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PROGRAMME ACTIONS CONCERTÉES

Devrait-on cibler tous les individus souffrant d'apnée du sommeil comme étant des conducteurs à risque élevé : Un profil de risque comportemental et psychologique

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BACKGROUND

1. Problem

Sleep apnea is a serious disorder that occurs when a person's flow of breathing is repeatedly interrupted or reduced during sleep, leading to intermittent drops in blood oxygen saturation. It is a common and often unrecognized disorder, affecting up to 10% of the middle-aged population and potentially 40 to 60% of adults over aged 60 (Peppard, 2013; Jennum, 2009; Young, 2004).

When an apnea event is prolonged, the effort to restore breathing causes cortical arousal and consequent disruption of the sleep architecture. Because sleep apnea causes both hypoxia and sleep disruption, its impact is widespread, affecting multiple organs and regulatory systems. Symptoms of the disorder include cognitive dysfunction, extreme daytime sleepiness, depression, anxiety, and memory problems (Akashiba, 2002; Harris, 2009; Macey, 2010; Bucks, 2013). Untreated sleep apnea can lead to high blood pressure, stroke, heart failure, diabetes, depression among other serious health issues (Coughlin, 2004; Peled, 2007; Lyons, 2015; Broussard, 2012; Punjabi N., 2009; Vgontzas, 2005; WHO/IDF, 2006).

Much of the research literature assessing motor vehicle accident risk focuses on the experience of “sleepiness at the wheel” as a key reason for highway accidents and fatal crashes. Many studies have examined endogenous factors that affect the physiological state of the individual and are associated with fluctuations of alertness. For example, it has been shown that in healthy normal individuals, one night of sleep deprivation produces excessive sleepiness, and two nights lead to sleepiness in the pathological range (Vandongen, 2003). Even 4 hours of sleep loss can produce comparable sedation and reduce performance to levels equal to legal intoxication (Roehrs, 2000). One of the most important functional outcomes associated with sleepiness is the occurrence of motor vehicle accidents (Lyznicki, 1998); higher rates of off-road incidents and lane deviations following sleep deprivation have also been confirmed in experimental driving in actual highway traffic (Philip, 2005).

Individuals with sleep apnea have commonly been involved in demonstrating the sleepiness/risk association; sleep apnea patients are expected to experience daytime sleepiness or drowsiness behind the wheel as one of their main problems. However, recent studies have indicated that the relationship between sleep apnea, sleepiness and driving risk is complex and often inconsistent with prevailing beliefs. Ward and colleagues aimed to determine whether the risk of motor vehicle car crashes was higher in patients with sleep apnea than in the general community and, if so, understand the nature of the risk (Ward, 2013). The researchers addressed relationships of near-misses and motor vehicle car crashes with sleep apnea severity, degree of daytime sleepiness, and other potential risk factors in a sleep clinic population using polysomnography, driving simulation and questionnaires. Results showed that: 1) subjects with untreated sleep apnea (AHI > 5 events per hour) reported crashes at a rate three times higher than the general population; 2) 11% of subjects reported having a crash because they felt sleepy or fell asleep behind the wheel; 3) a quarter of subjects (26%) reported at least one near-miss due to sleepiness; and 4) 32% reported having fallen asleep behind the wheel. What's more, a strong association between sleepiness and increased rate of reported near-misses was found.

On the other hand, a recent finding demonstrated that there was considerable inter-individual variation in daytime sleepiness and neurobehavioral impairment among sleep apnea patients (Vakulin, 2014). The study found that sleep apnea participants and controls showed significantly different outcomes on psychomotor vigilance tests (mean auditory reaction time test, lapse frequency test) and that driving simulator performance varied widely among patients with sleep apnea: 60% of sleep apnea patients showed trait-like *resistance* to simulator performance impairment when stressed with sleep restriction or alcohol. In addition, sleep apnea patients were able to sustain attention and steer normally to avoid crashes during a 90-minute country drive. The investigators also reported that impairment was not explained by clinical measures of sleep apnea (i.e. AHI, hypoxemia, frequency of arousals), that many sleep apnea patients reported little to no daytime sleepiness, and that many sleep apnea patients had driven without incident. The study also showed that some patients with mild sleep apnea were severely affected by sleepiness.

Recent evidence shows not only that many individuals with sleep apnea are not sleepy, but also that fatigue is another very common symptom associated with sleep apnea (Hossain, 2002). In 2008, our group identified four subgroups among individuals with sleep apnea characterized by combinations of high and low levels of daytime fatigue and daytime sleepiness. Of particular interest are those individuals who experienced high fatigue scores, with and without high sleepiness scores. This configuration was associated with the most negative consequences for daytime performance, such as problematic perceived health-related and psychological functioning (Bailes, et al., 2008). Of equal interest was the substantial number of individuals with relatively low daytime sleepiness and fatigue scores below clinical cut-offs who, despite an unmistakable sleep apnea diagnosis, appeared not to complain of diminished functioning or quality of life, and to be similar to individuals in a healthy comparison group (Bailes, et al., 2011).

