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Self-reported sleepiness while driving as a risk factor for traffic accidents in patients with obstructive sleep apnoea syndrome and in non-apnoeic snorers

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The obstructive sleep apnoea syndrome (OSAS) is a condition causing daytime sleepiness and has been related to an increased risk for traffic accidents. However, the evidence linking severity of OSAS to a higher rate of automobile crashes is based on limited data. The aims of this study were to study the traffic accident rate in the last 5 years in patients referred to our sleep clinic because of clinical suspicion of OSAS and to analyse variables related to an increased risk for traffic accidents. A series of 189 consecutive patients with a driving license referred for a sleep study because of OSAS clinical suspicion and a control group (CG) of 40 hospital staff workers who denied snoring, matched for age and sex with the study population, were studied. Patients underwent a full-night polysomnography and both patients and the CG completed a self-answered questionnaire. One hundred and twenty-two patients were diagnosed as OSAS and 67 patients as non-apnoeic snorers (NAS). The self-reported number of accidents was significantly higher in OSAS patients compared with CG. The self-reported number of times off the road was significantly higher in OSAS patients compared with NAS and with CG. Variables associated with an increased risk for traffic accidents were self-reported sleepiness while driving (OR 5, 95%CI 2·3–10·9), having quit driving because of sleepiness (OR 3, 95%CI 1·1–8·6) and being currently working (OR 2·8, 95%CI 1·1–7·7). We conclude that self-reported sleepiness while driving is associated with an increased risk for traffic accidents in OSAS patients and in NAS. We suggest that this symptom can be used to alert patients and to give priority in the sleep clinic for study and treatment.

Key words: sleep apnoea/hypopnoea syndrome; snoring; sleepiness; traffic accidents; self-answered questionnaire.

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Introduction

Automobile crashes are the third most important cause of death and injury in the U.S.A. (1) and the fifth in Spain (2). The number of crashes and severity of injury by distance driven are highest in young drivers (15–25 years) and in those over the age of 65 years (3). The two most recognized factors related to automobile crashes are speeding and alcohol (4), but inattentiveness, fatigue and sleepiness are primary or contributing factors (5). Sleep related vehicle accidents comprise about 16–23% of road accidents (6). Obstructive sleep apnoea syndrome (OSAS) is a disorder causing daytime sleepiness and is associated with an increased risk of automobile crashes. This has been shown in relatively small retrospective studies in the U.S.A. (7) and Canada (8), where the accident rates of patients with the disease were compared to rates in a control group of all the other drivers in the state. Patients with sleep apnoea had two to seven times the accident rate of controls and, in addition, approximately one third of patients with sleep apnoea were involved in an automobile crash over a 5 year period. The increased accident rate was retrospectively found in those newly diagnosed patients with the most severe disease (9). Objective measurements of driving performance using a driving simulator in patients with sleep apnoea have shown that performance of untreated subjects with severe sleep apnoea is worse than that of control subjects (10–12) and that it improves in patients treated with nasal continuous positive airway pressure (CPAP) and uvulo-palato-pharyngoplasty (11,13–15). Recently, in a case-control study, a strong association between sleep apnoea and the risk of traffic accidents was reported (16). These findings suggest that automobile crashes may be an important source of morbidity in patients with sleep apnoea and that many of these patients may be putting others at risk when they drive. To date no clinical or physiological predictors for traffic accidents have been found

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in OSAS patients. In addition, the prevalence of daytime sleepiness has been shown to be higher among snorers than non-snorers, and among women than in men (17).

The purpose of our study was to assess the prevalence of self-reported traffic accidents in a population of patients referred to a sleep study because of clinical suspicion of OSAS, and to analyse variables involved in an increased risk for having accidents while driving in these patients.

