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Maintenance of Wakefulness Test scores and driving performance in sleep disorder patients and controls ☆

Pierre Philip [a,b,c], Cyril Chaufton [c], Jacques Taillard [a,b,c], Patricia Sagaspe [a,b,c], Damien Léger [d], Monika Raimondi [e], Andrew Vakulin [f,g,h], Aurore Capelli [a,b,c,*]

[a] Univ. de Bordeaux, Sommeil, Attention et Neuropsychiatrie, USR 3413, F-33000 Bordeaux, France
[b] CNRS, SANPSY, USR 3413, F-33000 Bordeaux, France
[c] CHU Pellegrin, F-33076 Bordeaux, France
[d] Centre du Sommeil, Hôpital Hôtel-Dieu, F-75181 Paris, France
[e] Neurocenter of Southern Switzerland, Via Tesserete 46, 6903 Lugano, Switzerland
[f] Adelaide Institute for Sleep Health, Repatriation General Hospital, Adelaide, South Australia 5041, Australia
[g] University of Adelaide, School of Medical Sciences, Adelaide, South Australia 5005, Australia
[h] Sleep and Circadian Research Group and NHMRC Centre for Integrated Research and Understanding of Sleep (CIRUS), Woolcock Institute of Medical Research, The University of Sydney, NSW 2006, Australia

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ABSTRACT

Objective: Sleepiness at the wheel is a risk factor for traffic accidents. Past studies have demonstrated the validity of the Maintenance of Wakefulness Test (MWT) scores as a predictor of driving impairment in untreated patients with obstructive sleep apnea syndrome (OSAS), but there is limited information on the validity of the maintenance of wakefulness test by MWT in predicting driving impairment in patients with hypersomnias of central origin (narcolepsy or idiopathic hypersomnia). The aim of this study was to compare the MWT scores with driving performance in sleep disorder patients and controls.
Methods: 19 patients suffering from hypersomnias of central origin (9 narcoleptics and 10 idiopathic hypersomnia), 17 OSAS patients and 14 healthy controls performed a MWT (4 × 40-minute trials) and a 40-minute driving session on a real car driving simulator. Participants were divided into 4 groups defined by their MWT sleep latency scores. The groups were pathological (sleep latency 0–19 min), intermediate (20–33 min), alert (34–40 min) and control (>34 min). The main driving performance outcome was the number of inappropriate line crossings (ILCs) during the 40 minute drive test.
Results: Patients with pathological MWT sleep latency scores (0–19 min) displayed statistically significantly more ILC than patients from the intermediate, alert and control groups ($F(3, 46) = 7.47$, $p < 0.001$).
Interpretation: Pathological sleep latencies on the MWT predicted driving impairment in patients suffering from hypersomnias of central origin as well as in OSAS patients. MWT is an objective measure of daytime sleepiness that appears to be useful in estimating the driving performance in sleepy patients.

1. Introduction

Over the last 15 years, major epidemiological studies have highlighted the prevalence of sleepiness and sleep disorders among the general population (Connor et al., 2001a, 2001b; Ohayon et al., 1997; Young et al., 1993). Sleepiness at the wheel has been identified as one of the major causes of highway accidents and fatal crashes (Blazejewski et al., 2012; Connor et al., 2001a; Hakkanen and Summala, 2000; Philip and Sagaspe, 2011; Philip et al., 2010). Although alcohol and excessive speed are well known risk factors for traffic accidents (Huang and Lai, 2011) and are measured routinely among drivers, the evaluation of sleepiness at the wheel is more complex. Nevertheless, daytime sleepiness is a public health and safety issue that directly affects the patients with sleep disorders, but also the treating physicians, who in many countries are legally liable when permitting untreated sleepy patients to drive a motor vehicle or operate machinery. Thus, it is crucial from both clinical and traffic safety point of view to develop accurate measures of daytime sleepiness that can reliably assess the ability to drive safely.

In a recent study, Drake et al. (2010) showed that objectively measured sleep latencies using the Multiple Sleep Latency Test (MSLT)

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* Corresponding author at: CNRS USR-3413, 13ème étage, CHU Pellegrin, Place Amélie Raba-Léon, 33076 Bordeaux Cedex, France. Tel.: +33 5 57 82 01 82; fax: +33 5 57 82 00 38.
E-mail address: aurorecapelli@hotmail.com (A. Capelli).