Another research stream has focused on exogenous, task-induced factors that interact with endogenous characteristics to produce drowsiness and diminish driving performance. For example, time-on-task and time-of-day effects have been associated with fatigue and deterioration of driving performance (Pack, 1994; Smiley, 1998; Thiffault, 2003). Similarly, the impact of a monotonous, undemanding road environment on driver fatigue and driving errors has been demonstrated in driving simulation studies in which the road environment could be varied (e.g., Thiffault & Bergeron, 2003).

Specific Aims

The literature indicates that diminished daytime functioning is not related to sleepiness in isolation, but that fatigue, sleep duration and age also play significant roles (Bailes, et al., 2006; Norman, 2008; Sforza, 2010; Vandongen, 2003; Ward, Hillman, James, & Brenmer, 2013). Even in a sample of individuals with sleep apnea, who are traditionally characterized as fundamentally sleepy and, therefore, at high risk for impaired daytime performance, a substantial proportion have no sleepiness or fatigue complaints (Tregear, 2010; Bailes, et al., 2011; Thiffault & Bergeron, 2003; Thiffault P. B., 2003; Smiley, 1998). Therefore, the present study was designed to answer the following questions:

1. Can individuals with sleep apnea be differentiated from individuals without sleep apnea with respect to their driving behaviours?
2. What variables are correlated with driving behaviours?
3. What is the role of sleepiness and fatigue in relation to driving behaviours?
4. Does treatment for individuals with sleep apnea make a difference in driving behaviours of individuals with sleep apnea?

RESEARCH DESIGN AND METHODS

We recruited 44 individuals, newly diagnosed with sleep apnea (Apnea Group), between the ages of 25 and 65. We selected adults under the age of 65 in order to avoid the many health conditions that are more prevalent in the over 65 age group. This sample was recruited at one of the two sleep clinics in Montreal with whom we have been collaborating in past and ongoing research (Mount Sinai Hospital, OSR Medical). A comparison sample of 44 individuals, matched for age, with no complaints of sleep problems (Control Group) was recruited from the community through media advertisements. We evaluated all participants at baseline (T1) and the Apnea group again after 6 months (T2). We studied a subset of 18 individuals in each of the Apnea and Control groups with a questionnaire battery, SAAQ accident records, and a laboratory driving simulation test. The remaining 26 participants in each group did not do the laboratory driving simulation test.

Participants with sleep apnea were made aware of the study by their sleep specialist at their follow-up appointment after their polysomnography sleep study. They were asked for consent to have a member of the research team contact them to explain the study and request their participation. Control participants contacted the researchers directly for information about the study. The protocol was approved by the McGill University and the Université de Montréal Research Ethics Boards as well as by the SAAQ and the Research Ethics Board of the Mount Sinai Hospital and the Jewish General Hospital. Potential participants were informed of all aspects of the study, and screened for eligibility. Exclusion criteria were: inability to function in English or French, not having a valid driving license for the past two years, severe or acute medical or psychiatric condition or cardiovascular disease with end-organ effects (e.g., heart attack, stroke, and congestive heart failure). To rule out the presence of sleep apnea, Control group participants were administered the 7 item Sleep Disorder subscale of the Sleep Symptom Checklist (SSC), and a random subset were tested with the *Braebon Medybite* home monitoring device to rule out the presence of sleep apnea (Bailes, et al., 2008).

Time 1 (T1).

Step 1: Prior to sending participants to the Driving Simulation Laboratory, a pilot study was carried out (by team member Jacques Bergeron) with a separate sample of 16 individuals in order to (a) develop and validate a measure of the frequency and extent of deviations from a prescribed trajectory and (b) validate a monotonous simulation task (an 88 Km drive on a two-way rural road with simple and repetitive environments).

Step 2: All potential participants were sent two copies of the information and consent form, a questionnaire package, and a self-addressed stamped envelope to return completed materials to our laboratory.

Step 3: When sleep apnea is diagnosed, the usual treatment offered is continuous positive airway treatment (CPAP). Once prescribed, it usually takes several weeks to meet with a sleep medicine technician to choose a device that suits the patient. This time interval allowed us to complete all assessments at T1 for the sleep apnea group before CPAP treatment was begun.