Methods

STUDY SUBJECTS

The study population consisted of 189 consecutive patients referred to the sleep clinic of our hospital because of OSAS clinical suspicion, with a driving license and who underwent polysomnography (PSG). Forty volunteers from the hospital staff workers matched for age with the study population and posessing a driving license were selected as the control group (CG), if they reported they were not snorers according to their partners opinion.

STUDY DESIGN

At the time of the PSG night, patients were asked to complete a self-answered questionnaire (Table 1). The possible answers to the questionnaire were either 'yes' or 'no'. The control group answered the same self-answered questionnaire as patients. The questionnaire included one question about the recalled number of traffic accidents and one question about the times off the road in the past 5 years. Driving records were not used to measure driving accidents because these are not available in our country, except for serious injuries (resulting in blood or death).

TABLE 1. Self-answered clinical questionnaire

1. What is your job?
2. Are you currently working or are you retired?
3. Do you do shift work?
4. How many hours do you sleep at night?
5. Do you snore?
6. Do you fall asleep when you are doing nothing or doing sedentary activities?
7. Do you fall asleep while performing any activity?
8. Do you fall asleep while you are working?
9. Do you drive a car usually?
10. Do you drive a car sporadically?
11. Do you fall asleep while driving?
12. Have you quit driving because of sleepiness?
13. Have you had any accident in the past 5 years?
14. How many accidents have you had in the past 5 years?
15. Were the accidents due to sleepiness?
16. Did you drive off the road anytime during the past 5 years?
17. How many times did you drive off the road in the past 5 years?

Methods

Patients were asked not to take alcohol the night when PSG was performed at the sleep laboratory. PSG included electroencephalographic (C4/A1, C3/A2, O2/A1, O1/A2), chin electromyographic and electro-oculographic recordings for sleep staging according to standard criteria (18). Arterial oxygen saturation (Sa_{O_2}) was measured continuously with a finger probe using a pulse oximeter (Ohmeda 3700, Boulder, CO, U.S.A). Rib cage and abdominal motion were monitored by strain gauges placed over the thorax and abdomen. Airflow was assessed using a thermistor. All signals were recorded continuously on a polygraph (Grass 8–18E, Quincy, Mass, U.S.A.). A trained technician scored respiratory events as apnoeas when there was a cessation of airflow lasting 10 sec or more, and as hypopnoeas when there was a 50% reduction of airflow, or in thoracoabdominal motion in association with an arousal, or with a $> 2\%$ Sa_{O_2} dip. An apnoea-hypopnoea index (AHI) of ≥ 10 was considered diagnostic of OSAS.

ANALYSIS OF DATA

Data were expressed as mean $\pm$ SD. Self-reported traffic accidents and number of times off the road during the previous 5 years were used for analysis. A descriptive analysis of the following variables was performed: age, sex, body mass index (BMI), daily alcohol consumption (g day^{-1}), number of accidents and times off the road in the previous 5 years, mean and nadir Sa_{O_2} and AHI. Patients answered yes or no to the items of the self-administered questionnaire (see Table 1). The statistical association between the explanatory variables was assessed by means of the χ^2-test in case of qualitative variables, while non-parametric tests for comparison of means and the correlation coefficient were used with quantitative variables. A multiple logistic regression analysis taking as a dependent variable having had at least one traffic accident or a drive off the road during the last 5 years, controlling for several covariates was performed. Variables were included in the multiple regression if a P-value $< 0{\cdot}25$ was obtained in an univariant analysis, performed between the variable having had or not had an accident or a drive off the road in the past 5 years and items of the self-answered questionnaire, age, sex, BMI, alcohol consumption and the AHI. After looking at frequencies distribution, age, BMI and alcohol intake were modelled as a categorical variables (<43, 44–48, 49–58 and >58 years for age, higher or lower than 30 kg m^{-2} for BMI and more or less than 19·2 g day^{-1} for alcohol intake).

