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Original Article

Prevalence of and risk factors for obstructive sleep apnea syndrome in Brazilian railroad workers

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ABSTRACT

Objective: This study evaluated the prevalence of, and the risk factors for, obstructive sleep apnea syndrome (OSAS) among Brazilian railroad workers.
Methods: Male railroad workers (745) from a railway company in Brazil were analyzed after responding to questionnaires about their demographics, sleep habits, excessive daytime sleepiness (Epworth), and the likelihood of having apnea (Berlin). We also performed polysomnography and measured anthropometric data for all of the railroad workers.
Results: The results showed that 261 (35.03%) of the railroad workers presented with OSAS. These railroad workers were older (OSAS: 38.53 ± 10.08 versus non-OSAS: 33.99 ± 8.92 years), more obese according to body mass index (27.70 ± 4.38 versus 26.22 ± 3.92 kg/m^2), and employed for a longer period of time (14.32 ± 9.13 years) compared with those without OSAS (10.96 ± 7.66 years). Among those with OSAS, 9.5% were smokers and 54.7% reported alcohol use. The associated risk factors were age (OR = 2.51, 95% CI = 1.76–3.57), BMI (OR = 1.56, 95% CI = 1.04–2.34), alcohol use (OR = 1.28, 95% CI = 0.90–1.81), and a high chance of having sleep apnea, as assessed by the Berlin questionnaire (OR = 2.19, 95% CI = 1.49–3.21).
Conclusion: The prevalence of OSAS in Brazilian railroad workers was higher than that observed in the general population but similar to that found in the population of the city of São Paulo, Brazil. These results suggest that age, BMI, a high risk of developing apnea through subjective self-reporting (Berlin), and alcohol use are associated with a higher risk of developing OSAS. These data reinforce the need to be more attentive to this population because they have a higher propensity for accidents.

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1. Introduction

Studies have indicated that excessive sleepiness is a risk factor for accidents, and it can be inferred that patients with obstructive sleep apnea syndrome (OSAS) have an increased risk of transport-related accidents compared with the general population [1]. OSAS is characterized by repeated episodes of upper airway obstruction during sleep, which is associated with intermittent hypoxemia, increased respiratory effort, and arousals. The most frequent clinical symptom is excessive sleepiness [2,3].

Sleepiness and fatigue are frequent problems for workers in the transportation sector [4,5], particularly in night and shift workers because they have inverted sleep-wake cycles that lead to a significant reduction in the duration and effectiveness of sleep [6]. Excessive sleepiness is considered a problem because it affects quality of life and has negative effects on productivity and work safety. Excessive sleepiness may also result from sleep deprivation and may be associated with sleep-disordered breathing [7].

The prevalence of OSAS is variable and depends on an individual's age, gender, and nationality, as well as on the methodology of the criteria used for diagnosis. The prevalence of OSAS in the general population ranges from 2% to 32.8% [3,8–12]. In studies on transportation workers, most of which have focused on professional automotive drivers, such as bus and truck drivers, the prevalence ranges from 15.8% to 78% [13–17]. However, there are few studies on the prevalence of sleep-disordered breathing in railroad workers, among whom there is a very high risk for accidents.

Increases in body mass index (BMI), neck circumference, and the waist-hip ratio in non-obese persons are associated with a gradual increase in the prevalence of OSAS [18]. Additionally, other factors have been correlated with the apnea–hypopnea index (AHI), such as gender, age, tobacco use, and alcohol consumption

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[19–21]. However, little is known about OSAS or the risk factors for its onset in railroad workers. Therefore, the aim of this study was to evaluate the prevalence of and possible risk factors associated with OSAS in railroad workers employed by a Brazilian company.

2. Methodology

2.1. Participants

This study was conducted on a sample of 745 railroad workers employed by a railroad company in Brazil who were evaluated between January 2008 and November 2010. All of the railroad workers in the sample were male. The participants were informed about the study procedures prior to signing consent forms. The protocol was approved by the Ethics Committee at the Universidade Federal de São Paulo (REC 0547/08).

Of the 745 railroad workers, 715 were train conductors (486 were long-distance railroad conductors and 229 were rail yard conductors) and 30 were rail yard and terminal controllers. There were no exclusion criteria; all railroad workers were invited to participate in the study.