Step 4: As the completed questionnaires were returned, participants with sleep apnea and the "matched" Control participants without sleep apnea (those who consented to allow us to obtain their 5 year accident record from the SAAQ, and who agreed to participate in a driving simulator assessment), were given an appointment at the Driving Simulation Laboratory at the Université de Montréal, under the direction of Dr Bergeron. Driving performance tests were scheduled at 2:00 PM or 3:30PM, a time period associated with a peak for daytime sleep-related accidents.

Time 2 (T2).

In the 6 month period between T1 and T2, sleep apnea patients were followed with "usual medical care." After 6 months (T2), the Apnea group was re-tested: (1) they completed the questionnaire package, and (2) had their SAAQ accident records for the previous 6 months reviewed. (3) Participants with sleep apnea had their adherence to the CPAP treatment evaluated with an open-ended questionnaire. Thirty-four percent did not adhere to CPAP intervention. Participants with sleep apnea who, at T1 had completed the driving simulator test were re-evaluated on the driving simulator.

Measures

Our measures sampled: sleep and sleep disorder, sleepiness, fatigue, psychological adjustment, health-related quality of life, and driving behaviours. (See MEASURES in ANNEX)

RESULTS AND INTERPRETATIONS

We evaluated driving behaviour/performance using 4 measures:

- Actual driving infractions obtained from official SAAQ driving records: we collected data on driving infractions committed 5 years prior to recruitment and for the 6 month period between Time 1 (T1) and Time 2 (T2). Data was coded according to type of infraction using a list of 32 types of infractions provided by the SAAQ;
- Self-reported infractions obtained with the Infractions Checklist where participants are asked to report the frequency of the 32 different types of infractions listed by the SAAQ;
- The Driving Behavior Questionnaire and its 4 subscales (ordinary infractions, aggressive driving, errors, and lapses): participants are asked to rate the frequency in which they commit behaviors related to their driving habits. The items are then grouped into subscales validated in previous studies; and
- The driving simulator: participants are asked to perform a monotonous 88 Km drive on a two-way rural road with simple and repetitive environments. The variables used to measure driving performance are: general road position, deviation of lateral position, deviation of speed.

Question 1: Can individuals with sleep apnea be differentiated from individuals without sleep apnea with respect to their driving behaviours?

Actual infractions (data derived from the SAAQ)

Statistics obtained from the SAAQ at Time 1 revealed that our sample of individuals with sleep apnea had a total of 34 actual driving infractions (mean=1.17, SD=1.36) registered in their official records within the 5 years preceding their sleep apnea diagnosis. 14 participants with sleep apnea did not have any registered infractions. For the Control group, there was a total of 20 actual driving infractions (mean=.69, SD=1.17) registered in their official records, within the 5 years preceding their enrollment into this study. 19 control participants did not have any registered infractions. Within the sleep apnea group, 51.72% of individuals had at least 1 actual driving infraction. In the Control group, 34.48% had at least 1 actual driving infraction. Approximately half of the actual driving infractions were related to speeding for both groups (Figure 1 in the Appendix).

Furthermore, there were a total of 8 accidents registered for the entire sample: 7 accidents involved participants with sleep apnea, and 1 accident involved a Control participant; none were fatal or serious (see Table 1 in the Appendix).

It is to be noted that there were not enough actual driving accidents to be statistically analyzed in either the sleep apnea or the Control group. Also to be noted**,** there were no statistical differences on frequency of driving infractions between the sleep apnea and Control groups.

Self-reported driving infractions: actual infractions items used by the SAAQ in self-report format: (see Infractions Checklist measure in Annex)

Self-reported infractions revealed that this sample of individuals with sleep apnea reported a total of 245 driving infractions within the 5 years preceding their sleep apnea diagnosis. 2 participants with sleep apnea did not report any infractions. For the group without sleep apnea, there were a total of 253 self-reported driving infractions within the 5 years preceding their enrollment into this study. All participants without sleep apnea reported at least 1 infraction.

Analyses on the Infractions Checklist subscales revealed that:

- *Control group participants (i.e., without sleep apnea) had significantly higher self-reported infractions* related to "failing to stop" than participants with sleep apnea.
- *No differences* between groups were found for speeding, dangerous driving or overtaking (Figure 2).
- In general, individuals with sleep apnea did not report more driving infractions than individuals without sleep apnea.

Driving Behaviors Questionnaire (DBQ: see measure in Annex)

Results indicate *no* significant differences between groups on either the DBQ total score or on any of the 4 subscales.

Driving simulation: (see measure in Annex)

There were *no overall differences* between the sleep apnea and the control groups.

Possible considerations, impacts and implications of findings on policy-making:

Our various statistical comparisons consistently showed that, unlike some previous research findings, individuals with sleep apnea did not commit more driving violations than participants without sleep apnea.

Question 2: What variables are correlated with driving behaviours?