In some analyses, the AHI was divided at 5, 10, 30 and 50 to create subgroups. CG were assumed to have an AHI $<$ 10. Different combinations of variables were tried and the logistic regression model with best goodness of fit was finally selected. All predictive models were developed applying a stepwise backward selection method. All statistical procedures were developed using the statistical package SPSS-PC.

TABLE 2. General characteristics and number of self-reported accidents/times off the road in the last 5 years in patients with OSAS, NAS and CG

	OSAS (122)	NAS (67)	CG (40)
Age	51±9	45±10 (*)	50±9
Sex (male)	124 (95%)	57 (85%)	37 (84%)
BMI ($kg\,m^{-2}$)	31±5 (#)	28±3·5	26±5
Alcohol ($g\,day^{-1}$)	14±20	8±10	14±14
Hours of sleep	7±2	7±3	6,9±3
Number of accidents last 5 years	0·6±0·7 (&)	0·3±0·5	0·07±0·3
Number of times off the road last 5 years	0·6±1·5 (#)	0·3±0·7	0·07±0·3
Percentage of subjects with at least one accident/drive off the road	34	22	12·5 (**)
Percentage of subjects with sleepiness while driving	47	34	5 (**)
Percentage of sleepiness related accidents	10 (#)	1·5	0

Results are expressed as mean±SD.
* Significant differences ($P<0\cdot0005$) between NAS and the other groups;
** significant differences ($P<0\cdot01$) between CG and the other groups;
# significant differences ($P<0\cdot0001$) between OSAS and the other groups;
significant differences ($P<0\cdot05$) between OSAS and CG. For abbreviation see text.

Results

According to the results of PSG, 122 patients were diagnosed as having OSAS (mean AHI 42·5±2) and 67 patients as non-apnoeic snorers (NAS) (mean AHI 3±3).

The self-answered questionnaire is shown in Table 1. General characteristics of patients, number of accidents and times off the road during the last 5 years are shown in Table 2. OSAS patients had a statistically significant higher number of traffic accidents compared with CG but not with NAS. However the number of times off the road was significantly increased in OSAS patients compared with the other groups. The percentage of patients reporting at least one accident or a fall-off the road in the last 5 years was significantly higher in OSAS and NAS compared with CG.

Self-reported sleepiness while driving was significantly more prevalent in OSAS (43%) and NAS (34%) compared with CG (5%). Accidents related to sleepiness were significantly more frequent in OSAS (9%) compared to NAS (1·5%) and CG (0%).

Taking as the dependent variable any accident/drive off the road, variables included in a first multiple regression analysis were: being or not currently working, driving usually, having quit driving due to sleepiness, work at risk for traffic accidents, sleepiness while driving, alcohol consumption ($g\,day^{-1}$), BMI, age, sex, sleepiness in passive and active situations, sleepiness at work and AHI. Table 3 shows that statistically significant variables associated with an increased risk for traffic accidents were: reporting sleepiness while driving (OR 5), having quit driving because of sleepiness (OR 3·05) and being currently working (OR 2·88).

A second multiple regression analysis, taking sleepiness while driving as the dependent variable, showed that the risk of experiencing sleepiness during driving was higher in OSAS patients and in NAS compared with CG (OR 20·4, 95% CI 4·6–91 and OR 9, 95% CI 1·9–41·5 respectively). Patients younger than 58 years were also more likely to have sleepiness during driving (<43 years OR 4·7, CI 1·8–11·7, 44–48 years OR 3·1, 95% CI 1·2–8, 49–58 years OR 2·2, 95% CI 0·9–5·7). Alcohol consumption higher than 19 $g\,day^{-1}$ was also associated to an increased risk for sleepiness during driving and was included in the final regression equation, although it was not statistically significant (OR 1·2, 95% CI 0·6–2·3).