2.2. Experimental design

The railroad workers were invited to complete anthropometric assessments (weight, height, waist, hip, and neck measurements) to determine their BMI, obesity, and risk for cardiovascular disease. BMI calculations were determined using the criteria established by the World Health Organization [22]. After responding to the general questionnaire (to assess demographics, lifestyle, and daily routine) the Epworth Sleepiness Scale (ESS) and the Berlin questionnaire, the participants then underwent polysomnography to evaluate their sleep patterns and verify the presence or absence of OSAS. For the sleep record, railroad workers were invited to a hotel that was usually used for rest between work-related travel intervals.

2.2.1. General questionnaire

To assess demographics (age, years of schooling, and time employed as shift workers), lifestyle (alcohol and tobacco use), and daily routine (commute time from home to work and work responsibilities), the participants were asked to self-report using a general questionnaire.

2.2.2. Berlin Questionnaire

The Berlin questionnaire was used to evaluate the risk of OSAS, which has been previously described by Netzer et al. [23] and validated for use in Portuguese [24]. The questionnaire includes 10 items organized into three categories related to snoring and witnessed apneas (five items), daytime sleepiness (four items), and hypertension/obesity (one item). Information on gender, age, height, weight, neck circumference, and race is also requested. The determination of high or low risk for OSAS is based on the responses for each category of items.

2.2.3. Epworth sleepiness scale

The ESS is the most widely used subjective scale for assessing daytime sleepiness because it is able to distinguish people with and without sleepiness from those with excessive sleepiness. The ESS consists of eight questions that describe everyday situations that can induce sleepiness. Each question is graded from 0 to 3; total scores above 10 indicate significant daytime sleepiness, and scores above 15 are associated with pathological sleepiness present in specific conditions, such as sleep apnea and narcolepsy [25].

2.2.4. Polysomnography examination (PSG)

An all-night PSG was performed using a digital EMBLA Titanium™ system (Embla, Broomfield, USA). The room used for the recordings had a large comfortable bed, acoustic isolation, and controlled temperature and light. The following physiological characteristics were monitored simultaneously and continuously: electroencephalogram (3 canals F4-M1, C4-M1, O2-M1), electrooculogram, chin and side tibial electromyograms, electrocardiogram, airflow (thermal sensor), thoracic-abdominal movements, snoring as detected by a microphone placed on the lateral neck, pulse oximetry, and body position. Polysomnographic recordings were performed according to the criteria established by the AASM Manual for Scoring Sleep and Associated Events [26]. Electrode placement was performed according to the international 10–20 system [27]. Thirty-second epochs were staged according to standard criteria and were visually inspected by a sleep specialist. The following parameters were analyzed: (a) total sleep time (TST, in min), defined as the actual time spent asleep; (b) sleep latency (SL, 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 (SE), defined as the percentage of total recording time spent asleep; (d) wakefulness after sleep onset (WASO, in min), defined as the total time scored as wakefulness between sleep onset and final awakening; (e) stages 1, 2, 3, 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.

OSAS was diagnosed according to the American Academy of Sleep Medicine [28] based on the following criteria: an AHI ⩾ five events per hour and a daytime sleepiness score over 11 points, as diagnosed by the ESS or the presence of snoring or reports of apnea. An AHI > 15, regardless of the presence or absence of symptoms, was also used as a criterion for OSAS. The severity of OSAS was classified according to the AHI scale as follows: mild, 5–15; moderate, 15–30; and severe, >30 [3].

2.3. Statistical analyses

Statistical analyses were performed using the statistical software package PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL).

The Kolmogorov–Smirnov test was used to test for normal distribution. Variables with non-normal distribution were transformed using a Z-score to normalize their distribution prior to statistical analyses. Descriptive statistics were used. The data were presented as the mean ± SD. Differences between groups referring to continuous variables were assessed using the analysis of variance (ANOVA). Levene's test was used in ANOVA to evaluate homogeneity. The categorical variables were assessed using the Pearson χ^2 test. An α value < 0.05 was considered to be statistically significant.