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were a significant predictor of crash risk in drivers involved in traffic accidents. This epidemiological study was particularly important because it demonstrated that patients suffering from obstructive sleep apnea syndrome (OSAS) or hypersomnias of central origin have a much higher risk of traffic accidents than drivers free of sleep disorders. Sleepiness at the wheel is a key crash risk factor in these patients (George, 2007; Lloberes et al., 2000; Masa et al., 2000; Pack et al., 2006; Philip et al., 2010; Teran-Santos et al., 1999). Unfortunately, Drake et al. (2010) only used the MSLT scores to analyse the driving risk of sleepy drivers (Philip, 2010).

The MSLT and the Maintenance of Wakefulness Test (MWT) are currently used in sleep medicine for the evaluation of excessive daytime sleepiness. As indicated by the task force of the American Academy of Sleep Medicine (AASM) (Littner et al., 2005), the MSLT is not aimed to estimate the effects of sleepiness in patients facing potentially risky situations (i.e. automobile driving). Contrarily, the MWT which requires patients to fight against sleepiness in a soporific situation is better adapted to evaluate the severity of sleepiness in patients suffering from OSAS or hypersomnias of central origin. It is a robust and validated test measuring the ability to stay awake, suited for multi-centre studies thanks to a high degree of reliability (Wise, 2006).

Experimentally, impaired alertness causes an increase in lateral deviations during simulated (Davenne et al., 2012; George, 2000; George et al., 1996; Haraldsson et al., 1990; Juniper et al., 2000; Lenne et al., 1997; Reyner and Horne, 1998) and real driving (O'Hanlon et al., 1995; O'Hanlon and Volkerts, 1986; Philip et al., 2005; Sagaspe et al., 2007b, 2008). Banks et al. have compared the MWT with performance on a driving simulator in healthy sleep-deprived volunteers (Banks et al., 2005). This was the first evidence of the predictive value of MWT on driving performance. However, only a simplified 2 × 40-minute version of the MWT protocol was applied in this study, in contrast to 4 × 40 minute sessions described in the standard and validated MWT protocol. In our previous studies, we have shown that abnormal sleep latency during the 40-minute MWT (between 0 and 19 min) correlates with impaired driving as measured both on a driving simulator (Sagaspe et al., 2007a) and in real driving conditions (Philip et al., 2008) in untreated patients with OSAS. The study by Pizza et al. (2009) on untreated sleep apneics showed a stronger correlation between simulated driving performance and the ability to maintain wakefulness (MWT), compared with the propensity to fall asleep (MSLT). Previous epidemiological studies (Philip et al., 2010; Powell et al., 2007) have compared the driving risk of patients with hypersomnia with that of OSAS or insomniacs. However, to date there are no experimental studies that compared the efficacy of (4×) 40 minute MWT in predicting driving performances in patients suffering from excessive daytime sleepiness of different origins. For example, excessive daytime sleepiness could be due to a respiratory disorder such as in OSAS or it could be of neurological origin such as in narcolepsy or could have an undetermined origin such as in idiopathic hypersomnia (Bassetti et al., 2005).

The aim of this study was to determine the ability of the MWT in predicting driving performance in various patients suffering of excessive daytime sleepiness (untreated and treated patients suffering from OSAS, narcolepsy and idiopathic hypersomnia) compared to healthy controls.

2. Methods

2.1. Participants

Fifty volunteers participated in this study (Annex 1). Patients affected by sleep disorders (OSAS, narcolepsy and idiopathic hypersomnia) were recruited via the Sleep Clinic of Bordeaux University Hospital: Patients suffering from clinical OSAS and had an AHI >10 (confirmed by polysomnographic recordings) before treatment; patients suffering from narcolepsy fulfilled the diagnostic criteria for narcolepsy with or without cataplexy of the International Classification of Sleep Disorders ("American Academy of Sleep Medicine. International Classification of Sleep Disorders. Diagnostic and Coding Manual. 2nd edn. American Academy of Sleep Medicine, Westchester, IL," 2005) and presented with a high degree of pathological objective sleepiness (i.e. short < 8 min mean MSLT sleep latency). Patients suffering from hypersomnias of central origin fulfilled the diagnostic criteria for idiopathic hypersomnia according to A–B–C–D and F criteria of ICSD-2. The E criterion (the prolonged nocturnal sleep time (>10 h)) was documented by interview and questionnaire ("American Academy of Sleep Medicine. International Classification of Sleep Disorders. Diagnostic and Coding Manual. 2nd edn. American Academy of Sleep Medicine, Westchester, IL," 2005) or presented a symptomatic narcolepsy-like phenotype. Thirteen out of 19 patients with idiopathic hypersomnia or narcolepsy were treated with wake enhancing medications (modafinil) and 9 out of 17 OSAS patients were treated with continuous positive airway pressure (CPAP). Fourteen healthy volunteers (8 men and 6 women, mean age: 32 ± 9.14 years, range: 20–51, BMI: 22 ± 2.97 kg/m^2), were recruited via public announcements. Volunteers with pre-existing sleep disorders (diagnosed by clinical interview, polygraphy at home and actigraphy), who were night or shift workers or professional drivers were excluded. All participants had their driving licence.

