* = 209)	STOP-Bang ≥3 (*N* = 106)	Total (*N* = 315)	*p*-value
Occupational characteristic	Number (%)	Number (%)	Number (%)	
Driving experience (years)	16.80 (9.11)	21.83 (9.10)	18.49 (9.40)	< 0.001
Vehicle type				0.128
Truck	123 (58.9%)	58 (54.7%)	181 (57.5%)	
Bus	69 (33%)	30 (28.3%)	99 (31.4%)	
Pickup truck	6 (2.9%)	6 (5.7%)	12 (3.8%)	
Taxi	11 (5.3%)	12 (11.3%)	23 (7.3%)	
Shift type				0.807
Day	136 (65.1%)	65 (61.3%)	201 (63.8%)	
Night	16 (7.7%)	9 (8.5%)	25 (7.9%)	
Mixed	57 (27.3%)	32 (30.2%)	89 (28.3%)	

Abbreviation: STOP-Bang, Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index (BMI) > 35 kg/m^2, Age > 50 Years, Neck Circumference > 40 cm, and Male Gender.

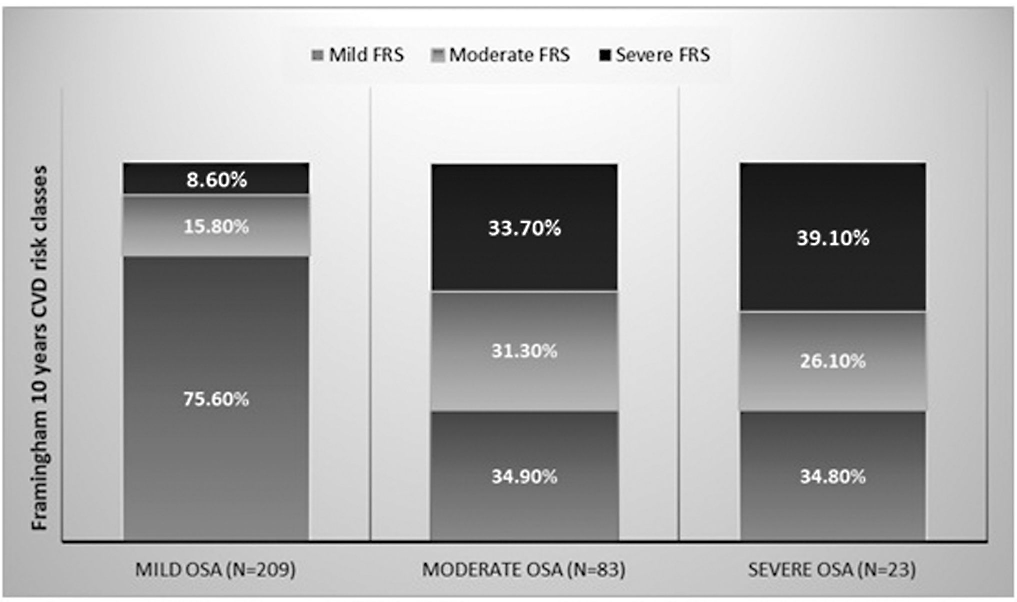

Fig. 2 Association of the 10-year FRS with increasing OSA severity, based on the enhanced STOP-Bang scores of the participants ($p < 0.001$).

Table 4 Logistic regression analysis of the 10-year risk of FRS covariates.

Variables*	B	Odds ratio	*p*-value
Stop-Bang score	0.65	1.92	0.001
Age	0.26	1.29	< 0.001
HTN	1.24	3.47	0.033
FBS (mg/dL)	0.05	1.05	< 0.001
TG (mg/dL)	0.01	1.00	0.002
LDL cholesterol (mg/dL)	0.02	1.02	0.014

Abbreviations: FBS, fasting blood sugar; FRS, Framingham Risk Score; HTN, hypertension; LDL, low-density lipoprotein; STOP-Bang, Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index (BMI) > 35 kg/m^2, Age > 50 Years, Neck Circumference > 40 cm, and Male Gender; TG, triglycerides.
Note: *Adjustment for age, body mass index, HTN, FBS, TG, LDL, high-density lipoprotein, and Stop-bang score (only significant variables are presented in the ►**Table 4**).

According to a previous study,[38] OSA is associated with various CVDs, including CAD, stroke, HF, atrial fibrillation, and HTN. Archontogeorgis et al.[39] conducted a study with 393 individuals without CVDs, newly-diagnosed OSA by polysomnography, and the ten-year CVD risk estimated by the Systematic Coronary Risk Evaluation (SCORE) and the FRS. Consistent with the present study, the authors[39] reported that increased OSA severity was associated with increased SCORE and FRS values. Another study[40] demonstrated that the STOP-Bang questionnaire (cutoff score $\geq$3) can predict cardiopulmonary events, including hypoxemia and hypotension occurring during bronchoscopy under sedation.