For individuals with sleep apnea, self-reported infractions were significantly correlated with total nocturnal sleep time, daytime sleepiness, psychological adjustment and to four poorer health-related quality of life measures: role limitations due to physical health, general health perceptions, vitality and role limitations due to emotional problems. Aggressive driving was also significantly correlated with physical functioning.

For Control participants, similar to the group with apnea, self-reported infractions were correlated with physical health-related quality of life and, unlike the group with apnea, to age.

None of these variables correlated with driving performance as measured by the driving simulator, neither in sleep apnea participants nor in participants without sleep apnea.

Possible considerations, impacts and implications of findings on policy-making:

Our results suggest that there is no constellation of age, sleep-related, sleepiness, fatigue, psychological, or quality of life aspects that differentiate individuals with sleep apnea at high risk for driving infractions from those at low risk.

Question 3: What is the role of sleepiness and fatigue in relation to driving behaviours?

Our past research has demonstrated that existing measures of sleepiness and fatigue are typically confounded. In order to distinguish between high and low sleepiness and fatigue, we developed the Empirical Sleepiness and Fatigue scale which attempts to identify sleepiness and fatigue as independent constructs.

To answer Question 3 we split individuals with apnea into high or low categories for sleepiness and fatigue and compared them to Control participants on driving infractions and driving behaviors. Results show that there were no significant differences on driving infractions and driving behaviours between high sleepy and low sleepy individuals with or without apnea. We also split the individuals with apnea into high or low fatigue categories, and again found no significant differences on driving infractions and driving behaviours.

We also explored whether sleepiness or fatigue was related to any driving variable, regardless of the presence of a sleep apnea diagnosis. There were no significant findings on these analyses.

Finally, we examined actual driving performance on the driving simulator task. Our analyses indicated a general effect of the fatigue variable only after about 40 minutes of driving on the simulator: a significant deterioration of position on the road was evident in the majority of participants who had high scores on the fatigue scale. Thereafter, that is after about 40 minutes, only the performance of participants with sleep apnea together with high scores on the fatigue scale deteriorated significantly on the deviation of the lateral position (see Figure 3). The latter measure is the traditional and most reliable indicator of decreased alertness in driving. Other results were not significant.

In summary, fatigue had an important effect on simulator driving; participants with and without apnea deteriorated on some aspects of driving performance after 40 minutes of driving. This effect was more pronounced in individuals with sleep apnea only after an extended time driving a monotonous route in the afternoon "dip" time period.

Possible considerations, impacts and implications of findings on policy-making:

This analysis demonstrated that when sleepiness and fatigue are identified as separate constructs, fatigue is related to risky driving for individuals both with and without sleep apnea. The fatigue effect is rarely taken into account in studies of driving risk. This is largely due to measures which confound both the sleepiness and fatigue constructs, and the fact that the two are frequently experienced at the same time.

The findings also indicate that pre-existing fatigue, not sleepiness, has a significant adverse relation with driving performance after about 40 minutes of driving for individuals with and without sleep apnea; this effect is compounded for individuals with sleep apnea when driving time is extended on a monotonous route.

Question 4: Does treatment for individuals with sleep apnea make a difference in driving behaviours of individuals with sleep apnea?

Individuals diagnosed with sleep apnea, whether they were adherent to CPAP treatment or not, reported fewer self-reported infractions, less aggressive driving, fewer errors while driving and less fatigue 6 months after they were diagnosed. There was no such time effect for sleepiness.

Possible considerations, impacts and implications of findings on policy-making:

Six months after diagnosis, there appeared to be a non-specific positive effect on driving behaviours for individuals with sleep apnea. Possibly the simple knowledge of having a sleep disorder makes the individual more careful when driving. It is also possible that some individuals, even if they do not adhere to prescribed CPAP treatment, still employ other measures that help alleviate their symptoms.

MAIN ACHIEVEMENTS

1. Numerous studies in the literature and prevailing belief in general characterize people diagnosed with sleep apnea (sleep apnea) as uniformly sleepy and inherently risky drivers. Results of our investigation clearly show that

   (a) A large percentage of people with sleep apnea do *not* experience excessive daytime sleepiness

   (b) Sleepiness in individuals with or without sleep apnea is not consistently related to driving infractions and accidents.

2. Our findings demonstrated that individuals with sleep apnea did not commit more driving violations than participants without sleep apnea.
3. We found no significant differences on driving infractions and driving behaviours between very sleepy and minimally sleepy individuals with or without sleep apnea.
4. In the present investigation, we were able to show that fatigue plays an equal, sometimes more, important role in driving behaviours and performance.

5. In an analog driving task (driving simulator, 66 minutes, monotonous circuit) we demonstrated that fatigue, not sleepiness, was related to deterioration of driving performance in both individuals with and without sleep apnea. The fatigue effect was enhanced for individuals with sleep apnea, but only in the latter part of this relatively lengthy and monotonous driving task.

