

Traffic Accidents in Commercial Long-Haul Truck Drivers: The Influence of Sleep-Disordered Breathing and Obesity

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Summary: This study assesses a possible independent effect of sleep-related breathing disorders and traffic accidents in long-haul commercial truck drivers. The study design included integrated analysis of recordings of sleep-related breathing disorders, self-reported automotive and company-recorded automotive accidents. A cross-sectional Population of 90 commercial long-haul truck drivers 20-64 years of age was studied. Main outcome measures included presence or absence, as well as severity, of sleep-disordered breathing and frequency of automotive accidents. Truck drivers identified with sleep-disordered breathing had a two-fold higher accident rate per mile than drivers without sleep-disordered breathing. Accident frequency was not dependent and the severity of the sleep-related breathing disorder. Obese drivers with a body mass > 30 kg/m² also presented a two-fold higher accident rate than nonobese drivers. We conclude that a complaint of excessive daytime sleepiness is related to a significantly higher automotive accident rate in long-haul commercial truck drivers. Sleep-disordered breathing with hypoxemia and obesity are risk factors for automotive accidents.

Daytime sleepiness is a common complaint of patients with sleep-disordered breathing (SDB) (1) and can be reversed by treatment with nasal positive continuous airway pressure (nCPAP) or maxillofacial surgery (2).

Patients with SDB have been shown to have significantly more automobile accidents than control subjects without the syndrome (3,4), and the number of accidents has been shown to increase with increasing severity of the sleep disorder (5). In a study performed by a German team, patients with SDB have attributed 23 out of 28 accidents to sleepiness at the wheel, whereas a control population without SDB did not attribute a single accident out of four to sleepiness at the wheel (6). It has been demonstrated that patients with SDB perform much more poorly in driving simulator test situations than subjects without the syndrome (7) and that their performance is improved after treatment with nCPAP (7).

We recently completed a study of the prevalence of nocturnal breathing abnormalities in commercial longhaul truck drivers. One hundred fifty-nine truck drivers were evaluated with a monitoring device that was validated against polysomnography to determine the presence of snoring and sleep-disordered breathing. Forty-six percent of all monitored drivers were shown to have abnormal breathing during sleep (8).

We evaluated whether a nonselected group of longhaul truck drivers with significant breathing abnormalities during sleep may be at risk for causing more traffic accidents than drivers without the syndrome.

METHODS

Study design

The study was performed at the main hub of a longhaul trucking company. All company truck drivers who came through this loading point during a 3-week period were asked to participate in the study after signing an informed consent approved by the Stanford University review board. The following information was collected for this study:

a) Every volunteer was asked to complete a questionnaire on sleeping habits and snoring and to report the number of driving accidents in which they had been involved over the last 5 years. They were also asked to report the number of these accidents that were fatigue related.

The questionnaire consisted of 20 questions and patient demographics and daytime functioning, daytime sleep tendency, alertness, snoring, smoking history and sleep quality. The questions concerning sleep-related items had been validated previously using polysomnography (9), and the questionnaire had been used with

177 truck drivers prior to this study to evaluate the feasibility of this approach with this subject population. Questions were answered and a 5-point scale, on which 1 = never and 5 = always.

Accident information for each driver over the last 5 years was obtained from company accident records. We did not rely solely on company accident records because the company did not have access to information on accidents that occurred outside the work schedule. We also obtained from the drivers self-reports of work-related truck accidents and accidents in private automobiles for the same time span. An "accident" was defined as the collision of the index case's vehicle with a stationary or moving object or as driving off the road in the absence of an obstacle.

b) Any volunteer who was planning to spend the night at the main hub before leaving with the next payload was asked to undergo a nocturnal monitoring, either in a company trailer on the premises or in his/ her own designated trailer kept in the company lot.

Population

The mean age of the total group was 36.5 ± 8.7 years. The Body mass index (BMI) averaged 29.2 ± 6.6 kg/m². Ninety-three percent of all drivers were male. For specific analyses we considered drivers with a BMI ≥ 30 kg/m² as obese and drivers below this cutoff as nonobese. Thus 38% of all drivers were identified as obese, with a mean BMI of 35.9 ± 5.3 kg/M², whereas the 62% nonobese drivers presented a mean BMI of 25.1 ± 3.0 kg/M² ($p < 0.0001$).

Monitoring

Two hundred thirteen drivers were scheduled to spend the night at the facilities. Of these, 193 (92%) agreed to undergo monitoring during sleep, but 34 had to terminate the monitoring prematurely due to the availability of a truck load, and their data had to be discarded. We performed 159 recordings of appropriate duration for analysis. As a portion of the monitored sample included student drivers with little professional driving experience, we decided only to include drivers with a driving history ≥ 2 months. Overnight recordings, completed questionnaires and accident records were therefore analyzed for 90 truck drivers.