The risk factors for OSAS in railroad workers were categorized and explored by employing the Receiver Operating Characteristic (ROC) curve for the continuous variables of age, waist circumference, and time employed as a shift worker. The area under the curve (AUC) was reported as well as its asymptotic p value. Individuals with a BMI ⩾ 25 kg/m^2 were classified as having excess weight (overweight and obese). The Berlin questionnaire was used to assess the risk of OSAS. The risk factors associated with lifestyle variables were dichotomized into "yes" and "no" responses, and alcohol consumption and cigarette smoking (either socially or regularly) were considered as a pair when considering the risk for OSAS. Odds ratios (OR) and 95% confidence intervals (CI) were determined. Variables showing association with an α value of <0.05 in univariate analysis were considered candidate risk factors for use in multivariate analysis. The analysis was performed with logistic regression to identify significant independent risk factors

for OSAS. In multivariate analysis, the variables that had high associations were excluded from the regression model. Two log-likelihood, Cox and Snell *R* Squared, and the Hosmer and Lemeshow tests were used to examine the fitness of the model.

3. Results

In the overall sample of railroad workers, the average age was 35.63 ± 9.59 years and the mean BMI was 26.74 ± 4.14 kg/m^2. The alcohol consumption rate was 59.6% and the tobacco use rate was 10.2%. The average length of time employed as shift workers was 13.9 ± 14.32 years. With regard to obesity, 69.5% of all railroad workers studied had above average weight (BMI $\geqslant$ 25 kg/m^2); 47.6% of railroad workers were overweight and 21.9% were obese.

Of the 745 railroad workers, 261 (35.03%) were diagnosed with OSAS; of these, 54.4% were diagnosed with mild OSAS, 25.3% with moderate OSAS, and 20.3% with severe OSAS. Descriptive data for the sample pool are shown in Table 1 and divided into OSAS and non-OSAS groups. Railroad workers who were diagnosed with OSAS were more obese, older, had worked for the company longer, and had consumed more alcohol compared with non-OSAS railroad workers. The variables associated with a risk for OSAS were age (AUC = 0.628, $p < 0.001$, cut-off: 37 years), waist circumference (AUC = 0.677, $p < 0.001$, cut-off: 98 cm), and time employed as a shift worker (AUC = 0.606, $p < 0.001$, cut-off: 12 years).

Table 2 depicts the risk factors for OSAS according to the univariate analysis. The variables showing association (α value of <0.05) according to univariate analysis were considered candidate risk factors for use in multivariate analysis. In the multivariate analysis shown in Table 3, the variables selected for the model were age, BMI, and symptoms related to the risk for OSAS, as evaluated using the Berlin questionnaire.

4. Discussion

The results of this study indicate that Brazilian railroad workers exhibit a high incidence of OSAS and that the risk factors most closely related to having the syndrome include age, BMI, and alcohol consumption.

This is the first study describing the prevalence and risk factors for OSAS in a group of Brazilian railroad workers; most of the current studies in the literature were performed on professional drivers who drove trucks, automobiles, and buses [1,29,30]. Among the 745 Brazilian railroad workers who participated in our study, the prevalence of OSAS was 35.03% (261 railroad workers). The diagnosis of OSAS was based on AHI scores between five and 15 events per hour and associated with excessive sleepiness, the presence of snoring or self-reporting of apnea, or AHI $\geqslant$ 15 events per hour. In addition, individuals over the age of 37 years who had a BMI

Table 2
Variables analyzed for the chance of OSAS (univariate analysis).

Variables	Non-OSAS[*] n = 484	OSAS[*] n = 261	OR (95% IC)[#]
Age			
Age < 37 years	345 (71.30%)	129 (49.30%)	1.0
Age > 37 years	139 (28.70%)	132 (50.70%)	2.71 (1.98–3.73)
Shift work time			
<12 years	339 (70.05%)	151 (57.85%)	1.0
>12 years	145 (29.95%)	110 (42.15%)	2.11 (1.51–2.94)
Waist circumference			
<98 cm	399 (82.40%)	158 (60.54%)	1.0
>98 cm	85 (17.60%)	103 (39.46%)	3.04 (2.15–4.29)
BMI			
<25 kg/m^2	178 (36.80%)	60 (23.00%)	1.0
$\geqslant$25 kg/m^2	306 (63.20%)	201 (77.00%)	1.86 (1.31–2.64)
Risk of sleep apnea (Berlin)			
Low	387 (79.95%)	158 (60.50%)	1,0
High	97 (20.05%)	103 (39.50%)	2.54 (1.82–3.56)
Smoking			
No	426 (88.00%)	236 (90.50%)	1.0
Yes	58 (12.00%)	25 (9.50%)	0.74 (0.45–1.22)
Alcoholism			
No	265 (54.75%)	118 (45.22%)	1.0
Yes	219 (45.25%)	143 (54.78%)	1.38 (1.00–1.90)

BMI: body mass index.
[*] Data represented as the absolute frequency (*n*) and relative frequency (%).
[#] Odds ratio represent the chance of OSAS in case group.