In the present study, the known CVD risk factors such age, BMI, diabetes mellitus, treated and untreated HTN, BP, and metabolic syndrome were significantly more prevalent in drivers with a high risk of developing OSA, but smoking status, pack-years, walking (MET-min/week) and sitting time (h/day) were similar in both low- and high-risk OSA drivers.

Recently, Ebrahimi et al.,[41] in a case-control study on the relationship between metabolic syndrome and risk of developing OSA among 428 Iranian professional drivers, indicated a significant correlation between metabolic syndrome (based on ATP III criteria) and high risk of developing OSA. In line with the present study, they[41] found a positive correlation in the high-risk STOP-Bang group with two obesity indicators, including hip circumference and wrist circumference, as we found regarding BMI and hip and waist circumference. In addition, the authors[41] also reported that FBS and both systolic and diastolic BP and the whole lipid profile, except for HDL, were associated with high-risk STOP-Bang. On the other hand, in the population of the present study, none of the components of the lipid profile were significantly different between the two groups.

A cross-sectional study by Hall et al[42]. on the association of OSA with physical activity in a population from Ontario, Canada, found that increased total physical activity, vigorous activity, and walking were all independently associated with a reduced incidence of OSA, while moderate activity was not associated with OSA risk. However, the present study showed no significant difference in METs regarding total physical activity and walking or sitting hours in high- and low-risk OSA drivers. This may be due to the high working hours of drivers and the limitations of sports activities due to the co-occurrence of the study with the coronavirus disease 2019 (COVID-19) pandemic, which may have affected both study groups.

There is a controversy in the relationship between cigarette smoking and OSA: several studies have shown no significant relationship;[43–45] inversely, other studies have demonstrated that smoking may result in an early development of OSA, which may be more severe.[46] In the present study, there was no significant difference in smoking (yes or no) and pack-years between the high- and low-risk groups.

Recently, sleep health, which includes the self-reported average hours of sleep per night, has been used in the new American Heart Association (AHA) quantitative cardiovascular health (CVH) assessment tool.[47] In this evaluation system, the average night time sleep for 7 to 9 hours gets a full score (100) and fewer or longer hours are considered suboptimal for CVH. In the present study, there was no significant difference between the hours of nightly sleep of CMV drivers in both groups (►**Table 1**), but the average number of hours of nightly sleep of all subjects was in the suboptimal category (< 7 hours), which can be attributed to a high workload.[47]

Previous studies[48] have reported a correlation between ESS scores and the Maintenance of Wakefulness Test in the screening for drowsiness among commercial drivers, but, in the present study, there was a significant difference in the ESS scores of the two groups according to the STOP-Bang score. This can be due to the proper trust building in drivers, about the separation of obtaining CDHL process from receiving the subjective data, in this survey.

The LR analysis adjustment for age, BMI, HTN, FBS, TG, LDL, HDL, and Stop-Bang score revealed that the STOP-Bang is independently associated with a higher ten-year risk of developing CVD among CMV drivers, accompanied by age, HTN, FBS, TG, and LDL.

Sometimes, it can be very difficult to determine the fitness of seemingly-healthy people with certain diseases, such as OSA and CVDs, for safety-sensitive jobs like driving, because some people refuse to cooperate and express their symptoms to access their CDHL more easily and quickly. Therefore, occupational medicine specialists can use the STOP-Bang questionnaire as an accessible, efficient, and inexpensive tool in their practice, because, in addition to determining OSA risk, it can also be used, to some extent, as a risk assessment for CVDs.

Limitations

The sample collection of the present cross-sectional study coincided with the COVID-19 pandemic, in which the drivers' CDHL was automatically renewed for at least 6 months, so their face-to-face visits were postponed. Moreover, during this period, due to quarantine and the closure of sports centers, people's physical activity decreased and inactivity increased significantly. Additionally, since in Iran women are rarely engaged in commercial driving, the population of the present study was forcibly limited to men,

Conclusion

The present study showed that the STOP-Bang score correlates with the estimated ten-year CVD risk by the FRS in commercial drivers seemingly healthy in terms of CVDs. The high risk of developing OSA (STOP-Bang score $\geq$ 3) among CMV drivers is accompanied by higher cardiovascular risk factors such as old age, diabetes, FBS, HTN, BMI, and neck, waist, and hip circumference. Therefore, attention to the risk of CVD and OSA during the fitness assessment of CMV drivers as individuals with safety-sensitive jobs is recommended.

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Conflict of Interests

The authors have no conflict of interests to declare.

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