2.2. Study design

The study lasted one night and one day. For patients, a nocturnal polysomnography to monitor their total sleep time before the objective evaluation of sleepiness with a 4 × 40-minute MWT was performed at the sleep clinic. For healthy volunteers, nocturnal polygraphy (nasal pressure, oximetry, thoracic and abdominal effort, ECG) was performed at home. The day after, the MWT test was performed at the laboratory. Subjective sleepiness was assessed using the Epworth Sleepiness Scale (ESS). For all participants, a 40-minute driving session on a real car driving simulator (Fig. 1) replicating a monotonous driving scenario was performed at 15:00 at the laboratory.

The local ethics committee (consultative committee for the protection of persons participating in biomedical research [CPP Bordeaux]) approved the study. Healthy volunteers were paid and

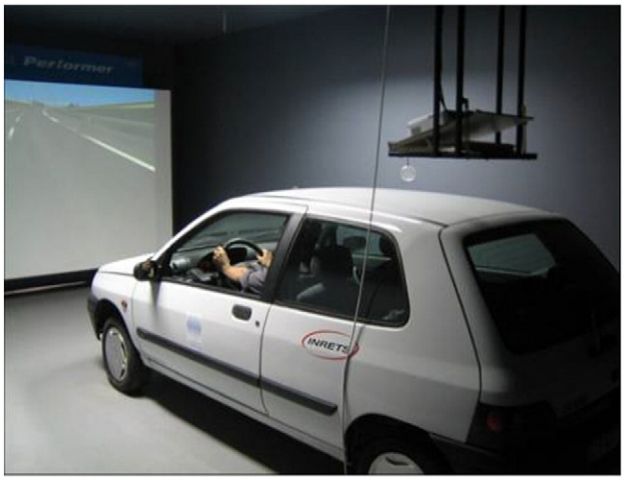

Fig. 1. Photography of the driving simulator.

signed an informed consent for participation. For patients, the simulated driving session was presented as a cognitive and behavioural test.

2.3. Nocturnal polysomnography

Nocturnal polysomnography for patients included the following recording: three electroencephalograms (F3/A2, C3/A2, O1/A1), 1 electromyogram, 2 electrooculograms, and 1 electrocardiogram. All traces were manually scored by an experienced sleep technician in 30-second epochs according to the recommendations of the AASM Manual for the scoring of sleep and associated events (Iber et al., 2007).

2.4. Evaluation of objective sleepiness (MWT test)

The four 40-minute tests of the MWT were completed at 10:00, 12:00, 14:00, and 16:00. The test was administered by an experienced sleep technologist. Data were recorded and manually scored in 30-second epochs. Sleep onset is defined as the first epoch of greater than 15 s of cumulative sleep in 30-second epoch. The test was ended after 3 continuous epochs of stage N1 or 1 epoch of any other sleep stage to avoid interfering with the sleep homeostasis process (Littner et al., 2005).

Patients who did not sleep during a trial were assigned a value of 40 min. Patients were video monitored during the whole test.

2.5. Driving performance

All subjects performed a 40-minute driving session in a real car equipped with driving simulator three-dimensional software (IFSTTAR-Faros, Paris, France). The driving track consisted of a monotonous scenario of a closed highway with infrequent vehicles. Subjects were instructed to drive at a speed of 130 km/h, and to stay in the right lane. A 15-minute training session was performed at 11:30. The 40-minute experimental driving session was at 14:40. The standard deviation of the vehicle position from the centre of the road (steering SD) and the number of inappropriate line crossings (ILCs) were calculated.

2.6. Data processing and analyses

Group data were expressed as mean ± SD unless otherwise specified.