TABLE 3. Variables associated with an increased traffic accident risk (only significant variables are shown)

	Adjusted OR	95% CI
Sleepiness while driving	5·05	2·3–10·9
Quit driving due to sleepiness	3·05	1·1–8·6
Currently working	2·88	1·1–8·6

Data are expressed as the adjusted odds ratio (OR) with the 95% confidence interval (95% CI). Goodness-of-fit test: $P=0\cdot9940$. All variables are significant with the likelihood ratio test.

When considering the whole population studied, comparison between subjects with and without self-reported sleepiness while driving is shown in Table 4. Subjects with sleepiness while driving were significantly younger, had a greater BMI, a greater alcohol intake, a significantly higher number of traffic accidents in the last 5 years and a higher AHI, but there were no differences in nadir or mean Sa_{O_2}, when compared with those without self-reported driving sleepiness.

TABLE 4. Clinical and polysomnographic data in patients with and without self-reported sleepiness while driving

	Somnolent drivers ($n = 82$)	Non-somnolent drivers ($n = 147$)	P-value
Age	47 ± 8	$50 \pm 10{\cdot}5$	$P < 0{\cdot}009$
BMI ($kg\,m^{-2}$)	$30{\cdot}6 \pm 6$	$28 \pm 4{\cdot}5$	$P < 0{\cdot}005$
Alcohol intake ($g\,day^{-1}$)	17 ± 22	$9{\cdot}5 \pm 14$	$P < 0{\cdot}02$
Number of accidents/drives of the road in the past 5 years	$1{\cdot}6 \pm 2$	$0{\cdot}2 \pm 0{\cdot}6$	$P < 0{\cdot}0001$
AHI*	36 ± 30	24 ± 25	$P < 0{\cdot}01$
Nadir Sao_2 (%)*	79 ± 11	81 ± 10	$P < 0{\cdot}06$
Mean Sao_2 (%)*	$89{\cdot}5 \pm 4{\cdot}4$	$91 \pm 3{\cdot}2$	$P < 0{\cdot}07$

*Only available in OSAS and NAS

Discussion

The results of our study show that patients with OSAS report a significantly higher number of accidents compared with CG, and a significantly higher number of times off the road while driving as compared with NAS and CG. Moreover, self-reported sleepiness while driving is, in our study, associated with a high risk for traffic accidents (OR 5); other significant variables associated with an increased risk are, in order of importance, having quit driving due to sleepiness and being currently working.

Although the association between OSAS and traffic accidents seems to be proved in the light of the recent literature, the evidence for a relationship between severity of OSAS and increased risk for accidents is based on limited data. A significantly higher rate of automobile crashes involving OSAS patients compared to a control group was found in two relatively small retrospective studies (7,8), and in larger populations (19–21). Findley *et al*. (9) found a significantly higher accident rate in the group with 'severe OSAS' as compared with all drivers in Virginia. However, possible confounding variables were not assessed in these studies, and in two of them OSAS was not confirmed by polysomnography in all patients (8,19). Recently, George *et al*. found, in a series of 460 OSAS patients, a higher accident rate in patients with AHI > 40 as compared with those with lower AHI or controls (22). Results from other investigators are more controversial. Aldrich (23), in a population referred to a sleep clinic, found a significantly higher accident rate in male patients with AHI > 60 compared with those with AHI < 60, but did not make the same finding in women. In a general truck driver population, Stoohs *et al*. (24) did not find differences in the accident rate between drivers with and without sleep disordered breathing. Moreover (23), accident frequency was significantly associated with excessive daytime sleepiness and obesity but not with increasing severity of sleep disordered breathing. Barbe *et al*. (25) reported an increased risk for automobile accidents (OR 2·3) in OSAS patients compared with controls, but they were unable to find clinical or physiological markers which could discriminate patients at risk for accidents.

To our knowledge, there are few studies (6,21,22,26) on large populations of patients with suspected OSAS that use a multiple regression analysis to assess the risk for vehicle accidents in which the diagnosis of OSAS was associated with an increased risk for accidents. Our study shows that self-reported sleepiness driving is strongly associated with traffic accidents. On the other hand, the risk for reporting sleepiness while driving is higher in OSAS and NAS compared with CG. Even if in our sleep laboratory we use a clinical cut-off of AHI ≥10 for the definition of OSAS, our data were also analysed under the cut-off of AHI > 5 and similar results were obtained.