6. Somewhat unexpectedly, when re-evaluated 6 months later, individuals who were diagnosed with sleep apnea improved in their driving behaviours, whether they had adhered to their prescribed treatment (CPAP) or not. This might reflect

a non-specific enhanced vigilance by virtue of the knowledge that they had a sleep disorder. Perhaps some of these individuals may have tried some non-prescribed treatment measures (e.g. weight loss, changing their sleep position). We cannot really interpret this finding because we have no comparable test-retest data for the Control group without apnea.

CONCLUSIONS, CONTRIBUTIONS & SOLUTIONS

There were *no* statistical differences in frequency of driving infractions, actual or self-reported, between people with sleep apnea and those without. There was considerable variability among individuals with sleep apnea, and we were unable to identify a risk profile in our sample. Although other research has implicated problematic daytime sleepiness in increased crash risk, and individuals with sleep apnea have commonly been designated as prototypically sleepy, the majority of people with sleep apnea in our sample had not been involved in a motor vehicle crash in the past 5 years.

Sleepiness in this group was not consistently related to driving infractions and accidents, nor to actual driving performance on the driving simulator. There was, however, evidence that fatigue played a role in driving errors in the simulator situation for everyone after about 40 minutes; fatigued people with apnea committed somewhat more frequent errors in the latter segment of the lengthy driving task. This supports the rationale for advising frequent rest stops during lengthy highway driving (possibly such highway signage should be increased). People with sleep apnea should be made aware of their particular sensitivity to the effects of fatigue on long distance driving.

In our study, when people with sleep apnea were re-tested 6 months after being diagnosed, they improved, although minimally, in some aspects of their reported driving behaviours and on fatigue, whether they had adhered to prescribed CPAP treatment or not.

Our findings imply that directives for physicians to remove driving privileges because of sleep apnea that exist in some regions are of very questionable validity. The most recent document from experts in Québec leaves the decision to the individual patient-doctor interaction (Mayer, 2010), underlining the importance of transfer of information about our findings to the medical community. It is also important to distribute informational materials to Québec police services, to schools for driver education across the province, as well as to companies involved in commercial driving.

RESEARCH TRACKS

A number of our analyses indicated that it is fatigue rather than sleepiness that is related to risky driving for both people with sleep apnea and without. Sleepiness is the more easily defined construct, mainly encompassed by the concept of sleep propensity. Fatigue is much more complex and diverse. It is commonly thought of as lack of vitality and exhaustion, but the construct is closely linked to daytime, physical and psychological functioning, as well as quality of life aspects. More research is needed to understand how the particular aspects of fatigue are related to driving behaviours and performance both in general and in people with apnea in particular.

Aspects of sleepiness and fatigue should be evaluated in driving risk; however, given the nature and importance of the fatigue construct, psychological, physical and daytime functioning, which are related to fatigue, should be taken into account as well.

It appears that individuals with sleep apnea have been generally unfairly targeted as risky drivers. In the process of investigating the validity of this belief, it became clear that the range of impaired driving performance and behaviours is equally evident in individuals without apnea. Evaluations of driving quality must go beyond actual infractions and look at self-reported infractions as well. In addition, self-report measures of driving behaviours allow an indication of driving style that is more indicative of risky driving than episodes for which the individual was "caught".

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ANNEX 1

MEASURES

Objective Sleep Measures

Polysomnography (PSG). The three sleep laboratories are certified by the American Academy of Sleep Medicine and use standardized methods of evaluation. We will obtain the following information from the participants' polysomnography record: basal oxygen saturation (SpO2%), respiratory distress index (RDI), and apnea hypopnea index (AHI).

CPAP treatment adherence will be measured as the average duration of machine use, as well as % of nights used, taken from the microprocessor chip output on the patient's machine. These will be recorded at T2 with the sleep lab CPAP home care provider.

Self-Report Measures

Demographics: Background Information Form. This measure evaluates sex, age, marital status, living, conditions, etc. It has been used by our research team in most of our studies (e.g. 16, 17).

Sleep Symptom Checklist (SSC).[16] The SSC is a 21 item survey of a broad range of symptoms that are both directly and indirectly related to sleep disorders. It is easily completed by older patients. Participants rate each symptom for its severity from 0 (not at all) to 3 (very severe) based on the previous month. Temporal stability of the severity ratings was found to be acceptable (total score $r = 0.79$, $p < .01$). Cronbach's alpha was 0.74. Factor analysis yielded four distinct subscales: Insomnia, Daytime Distress, Sleep Disorder, and Psychological Maladjustment.