Table 3
Logistic regression model of factors associated with the risk of OSAS.

Variables	Adjusted OR (95% IC)
Age (>37 years)	2.51 (1.76–3.57)
BMI ($\geqslant$25 kg/m^2)	1.56 (1.04–2.34)
High risk of sleep apnea	2.19 (1.49–3.21)
Alcohol use	1.28 (0.90–1.81)

Hosmer and Lemeshow test (χ^2 = 4.99, p = 0.66), Cox and Snell = 0.096.
BMI: body mass index.

above 25 kg/m^2, a subjective self-report for a high risk of developing apnea (Berlin), and who reported alcohol use showed a higher risk of developing OSAS.

When only subjective parameters and AHI were evaluated in professional drivers, the prevalence of obstructive sleep apnea (OSA) ranged from 11.5% to 78% [7,13–16,31,32]. In studies conducted with professional drivers in Philadelphia (truckers), Australia (automotive), and Spain (automotive), the prevalence of OSAS was shown to be lower (28.2%, 15.8% and 8.6%, respectively) when compared with the railroad workers in our study (35.03%) [13,14,31]. However, in a study of train engineers in Greece,

Table 1
Demographic characteristics of the study population (*n* = 745).

	Non-OSAS (n = 484)	OSAS (n = 261)	Statistic test	*p*
Age (years)	33.99 ± 8.92	38.53 ± 10.08	39.45	<0.001
Body mass index (kg/m^2)	26.22 ± 3.92	27.70 ± 4.38	3.38	<0.001
(BMI $\geqslant$ 25 kg/m^2) (%)	314 (65%)	202 (77.6%)	12.58	<0.001
Neck circumference (cm)	38.48 ± 3.37	39.57 ± 3.06	1.32	<0.001
Waist circumference (cm)	89.37 ± 9.14	95.36 ± 10.06	1.76	<0.001
Berlin (%)	99 (20.5%)	103 (39.5%)	30.64	<0.001
Epworth (mean)	7.49 ± 3.46	8.79 ± 3.62	0.61	<0.001
Epworth $\geqslant$ 10 (%)	122 (25.2%)	114 (43.7%)	24.66	<0.001
Shift work time (years)	10.96 ± 7.66	14.32 ± 9.13	26.91	<0.001
Alcohol use (%)	219 (45.2%)	143 (54.7%)	3.88	0.04
Smoke (%)	58 (11.9%)	25 (9.5%)	1.37	0.24

Data presented as the mean and SD (±), comparison made using ANOVA.
Data presented as the absolute frequency (relative frequency %), comparison performed using χ^2 test.

the prevalence of sleep-disordered breathing (OSA) was 62% [16]. Regarding the severity of apnea, professional automotive drivers in Australia and railroad drivers in Greece had a lower prevalence of mild OSA (34.8% and 40%, respectively) compared with our study sample (54.4%). However, this large variation in prevalence in the literature may be due to the definitions used for diagnosis, the selected study population, or to other criteria including age, BMI, time employed, and the duration of sleep during polysomnography.

Despite the diversity of prevalence rates in the literature, we found that the prevalence of OSAS in Brazilian railroad workers was higher when compared with the rates in the American and Italian general adult population [2,9]. However, the prevalence in our study sample is similar to that of the population of the city of São Paulo, Brazil [12], perhaps because the two studies had similar criteria for diagnosing OSAS and a population with a similar genetic makeup.

Several factors have been associated with an increased risk of OSAS, including age, male gender, obesity, alcohol abuse, otorhinolaryngological changes, inherited traits, and aging [2,33]. Our study results corroborate previous findings that obesity is a major modifiable risk factor for OSAS [34]. Longitudinal studies, such as the Sleep Heart Health Study, the Wisconsin Sleep Cohort Study, and the Cleveland Family Study, have shown that increased levels of BMI over time can accelerate the progression of obstructive sleep apnea or lead to the development and increased severity of apnea [35].