We used the classification of MWT latencies published by Doghramji (Doghramji et al., 1997) and previous studies (Philip et al., 2008; Sagaspe et al., 2007a). Our patients were classified into 3 groups according to their degree of objective sleepiness (defined by their mean sleep latency scores) and independently of their sleep disorder or treatment: pathological group (0–19 min), intermediate group (20–33 min) and alert group (34–40 min) (Doghramji et al., 1997). Healthy controls were classified in a fourth group (>34 min). The patients were also classified into 2 groups, according to their subjective sleepiness (defined by their scores at the Epworth Sleepiness Scale): sleepy group (11–24) and alert group (0–10). The influence of their sleep latency scores and of their subjective sleepiness scores on driving performance (number of ILC, steering SD) was investigated using one-way analyses of variances (ANOVAs). $p < 0.05$ was considered significant and a Tukey post hoc test was used when an effect was significant.

Pearson correlations were computed between MWT scores and driving performance (ILC, steering SD) and between subjective sleepiness scores and driving performance (ILC, steering SD) of the participants.

3. Results

3.1. Demographic data

Among the fifty volunteers recruited, 26 are men and 24 are women (mean ± SEM age: 40.52 ± 13.81 years, range: 21 to 79 years; body mass index (BMI): 25.5 ± 8.1 kg/m^2). Out of all the volunteers, 36 were patients (18 males and 18 females) affected by sleep disorders: 17 were suffering from OSAS (mean age: 49.70 ± 14.47 years, range: 26–79; BMI: 30.8 ± 11.4 kg/m^2, range: 19–67, AHI: 21.51 ± 7.47), 9 from idiopathic hypersomnia and 10 narcoleptics (mean age: 38.57 ± 11.50 years, range: 21–58; BMI: 23.2 ± 4.1 kg/m^2, range: 18–34).

3.2. Sleep latency groups and driving performance

Participants were divided into 4 groups defined by their sleep latency scores. The pathological group consisted of 8 patients with OSAS (2 untreated and 6 treated) and of 7 patients with hypersomnias of central origin (3 untreated and 4 treated) and has a mean MWT score of 12.28 ± 5.24 min. The intermediate group consisted of 6 patients with OSAS (4 untreated and 2 treated) and of 6 patients with hypersomnias of central origin (2 untreated and 4 treated) and has a mean MWT score of 27.26 ± 3.43 min. The alert group consisted of 3 patients with OSAS (2 untreated and 1 treated) and of 6 patients with hypersomnias of central origin (5 treated) and has a mean MWT score of 40.00 ± 0 min. Finally, the control group has a mean MWT score of 38.94 ± 2.11 min. Table 1 presents

Table 1
Clinical, polysomnographic characteristics and driving performance of the 4 sleep latency groups. BMI stands for Body Mass Index, AHI stands for the apnea/hypopnea index, AI corresponds to the mean Arousal Index, TST corresponds to the Total Sleep Time, MWT stands for the mean sleep latency at the Maintenance of Wakefulness Test and ESS corresponds to the subjective sleepiness scores at the Epworth Sleepiness Scale.

Sleep latency group	Groups of patients						
	Pathological (0–19 min)		Intermediate (20–33 min)		Alert (34–40 min)		Control (>34 min)
Pathology	8 OSAS (6 treated)	7 hypersomnias of central origin (4 treated)	6 OSAS (2 treated)	6 hypersomnias of central origin (4 treated)	3 OSAS (1 treated)	6 hypersomnias of central origin (5 treated)	14 No pathology
Age	56.25 ± 17.35	40.14 ± 7.60	42.66 ± 10.28	38.00 ± 15.33	46.33 ± 4.62	37.33 ± 12.90	32 ± 9.14
BMI	27.42 ± 5.47	25.17 ± 5.48	36.60 ± 16.45	22.33 ± 3.81	28.13 ± 9.87	21.92 ± 1.02	22 ± 2.97
AHI	17.71 ± 6.16	6.62 ± 8.07	27.07 ± 7.65	2.98 ± 5.62	20.52 ± 3.92	3.02 ± 3.18	0.38 ± 0.59
AI	22.89 ± 10.69	9.09 ± 1.80	25.54 ± 9.53	15.64 ± 5.43	27.07 ± 2.76	11.65 ± 3.26	
TST	427.41 ± 40.87	401.17 ± 65.96	381.40 ± 173.25	389.70 ± 63.11	489.66 ± 63.06	434.13 ± 50.09	408.08 ± 44.93
MWT	12.45 ± 4.53	12.09 ± 6.33	27.37 ± 4.37	27.14 ± 2.59	40	40	38.94 ± 2.11
ESS	14.87 ± 4.85	11.00 ± 6.27	12.16 ± 4.99	13.66 ± 6.41	7.00 ± 5.57	10.50 ± 5.47	3.93 ± 2.70