Subjects who agreed to be monitored were tested overnight with an ambulatory screening device, the Mesam IV ®. The specificity and sensitivity of the equipment in recognizing breathing disturbance during sleep have been determined in a double-blind comparison with polysomnography (9). The device is a microprocessor that continuously monitors four variables throughout the night:

1. heart rate (HR), monitored through a single-lead electrocardiogram (modified V-2), with determination of R-R intervals in milliseconds;
2. snoring sounds, monitored through an encapsulated electric subminiature microphone placed on the larynx;
3. oxygen saturation (SaO₂), measured by pulse oximetry through a flexible finger probe; and
4. body position/movement, measured through a flat cylinder sensor placed on the lower part of the sternum.

Each monitor is initialized by an IBM-compatible portable computer. The start of the recording can be preset and is independent of electrode placement, which occurred between 6:00 and 9:00 p.m.

During placement of the microprocessor, each individual received a sleep log in which to record lights-out and lights-on times, as well as behavioral awakenings and time spent awake. At morning awakening, patients were asked to fill out a questionnaire rating sleep quality, sleep disturbances and disturbances related to the equipment. Subjects returned the equipment between 8:00 and 10:00 a.m. the next morning.

Analyses

Analyses of overnight recordings were performed on an IBM-compatible computer using the validated commercially available software accompanying the Mesam IV® equipment. The algorithms used for heart rate and snoring analyses are derived from those developed at the University of Marburg (Germany) and published by the University research group (10). Prior investigations have indicated that obstructive hypopnea and apnea can be identified based on an analysis of sound signal (snoring), heart rate (brady- or tachycardia) and oxygen saturation drops (10,11). Sleep logs were used to calculate total sleep time (TST) and the "oxygen desaturation index" (ODI). The ODI is calculated by dividing the total number of SaO₂ drops $> 3\%$ by the determined TST in hours. The ODI does not differentiate between central, mixed and obstructive apnea and hypopnea. Because the total number of SaO₂ drops and the ODI had the best sensitivity and specificity of all indices in the previously published validation study (9), all analyses were performed using these indices.

Statistical analyses

One-way analysis of variance was performed to determine significance of changes between groups. Student's *t* test was applied for testing means of two groups. Pearson product moment correlations were used to

determine the interdependence between sets of variables. These analyses are part of the "StatView V4.0" computer statistical package (12) and were performed on a Macintosh Quadra 700 computer. A *p* value of < 0.05 was regarded as statistically significant for all analyses.

RESULTS

For analysis, we considered the total number of vehicle accidents. We obtained information on mileage both from the trucking company and from the drivers' self-reported usage of private vehicles. All accident rates were adjusted for annual mileage of individual truck drivers. The drivers reported a total of 42 accidents. Four drivers reported two accidents and two drivers reported three accidents within the last 5 years. Seven of the 42 accidents were reported to be fatigue related. Drivers with accidents were a mean of 37.0 ± 8.8 years old, whereas drivers without accidents had a mean age of 36.2 ± 8.8 years ($p = ns$). The number of self-reported accidents was twice as high as work-related accidents only. Thus, the correlation between company-reported and self-reported accidents was moderately high ($R = 0.3$; $p < 0.0002$). This suggests that half of the self-reported accidents occurred Off duty.

Accidents and sleep-disordered breathing

We classified drivers based on their number of abnormal respiratory events during sleep associated with oxygen desaturations $> 3\%$ from a moving averaged baseline. For each driver the total number of these events was divided by the TST in hours, indicating the ODI.

Drivers diagnosed with SDB accounted for 23 of the 42 accidents, whereas drivers without SDB caused 19 of all reported accidents. This difference was not statistically significant. We then divided truck drivers by apnea severity into groups. Each group was defined by the number of ODI, that is more than 5, 10, 20 and 30 oxygen desaturations/hour of sleep. Although drivers with SDB caused twice as many accidents/mile driven (0.085 accidents/10,000 miles) than drivers without SDB (0.046 accidents/10,000 miles) ($p = 0.14$), this difference was not statistically significant. Figure 1 shows that though accident frequency was about 100% higher in drivers with SDB, increasing severity of SDB was not significantly associated with an increase in accident frequency. Similar findings were obtained when we separately analyzed the relationship between SDB and company-reported accidents, and SDB and self-reported accidents.