Sleep Questionnaire. This brief retrospective measure inquires about usual sleep experiences during the past typical month, including Non-Refreshing Sleep, Sleep Quality, Time in Bed, Total Sleep Time [TST), Sleep Onset Latency (SOL), and Wake After Sleep Onset (WASO) during a typical week in the past month. It also asks about frequency (07 days/week) of non-refreshing sleep, difficulty falling asleep and getting back to sleep after nocturnal awakenings. The information provided allows us to diagnose the presence or absence of difficulty initiating or maintaining sleep (DIMS) in accordance with typically used research criteria (i.e., complaint of insomnia, at least 31 minutes of undesired awake time at least 3 times per week with a problem duration of at least 6 months. In accordance with established practice, self report rather than PSG will be used to diagnose insomnia. The Sleep Questionnaire has been validated in both English and French in our research. For example, data indicate good test-retest reliability: r values range from .58 to .92 for intervals ranging from 2 weeks to 15 months. High correlations between equivalent scores on this measure and on the Sleep Diary were also found (e.g., $r = .83$, .64, and .69 for TST, SOL, and WASO, respectively.

***Sleepiness and fatigue: Empirical Sleepiness and Fatigue Scales*.** Since existing scales measuring fatigue and sleepiness confounded the two concepts, the Empirical Sleepiness and Fatigue Scales were developed by our team[16] through correlation and factor analysis of all items from four popular measures purporting to measure sleepiness and fatigue: Stanford Sleepiness Scale, Epworth Sleepiness Scale, Fatigue Severity Scale, and the Chalder Fatigue Scale. The Empirical Sleepiness Scale consists of 6 items from the Epworth Sleepiness Scale (items are scored on a 4-point scale, with a minimum total score of 0 and a maximum score of 18. Higher scores indicate greater sleepiness or sleep propensity. The Empirical Fatigue Scale consists of 1 item from the Fatigue Severity Scale and 2 from the Chalder Fatigue Scale; scoring uses a 6-point Likert scale (1 = strongly disagree, 6 = strongly agree), with a minimum score of 3 and a maximum score of 18. Higher scores indicate greater fatigue or diminished energy. The two Empirical Scales represent different constructs that were found to have distinctive patterns of associations and were only minimally correlated with each other in three different samples (r ranged from .06 to .33). Analyses reported by the Scales' authors indicate good test-retest reliability over two different four hour periods for both the Sleepiness (r = .69, and .88) and the Fatigue (r = .87, and .91) Empirical Scales. Internal consistency was also good, with Cronbach's alpha scores for the Empirical Sleepiness Scale ranging from .92 to .95 and those for the Empirical Fatigue Scale ranging from .74 to .86. Extensive validity information is provided by the authors of the Scales for two samples; this shows that the two measures are logically related to a large number of criterion variables. Higher scores indicate greater sleepiness or fatigue.

Epworth Sleepiness Scale. This brief self-administered retrospective questionnaire of the behavioral aspects of sleepiness was constructed by Johns (Johns MW. A new method for measuring daytime sleepiness (Johns, 1991) to evaluate self-reports of sleep tendency. Participants rate how likely they are to doze off or fall asleep in eight different situations commonly encountered in daily life on a four-point scale (0=never doze off, 3=high chance of dozing). Scores are summed and vary from 0 to 24. This measure has high 5-month test–retest reliability in normals (r =.82), as well as high internal consistency (Cronbach's a=.88). This measure will be administered because it is the most commonly used test in studies of sleep apnea.

Depression: Beck Depression Inventory (BDI-II): Primary Care Subscale (PC). The 7 item PC Subscale of the BDI-II will be used to evaluate the affective and cognitive symptoms of depression independent of fatigue, sleepiness, insomnia and agitation. Beck et al. report that the test-retest reliability for the PC Subscale is .82, while its internal consistency is .86. Items are scored on a 4-point scale (03). Scores are summed and produce a range from 0 to 21. Higher scores indicate greater depression. The PCI Subscale has no questions that inquire about non-refreshing sleep and, as a result, it measures distinct domains unique to depression.

Anxiety: Spielberger State Trait Anxiety Inventory Form Y2 (STAI). This frequently used measure consists of two separate 20item self-report scales for measuring trait and state anxiety. In the present investigation only trait anxiety will be evaluated. The trait measure asks people to describe how they generally feel on 4-point Likerttype scales (1 = almost never, 4 = almost always). Scores range from 20 to 80. The Inventory's authors report a mean of 35 (SD = 9) for a normative sample of adults. Higher scores indicate greater anxiety. Psychometric properties of this scale have been shown to be excellent with test-retest reliability data, based on student samples, ranging from .65 to .86, and internal consistency indicating a median alpha coefficient of .91 for a working adult sample.