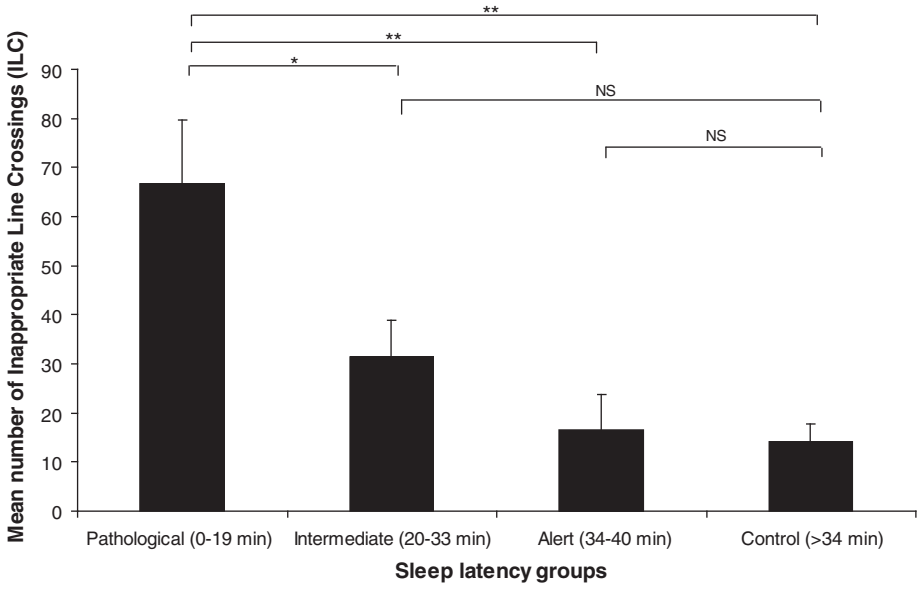

Fig. 2. Mean number of inappropriate line crossings (ILCs) + standard error (SE) for the 4 sleep latency groups.

the clinical and polysomnographic characteristics of the 4 sleep latency groups.

A one-way ANOVA with the sleep latency group (pathological vs intermediate vs alert vs control) as a predictive factor was applied on the driving performance. This analysis revealed a main effect of the sleep latency group on the number of ILCs ($F(3, 46) = 7.47$, $p < 0.001$), indicating that the MWT pathological group performed significantly more ILCs than the intermediate group ($p = 0.039$), the alert group ($p = 0.0042$) and the control group ($p = 0.0006$) (Fig. 2). Similarly, a main effect of the sleep latency group was found on steering SD ($F(3, 46) = 6.12$, $p < 0.05$), indicating that the MWT pathological group exhibited higher steering SD than the alert group ($p = 0.023$) and the control group ($p = 0.002$) but not than the intermediate group (p = NS).

Pearson correlations indicated that mean MWT scores were inversely correlated with ILC on the driving simulator ($r = -0.652$, $p < 0.0001$). Participants with the smaller MWT sleep latencies (sleepier participants) exhibited higher number of ILC (Fig. 3). Similarly, mean MWT scores were inversely correlated with steering SD ($r = -0.566$, $p < 0.0001$).

3.3. Driving performance and subjective sleepiness groups

Concerning the subjective sleepiness groups, the sleepy group ($n = 21$) has an ESS score of 15.85 ± 3.22 (mean $\pm$ SE) and the alert group ($n = 29$) has an ESS score of 5.41 ± 3.53.

A one-way ANOVA with the subjective sleepiness Group (sleepy vs alert) as a predictive factor was also applied on the driving performance. This analysis revealed a main effect of the subjective sleepiness group on driving performance, indicating that participants that evaluated themselves as sleepy made significantly more inappropriate line crossings than participants that evaluated themselves as alert ($F(1, 48) =$