The accumulation of fat in the neck (leading to the obstruction of airways) is one of the primary reasons for the onset of OSAS [36]. The accumulation of abdominal fat and the presence of metabolic syndromes can also lead to the onset and development of OSAS due to declining respiratory function (e.g., a reduction in pulmonary volume) [37,38]. Our sample of individuals over the age of 37 years had a higher chance of developing OSAS. These data are supported by other studies reporting that difficulties in sleeping normally increase with advancing age [39]. In a sample of the general population, the prevalence of sleep apnea ($AHI \geqslant 10$) in men from Pennsylvania increased progressively with age; the group between 65–100 years in age had an OR of 6.6 (95% CI = 2.6–16.7) compared with those 20–44 years in age. This is also observed in epidemiological data from Brazil, where people between 60–80 years in age had an OR of 34.5 (95% CI = 18.5–64.2) compared with those between 20–29 years in age [12].

The aging process exposes the body to physiological changes that alter the functionality of different systems, including the nervous and endocrine systems [40]. The hypothalamic–pituitary–adrenal (HPA) axis is essential for homeostasis in mammals and is closely related to the sleep-wake cycle. This axis plays a central role in integrating the responses of both the endocrine and nervous systems to external and internal stimuli. With aging, there is a decline in the amplitude of markers for the sleep-wake cycle, such as body temperature, melatonin, and cortisol. Such changes are closely related to the deterioration of sleep quality during aging [41]. These reports corroborate our data because age was a determining factor for the decline in sleep quality for Brazilian railroad workers.

Risk factors, such as alcohol consumption, appear to decrease professional performance [42]. In our sample population, alcohol had an OR of 1.28 (95% IC 0.90–1.81) for OSAS. Even though this factor was not statistically significant, we kept it as a risk factor in multivariate analysis because it was a significant variable in univariate analysis together with other parameters (e.g. age, BMI, etc.). Other studies have demonstrated that alcohol use is associated with increased OSAS severity [43,44]. Proposed mechanisms for side effects of alcohol upon OSAS include selective reduction upper airway obstruction via reduced dilatory muscle tone, or by blunted ventilator response to hypoxia [43,44].

OSAS has been associated with a myriad of symptoms, such as trouble sleeping, memory loss, impaired concentration, and loss of attention span. These effects arise from the sleep architecture assessed in this study. Although polysomnography is considered the gold standard for diagnosing OSAS, it is an expensive examination, and many population studies have used other subjective instruments to identify individuals at higher risk of developing apnea [23,32]. According to our results, the subjective evaluation (based on the Berlin questionnaire) showed an OR of 2.19 (95% CI = 1.49–3.21) for developing OSAS, which is consistent with that reported in the literature.

Previous studies have reported that in the general population, despite the scientific and clinical advances in relation to obstructive sleep apnea, the vast majority (70–80%) of those affected remain undiagnosed [45]. It is very likely that, as in the general population, train conductors are similarly under diagnosed. One reason that diagnosis may be missed is because patients remain unaware of the associated symptoms, which are often identified by a spouse or another family member. Compounding the lack of awareness on the part of the patient [46], few health professionals have the knowledge and training necessary to make the diagnosis and then recommend treatment [47]. Therefore, detecting the risk factors associated with obstructive sleep apnea is very important in making the appropriate diagnosis in high-risk populations.

Many studies have correlated OSAS with automotive accidents, showing an increased risk for individuals with OSAS compared with the general population [2]. This often occurs because the majority of professional drivers, such as truck drivers, bus drivers and train drivers, may also have irregular sleeping habits, sleep deprivation, or sleep disorders such as OSAS. These factors or their cumulative effects may increase the predisposition toward excessive sleepiness and alter circadian rhythms [48,49]. In the case of railroad workers, working conditions may exacerbate these symptoms because of the irregular shift system and the automation and monotony of the journey [5].

Self-reporting of excessive sleepiness, alcohol use, and smoking through questionnaires was one of the limitations of this study because workers usually omitted information even when they were informed that all data were highly confidential. The failure to quantify alcohol consumption may have been a further limitation to the study. However, these limitations are not a mitigating factor because even with the potential omission of information, we found a high prevalence of OSAS in the study population.

In conclusion, we found a high prevalence of OSAS in Brazilian railroad workers that was similar to the rates found in the general population of the city of São Paulo, Brazil [12]. Our results further suggest that age, BMI, a self-reported higher risk of developing apnea (Berlin), and alcohol use increase the risk of developing OSAS. These data reinforce the need to be attentive to the population because they may be at a higher risk for having accidents as well as experiencing loss of productivity and work-related injuries.

Conflicts of interest

Acknowledgments

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