Although according to some authors the prevalence of hyper-sleepiness does not vary according to age, in the general population, our study patients under 58 years showed an increased risk for sleepiness while driving.

In our study other variables involved in a high risk for traffic accidents are an active working status and having quit driving due to somnolence. We suggest the possibility that currently working people drive more, which can increase the chance of experiencing situations of sleepiness while driving and traffic accidents. It also seems logical that patients having had any accident and experiencing sleepiness driving decide to quit driving.

An issue raised by our results is the cause for the high proportion of NAS patients who referred sleepiness while driving. To our knowledge, this has not been reported previously but is consistent with published data on excessive daytime sleepiness in snorers without sleep apnoea. Ulfberg *et al*. (27) showed that the risk ratios for reporting excessive daytime sleepiness at work were four-fold for snorers in the general population, 20-fold for snoring patients and 40-fold for patients with OSAS as compared with non snoring men in the general population. Young *et al*. (17) showed that both usual snorers and subjects with apnoea-hypopnoea scores > 5 were significantly more likely to have hyper-sleepiness compared with non-snorers. They showed that the OR for having any motor vehicle accident was 3·4 (for snoring men with AHI > 15) and 4·2 (for AHI > 5) compared with non-snorers in the general population (26). Interestingly, they also found that habitual snorers with AHI < 5 had an 1·5 increased risk compared with non-snorers.

As far as we know, our study is the first to show a strong association between self-perception of sleepiness while driving and the risk of traffic accidents. Teran *et al.* (16) found that those subjects taken to hospital because of a traffic accident and controls had similar mean scores on the Epworth Sleepiness Scale. Several reasons might explain why other authors have not found an association between sleepiness measures and accident risk. Perception of sleepiness may be different between a general population and a population referred to a sleep clinic. The specific questions addressing sleepiness are also different between studies. In Young's study (26), questions addressing excessive daytime sleepiness were coded as positive if a frequency of often (at least 5 per month) was reported. In our questionnaire all possible answers were either yes or no and this could explain the high proportion of patients answering yes. Another possible explanation, which we cannot exclude from our analysis, is that a proportion of NAS patients might suffer from upper airways resistance syndrome (28).

Alcohol intake higher than19 g day^{-1} was included in the logistic regression equation as a risk factor for sleepiness while driving, although it did not show statistical significance (95% CI 0·6–2·3).

The main limitations of our study are the lack of objective data about traffic accidents and the selection of controls. We used a self-administered questionnaire and not state records, due to the lack of this information in our country, so data were merely subjective and depended on the recalling capacity of patients. However, it could be argued against information obtained from state records that trivial accidents and one-car crashes might be missed, in drivers with a bad driving record fearing insurance problems or legal repercussions. In fact, our patients reported a number of times off the road which can be considered as near missed accidents and which would have not been considered if relying on state or insurance companies recordings. Controls were also selected if the partner's told them they did not snore usually, but this was not objectively assessed by PSG. However, in most studies in the literature, controls are selected on a subjective basis.

At the present time, driving risk in OSAS patients is considered elevated by the presence of moderate and severe sleepiness, as based upon historic information from the patient or an informed observer, of which the strongest evidence is a history of a previous motor vehicle crash. There is no reliable objective test that is predictive of increased driving risk or that would indicate that, after treatment, driving risk has been reduced to an acceptable level (29).

We conclude that, in a population referred for OSAS suspicion, self-reported sleepiness while driving is strongly predictive of a traffic accident/fall off the road. This symptom provides a simple clinical tool in order to alert patients of the risks of the untreated disease and to give priority in the sleep clinic for study and treatment.

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