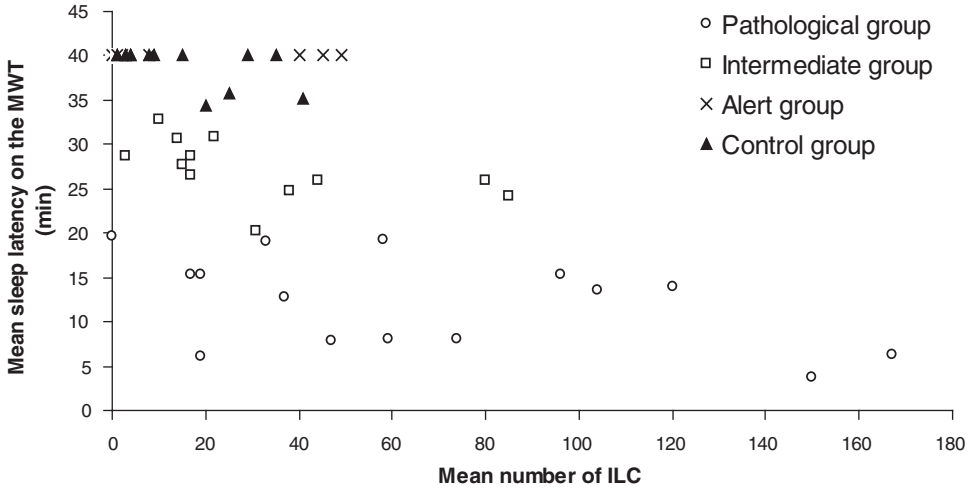

Fig. 3. Mean number of inappropriate line crossings (ILCs) as a function of mean sleep latency at the MWT, separately for the 4 sleep latency groups (pathological, intermediate, alert and controls).

10.81, $p < 0.05$). Similar results were found for the steering SD ($F(1, 48) = 10.591$, $p < 0.01$).

Simulated driving performance (ILC and steering SD) was correlated with subjective sleepiness (ESS score). Participants with the higher ESS scores (sleepier participants) exhibited higher number of ILC ($r = 0.47$, $p < 0.001$) and higher steering SD ($r = 0.59$, $p < 0.0001$).

4. Discussion

In this study we investigated whether the MWT could be a useful tool for predicting driving simulator performance of untreated and treated patients suffering from excessive daytime sleepiness resulting from OSAS, narcolepsy or idiopathic hypersomnia compared to healthy controls. We found that participants with shorter sleep latencies on the MWT exhibited deteriorated driving performance compared to other participants (participants with intermediate and long sleep latencies), regardless of which sleep disorder they were diagnosed with and despite some patients being successfully treated for their condition. This study highlights the wide utility of the MWT as a reliable measure of daytime sleepiness that is related to driving performance impairment in patients with a variety of sleep disorders, sleepiness levels and treatment status.

Previous studies (Sangal et al., 1992) already indicated that for a heterogeneous sample of patients with excessive daytime sleepiness, the MWT is more sensitive to changes in the ability to remain awake as the result of treatment, while MSLT scores however, did not or change a little with therapy. Several studies have also showed that mean sleep latency on MWT is increased in narcolepsy patients following the administration of modafinil; equally, mean sleep latency is also prolonged following the administration of stimulants or CPAP and is decreased after the administration of sedative medications (Littner et al., 2005). However, there were no established cutoff values for a change in mean sleep latency on MWT and it remained unclear if those changes reflect an improvement of driving performance. Looking at the most sleepy patients, our results clearly show that participants with MWT scores under 19 min exhibited impaired driving performance. This result is consistent with our previous driving simulator study (Sagaspe et al., 2007a) and real driving (Philip et al., 2008) study and that of Pizza et al. during simulated driving (Pizza et al., 2009) showing that for untreated OSAS patients, MWT seems to be a good predictor of simulated driving performance. This study used a driving simulator which can be a handicap for certain drivers but overall, real driving performance tends to follow simulated driving performance in a linear relationship (Davenne et al., 2012), we thus believe that the impact of simulation should be minimal on our findings.

It is important to note from previous epidemiological studies (Philip et al., 2010; Powell et al., 2007) a significantly higher risk of sleep and non sleep related accidents in narcoleptics compared to other sleep disorder patients.

This study is part of the debate for the identification of an objective tool applicable to the routine clinical practice of sleep medicine to document and follow up sleepiness of drivers (Pizza et al., 2012; Sunwoo et al., 2012). The novel finding from the current study is that the MWT scores are associated with driving performance as measured on driving simulator, both in untreated and treated patients with various sleep disorders and in healthy controls. Driving performance is correlated with sustained sleep latency on MWT independently of underlying sleep disorder. The participants defined as control (mean sleep latency >34 min), alert (mean sleep latency ≥34 min) or intermediate (mean sleep latency ≥20 min and <33 min) on MWT score have significantly less ILC on driving session compared to those with pathological score (mean sleep latency <19 min). This clearly indicates that this last group is the most at risk in terms of driving performances. Further studies are warranted to verify whether short or long MWT sleep latency could be a reference to restrict or allow driving licence and to identify appropriate MWT cutoffs for the risks of drowsy driving.

Other categories need to be considered with more precaution unless absolutely no episode of sleepiness is observed during the MWT test which definitely extracts patients from the sleepiness problem.