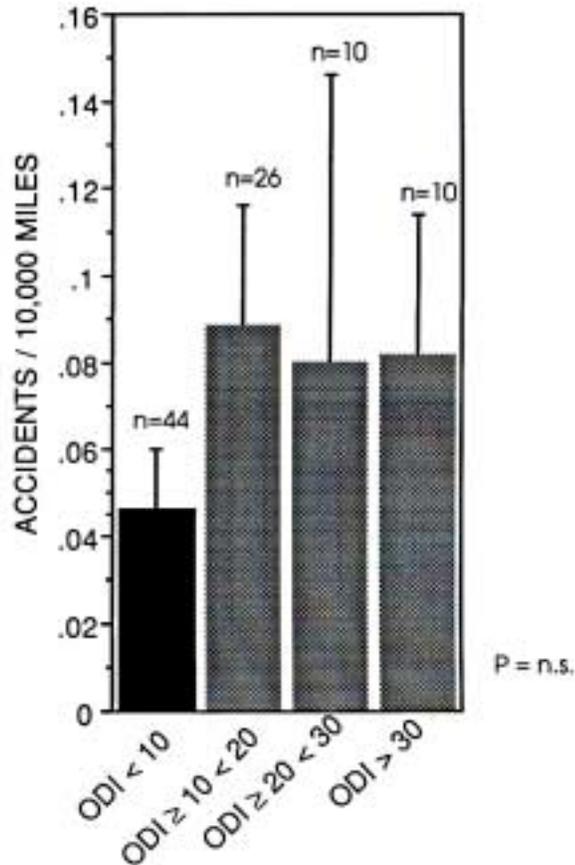


FIG. 1. Accident frequency by severity of sleep-related breathing disorder. The leftmost hatched bar represents the controls, whereas all other bars represent cases with sleep-disordered breathing. ODI, oxygen desaturation index (number of abnormal respiratory events associated with an oxygen desaturation $\geq 3\%$ per hour of sleep). The lines indicate standard error means.

Accidents and excessive daytime sleepiness

Evaluation of the different items from the questionnaire regarding complaints of daytime alertness and nocturnal sleep quality indicated a significantly higher accident frequency in drivers complaining of excessive daytime sleepiness (EDS) (0.18 accidents/10,000 miles) as opposed to drivers without a complaint of EDS (0.06 accidents/10,000 miles) ($p < 0.03$). Figure 2 compares the mean accident frequency of drivers with EDS to drivers without EDS. Using the scores for self-reported sleepiness, the isolated use of EDS as a predictive parameter for the occurrence of accidents had a sensitivity of 9% and a specificity of 92%.

Accidents and obesity

Because obesity has been reported to be associated with complaints of daytime sleepiness (13), we inves-

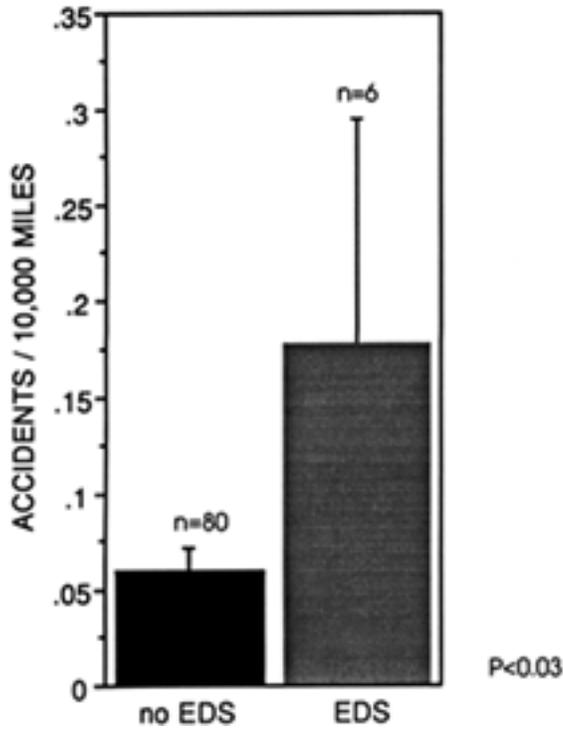


FIG. 2. Accident frequency by daytime sleepiness. The left bar represents all drivers without daytime sleepiness. The right bar represents all drivers with daytime sleepiness. EDS, excessive daytime sleepiness. The lines indicate standard error means.

tigated the relationship between excessive body mass and the occurrence of traffic accidents in our long-haul truck driver population. We classified drivers exceeding a body mass of ≥ 30 kg/m² as obese. Figure 3 shows the relationship between obesity and the mean number of traffic accidents in our commercial truck driver population. Nonobese drivers had a mean of 0.045 accidents/10,000 miles within the last 5 years compared to a mean of 0.1 accidents/10,000 miles ($p < 0.03$) within the last 5 years in obese truck drivers. Analysis of questionnaire items showed that obese truck drivers were significantly more sleepy than nonobese truck drivers. Obese truck drivers reported falling asleep unintentionally more often than nonobese truck drivers (mean of 2.76 ± 0.90 vs. 2.40 ± 0.82 on the 5-point scale in nonobese truck drivers; $p < 0.05$). Nonobese truck drivers without SDB caused 77% more traffic accidents/10,000 miles than nonobese drivers with nocturnal breathing abnormalities, but this difference, despite the trend, did not reach statistical significance. Obese truck drivers with SDB caused 45% more accidents/mile driven than obese drivers without SDB ($p = \text{ns}$).