Quality of Life: SF-36 Health Survey. This popular 36-item measure will be used to assess quality of life in eight health domains: (1) limitations in physical activities because of health problems; (2) limitations in social activities because of physical or emotional problems; (3) limitations in usual role activities because of physical health problems; (4) bodily pain; (5) general mental health (psychological distress and well-being); (6) limitations in usual role activities because of emotional problems; (7) vitality (energy and fatigue); and (8) general health perceptions. Ware et al. report reliability data based on both patient and non-patient samples. Reliability of the subscales ranged from .64 to .96. The SF-36 has demonstrable validity in that the subscales were found to correlate with ability to work, utilization of health services, as well as other mental health and quality of life measures. Low scores on all subscales indicate disability due to illness; high scores indicate better functioning due to relatively good health.

Driving Performance Measures

Driving Simulator. The Université de Montréal simulator is one of the best in Canada thanks to funds granted by the Ministry of Transportation of Quebec, SAAQ, Transport Canada and the AUTO21 Centre of Excellence. It is a fixed-based driving simulator composed of a complete automobile, fully functional pedals and dashboard, and a large screen showing highway images projected by a high resolution projector. Simulated highways have been designed using actual Canadian geometric route design standards. The images are generated by an IBM compatible computer. During a simulation test, the location of the pedals and the location and speed of the vehicle on the *x*, *y* and *z* axes are recorded. A potentiometer attached to the steering column allows detailed recording of steering wheel movements (SWM).

Manchester Driver Behavior Questionnaire (DBQ). This is a self-report questionnaire assessing driving incidents (i.e., errors and violations) used to measure driver behaviors. Participants are asked to indicate how often they commit each of 28 behaviors on a six-point scale (0 = never; 5 = nearly all the time).

Infractions Checklist. This is a self-report questionnaire used to compare self-reported driving infractions with actual driving infractions from their SAAQ driving records. Participants are asked to indicate how often they commit each of the infractions on the official SAAQ infractions list on a six-point scale (0 = never; 5 = nearly all the time).

SAAQ accident reports. Frequency of accidents associated with costs of $500 and over, injury, and police reports will be recorded for each participant.

ANNEX 2

TABLES

Table 1

Distribution of types of accidents, OSA and Control groups

Type of accident	OSA group	Control group
Fatal accidents	0	0
Serious accidents	0	0
Mild accidents	2	1
Accidents causing material dammage only	5	0

Table 2

Factor Loadings of 7 Emprirical Sleepiness and Fatigue Scale items

Questionnaire Item/ Factor Label	Solitary (Sleepiness scale)	Fatigue	Social (Sleepiness scale)
Sitting and reading	0.992		
Watching TV	0.645		
As a passenger in a car for an hour when circumstances permit	0.555		
I lacked energy		0.904	
I started things without difficulty but got weak as i went on		0.727	
Exercise brought on my fatigue		0.398	
Number of infractions		0.242	
Sitting quietly after lunch without alcohol			0.801
Sitting, inactive in a public place			0.788
Sitting and talking to someone			0.568

FIGURES

Figure 1
Distribution of types of actual driving infractions, OSA and Control groups