In our study, patients with narcolepsy with and without cataplexy or idiopathic hypersomnia with or without long sleep time were put together in a group called patients suffering from hypersomnias of central origin. This classification is not in line with the current diagnostic framework provided by the International Classification of Sleep Disorders, second edition, 2005 and constitutes a limitation of the current study due to a limited number of available patients. It would be interesting of course to take groups of patients characterized by clearly identified diseases. Another limitation of our study concerns the strong heterogeneity within our groups of patients and the presence of comorbidities that prevents identifying pathophysiological correlates of daytime sleepiness in various sleep disorders. Therefore, further studies with more homogeneous and larger groups of patients tested at diagnosis and after optimal treatment are warranted to gain insights on different correlates of excessive daytime sleepiness and driving performance.

In our study, the use of the Epworth Sleepiness Scale to classify the patients shows that high levels of subjective sleepiness are associated with a driving impairment. These results corroborate those of past epidemiological studies showing that high scores at this scale seem to be clearly linked with accidental risk (Howard et al., 2004; Philip et al., 2010). However, the MWT constitutes an objective measure of sleepiness that does not depend on the participant's subjective perception of their sleepiness and should thus be favoured.

In conclusion, this study demonstrates that excessive daytime sleepiness in various kinds of patients as measured by the MWT is associated with impaired driving performance. It supports the utility of the MWT as a clinical tool to estimate driving performance during monotonous driving situations, in patients with pathological sleepiness of different origins.

Contributors

Pr Philip had full access to all of the data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis.

Study concept and design: Philip, Capelli, Sagaspe, Taillard, and Léger.

Acquisition of data: Taillard, and Capelli.

Analysis and interpretation of data: Capelli, Taillard, Vakulin, Sagaspe, Philip, Raimondi, and Chaufton.

Drafting of the manuscript: Capelli, Philip, Sagaspe, Taillard, Vakulin, Léger, Raimondi, and Chaufton.

Critical revision of the manuscript for important intellectual content: Vakulin, Raimondi, and Chaufton.

Statistical analysis: Capelli, Vakulin, and Sagaspe.

Obtained funding: Philip.

Administrative, technical, or material support: Taillard.

Study supervision: Philip, and Taillard.

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Annex

Annex 1

Demographic, clinical and polysomnographic characteristics of the 50 participants. BMI stands for Body Mass Index, ESS stands for subjective sleepiness scores at the Epworth Sleepiness Scale, Sleep latencies at the MWT stands for Maintenance of Wakefulness Test and MSLT stands for Multiple Sleep Latency Test, SOREMP corresponds to sleep-onset REM periods, TST corresponds to the Total Sleep Time, AHI stands for the apnea/hypopnea index, AI corresponds to the average number of arousals per hour of sleep, OSAS stands for Obstructive Sleep Apnea Syndrome, NC is for Narcolepsy with cataplexy, NWC is for Narcolepsy without cataplexy, IHNTST is for Idiopathic Hypersomnia with normal total sleep time, IHPTST is for Idiopathic Hypersomnia with prolonged total sleep time, CPAP is for Continuous Positive Airway Pressure and RLS is for Restless Legs Syndrome.