Both drivers who reported three accidents within the

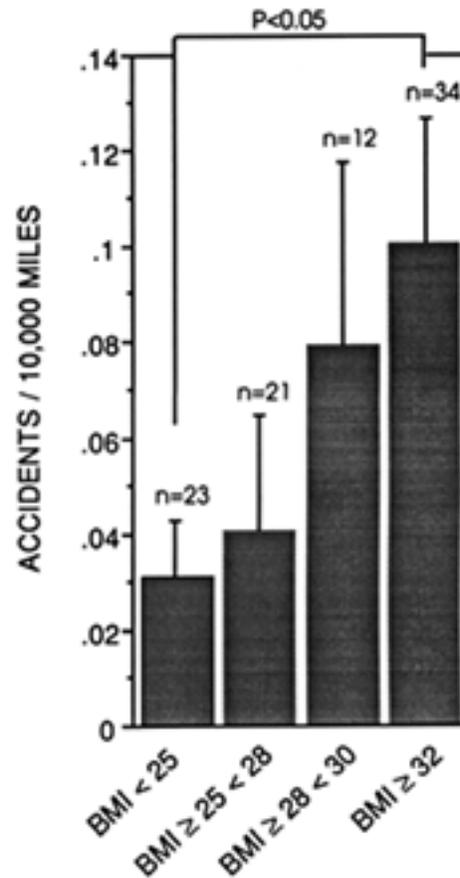


FIG. 3. Accident frequency by body mass index (BMI). The lines indicate standard error means.

last 5 years were obese (BMI = 36 and 37 kg/m²), and one of them had an ODI of 18 abnormal respiratory events per hour of sleep. The other presented an ODI of 8. Interestingly, both of them also reported one fatigue-related driving accident where they ran off the road.

Using the scores for obesity (≥ 30 kg/m²) as a predictor for driving accidents, we found that this predictor had a sensitivity of 49% and a specificity of 71%. When we combined the report of EDS and a BMI ≥ 30 kg/m², these two parameters had a sensitivity of 53% and a specificity of 68% in predicting drivers with accidents. The addition of the presence of SDB to these two parameters produced a sensitivity of 76% and a specificity of 35% in predicting drivers with accidents.

DISCUSSION

This investigation indicates that obese truck drivers have a significantly higher risk of causing driving ac-

Unfälle als nicht übergewichtige Lastwagenfahrer.

cidents than nonobese truck drivers. It appears that daytime sleepiness is one of the mechanisms that is involved in this increased accident frequency. SDB is a cause of daytime sleepiness, and SDB has been shown to be common in overweight individuals. However, there is not a complete congruency between SDB, obesity and driving accident frequency, although there was a clear trend of a higher accident frequency in truck drivers with SDB, who presented twice as many accidents per mile driven as drivers without SDB. These data on commercial long-haul truck drivers are similar to the findings of Findley et al., obtained from a much smaller sample of noncommercial drivers (4).

In the recent past it has been shown that obstructive sleep apnea syndrome is only the extreme end of the sleep-related breathing disorders that can induce daytime sleepiness. It has been shown that increased levels of daytime sleepiness can be related to increased upper airway resistance during sleep in the absence of apnea, hypopnea and recurrent hypoxia (14,15). One may hypothesize that some of the obese drivers did not fit the criteria for the diagnosis of obstructive sleep apnea syndrome but may have fit the criteria for the upper airway resistance syndrome (UARS) (14-17). These criteria include repetitive short arousals from sleep associated with an increase in respiratory effort in the absence of oxygen desaturation (15,16). Unfortunately, at this time there is no ambulatory system available that can recognize UARS. Only overnight polygraphic monitoring with quantification of respiratory effort will identify subjects with UARS. It is one of the limitations of the current ambulatory recording techniques used to detect SDB and a limitation of our study.

Independently of the possible presence or absence of UARS and associated daytime sleepiness in some of the obese truck drivers, this study confirms that a complaint of EDS is associated with more driving accidents per mile driven. We suggest that all commercial drivers should be educated about organic and behavioral causes of daytime sleepiness and their possible treatments. Thus, elimination of SDB could reduce driving accidents in professional drivers.

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