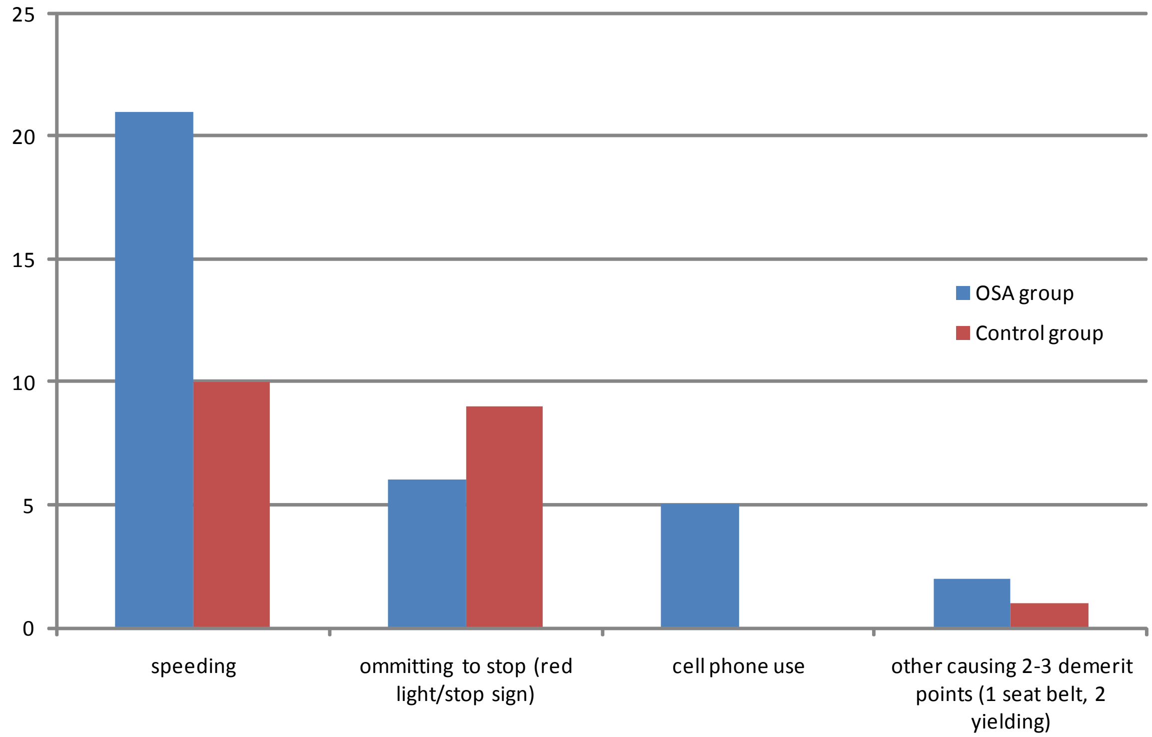

Figure 2
Distribution of types of self-reported driving infractions, OSA and Control groups

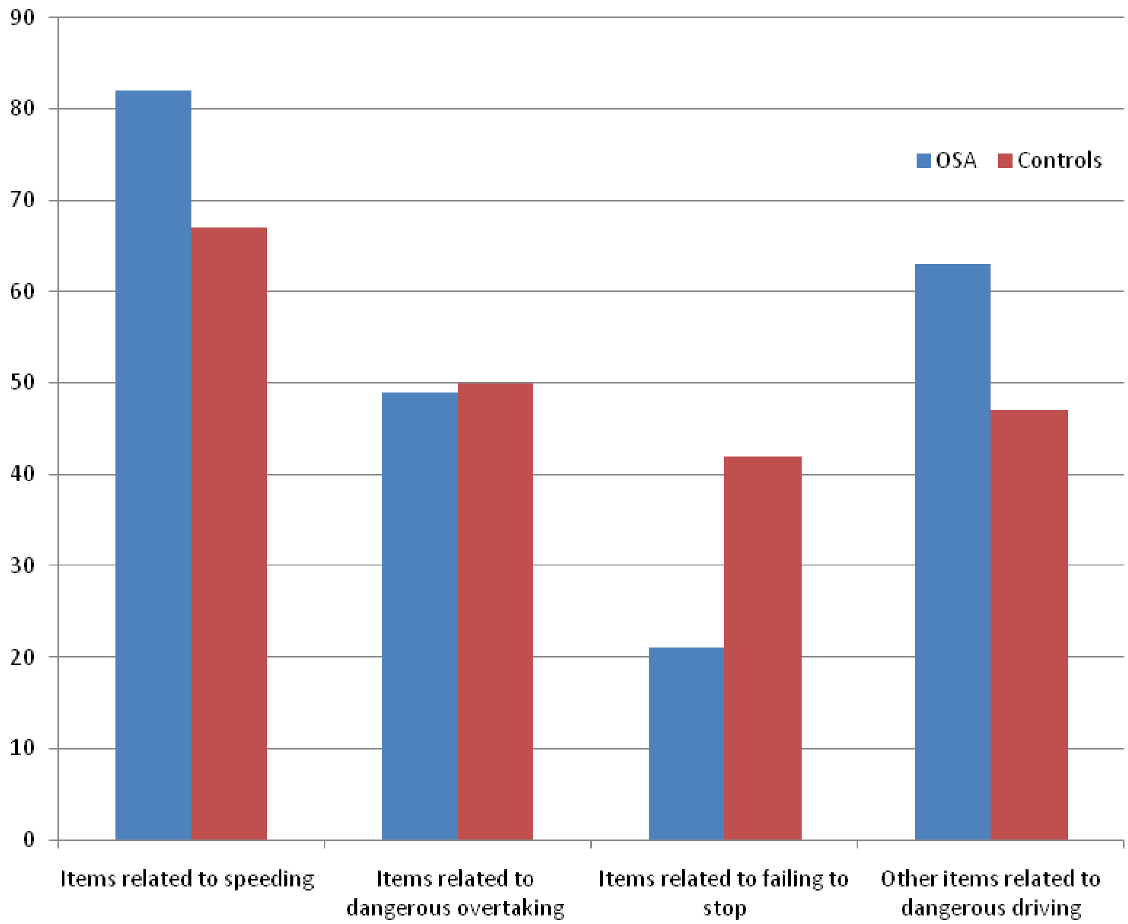

Figure 3
Evolution of deviations of lateral position during the task on driving simulator