Subjects	Main pathology	Sex	Age	BMI	ESS	Sleep latency at the MWT	Sleep latency at the MSLT	SOREMP	TST	AHI	Desaturation Index	Mean nocturnal Sa02	AI	Sleep efficiency	Time until diagnosis (month)	Treatment of the main disease	Dose (in mg)	Comorbidities that may cause sleepiness	Other treatment that may cause sleepiness
										For patients treated with CPAP: before treatment									
1	OSAS	F	54	34.5	22	15.4			487	13	11	95	16	87	0	None		Multiple sclerosis	
2	OSAS	M	53	26.1	20	20.2			512	26.3	35.12	96	17.6	87.79	0	None			
3	OSAS	F	49	19.5	12	40			522	16.8			30.2	92.85	52	None			
4	OSAS	M	49	25.7	12	19.2				19.5	0.9	96			3	None			
5	OSAS	M	32	67.3	5	30.9			169	40.8	31.8	93	36.8	60.4	1	None			
6	OSAS	M	49	26.0	8	40			417	24.6	7	95.9	25	84	0	None			
7	OSAS	M	55	24.0	11	32.9			322	23.6	1.9	94.6	17.7	65.6	0	None			
8	OSAS	M	33	25.3	11	27.6			303	20.6	3.56	95	30.1	62.05	25	None			
9	OSAS	F	47	40.5	11	26				30.3	14.2	96			9	CPAP			
10	OSAS	F	47	33.8	13	15.2			388	12.5	5.41	97	19.9	90.14	1	CPAP			
11	OSAS	M	36	36.4	15	26.6			601	20.8	21.1	95.7			2.5	CPAP			
12	OSAS	M	70	21.9	7	7.9			387	27.1	28.6	93.1	15.2	77.4	8	CPAP			
13	OSAS	M	74	25.5	17	6.4			431	14.5	9	93.8	22.7	76.9	60	CPAP		Parkinson disease, history of stroke	
14	OSAS	M	41	38.9	1	40			530	20.2	17	95	26	87	120	CPAP			
15	OSAS	M	79	33.1	12	14				26	27	94			156	CPAP			
16	OSAS	M	51	22.3	20	13.5			463	10.9	44	97	11	90	56	CPAP		RLS	
17	OSAS	F	26	22.6	16	8			408	18.2	7.2	95	19.5	81.95	4	CPAP			
18	NC	F	29	33.6	3	19.6	4.7	5	461	4			8.2	98.3		None			
19	NC	M	48	18.7	18	19.1	6.6	3		8					64	None			Clomipramine
20	NC	M	41	28.0	3	8	1.2	4		3					180	Modafinil	300		
21	NC	M	40	27.8	10	12.7	4	5		23.5	32.4	94.7			144	Modafinil, sodium oxybate		OSAS (treated with CPAP ; residual AHI < 5/h)	
22	NC	M	21	23.4	15	40	6.4	3	491	0.5			12.1	94.7	3	Modafinil	400	RLS	Clonazepam
23	NC	F	56	24.8	20	25.9	8	2	435	0			16	78	70	Modafinil	400	RLS	Clomipramine
24	NWC	F	32	22.6	18	24.7	5	3	366	0.8			16.9	85.89	1	None			
25	NWC	F	33	22.0	7	40	5	4	379	0.3			12.2	95.1	2.5	Modafinil	400		
26	NWC	F	32	22.6	14	40	5	3	366	0.8	9.18	97	16.9	85.89	0	Modafinil	400		

27	IH-NTST	M	22	22.2	4	30.6	8	435	2.5			11.6	92.63	1	None				
28	IH-NTST	F	51	26.8	14	3.7	10.7	319	7.5			8.3	75	0	None				
29	IH-NTST	F	34	18.5	18	6	4.6	377	0.3			8.1	72.2	23	Modafinil	100			
30	IH-NTST	F	34	18.5	19	28.7	4.6	377	0.3			8.1	72.2	29	Modafinil	200			
31	IH-NTST	M	58	28.0	9	24.1	3.5	280	14.3	13	93.7	17.3	90.3	1	Modafinil	400	Neurosarcoidosis with hydrocephalus (diagnosed 30 years ago). Hypersomnia diagnosed in 2005. OSAS treated with CPAP (residual AHI < 5/h)	Morphine, tramadol	
32	IH-NTST	F	38	22.8	11	15.4	3.2	447	0			11.8	96.5	59	Modafinil	400			
33	IH-PTST	F	32	21.9	14	40	7.2	447	2.5			6.7	91.25	72	None				
34	IH-PTST	F	53	20.8	1	40	16.7	461	7			11	80	67	Modafinil	400			
35	IH-PTST	F	53	20.8	12	40	16.7	461	7			11	80	89	Modafinil	300			
36	IH-PTST	F	26	17.9	12	28.7	4.5	445	0			24	95	30	Modafinil	600	RLS (without PLMS on PSG)		
37	None	F	26	20.5	2	40		406	0.3				85.6						
38	None	M	24	20.9	5	40		431	0.9				92						
39	None	F	31	24.7	5	40		449	0.3				92.6						
40	None	M	30	25.2	0	40		401	2.2				89						
41	None	M	47	20.9	2	35.7		451	0.7				93						
42	None	M	22	22.6	2	40		384	0				86.9						
43	None	M	40	28.1	5	40		388	0				87.3						
44	None	M	23	19.2	7	34.4		368	0				78.6						
45	None	F	26	16.7	7	40		505	0.3				98.1						
46	None	F	39	18.8	5	40		413	0				87.7						
47	None	F	33	24.2	1	40		322	0.4				72.2						
48	None	F	51	20.4	8	35.1		376	0				87.4						
49	None	M	24	22.8	0	40		416	0				90.6						
50	None	M	32	23.0	6	40		444	0.2				87.8						

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