SLEEPINESS AND DRIVING RISK

Maintenance of Wakefulness Test as a Predictor of Driving Performance in Patients With Untreated Obstructive Sleep Apnea

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Study Objective: To determine the ability of Maintenance of Wakefulness Test (MWT) to predict simulated driving performance in patients suffering from sleep apnea syndrome.

Design: Study involving one hour of simulated driving, one night of polysomnography (PSG), and a 4x40-minute MWT.

Setting: Sleep laboratory.

Patients: Thirty male patients with untreated obstructive sleep apnea syndrome (OSAS) (mean age ±SD = 51 ± 8 years, range 34-62; mean body mass index (BMI) ±SD = 29 ± 3, range 24-37; mean apnea/hypopnea index (AHI) ±SD = 43 ± 24, range 14-96). As defined by MWT mean sleep latency, 23.3% of the patients were sleepy (0-19 min), 33.3% were alert (20-33 min), and 43.4% were fully alert (34-40 min).

Measurements: Nocturnal PSG, mean sleep latency at 4x40-minute MWT trials, Epworth Sleepiness Scale (ESS), and standard deviation from the center of the road (SDS) on driving simulator.

Results: Mean MWT scores inversely correlated with SDS during the simulated driving session (Pearson’s r = -0.513, P<0.01). We found a significant effect of MWT groups (sleepy, alert, or fully alert) on SDS (ANOVA, F2, 29 = 5.861, P<0.01). Post hoc tests revealed that the sleepy group had a higher SDS than the fully alert group (P = 0.006). ESS, AHI, microarousal index, and total sleep time did not predict simulated driving performance.

Conclusions: A pathological MWT mean sleep latency (0-19 min) is associated with simulated driving impairment. Before MWT can be used to predict the driving ability of untreated patients with OSAS, further studies are needed to confirm that pathological MWT scores are associated with real driving impairment.

Keywords: Sleep apnea, MWT, driving simulator, sleepiness.

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INTRODUCTION

OVER THE LAST 15 YEARS, MAJOR EPIDEMIOLOGICAL STUDIES HAVE HIGHLIGHTED THE PREVALENCE OF SLEEPINESS AND SLEEP DISORDERS AMONG general population.1,2 Sleepiness at the wheel3,4 has been identified as one of the major reasons for highway accidents and fatal crashes. Patients with obstructive sleep apnea syndrome (OSAS) have a much higher risk of accidents than drivers without nocturnal breathing disorders. Sleepiness at the wheel is a key factor in these accidents.5,7

Multiples Sleep Latency Test (MSLT) and Maintenance of Wakefulness Test (MWT) are useful clinical tests for the evaluation of excessive sleepiness. Unfortunately, these tests are time-consuming and focused on a single day. For patients who suffer from OSAS, the MSLT which quantifies the ability to fall asleep, is not appropriate for the usage suggested by the Task Force of the American Academy of Sleep Medicine (AASM).8 The MWT (which requires the patient to fight against sleepiness in a soporific condition) is considered as a validated, objective measure of

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Study Design

Study involved one hour of simulated driving after controlled habitual sleep (8 hours), one night of polysomnography (PSG), and a 4x40-minute MWT the following day.

Patients

Thirty male patients with untreated OSAS were recruited. They completed an Epworth Sleepiness Scale (ESS), a subjective questionnaire used for the assessment of chronic daytime sleepiness, which requires rating the tendency to fall asleep in 8 different situations of everyday life. Each patient had a clinical interview with 1 of 2 sleep medicine specialists (one was first investigator in this study; the other was not associated with this study). A nocturnal PSG ruled out any sleep disorder other than obstructive sleep apnea syndrome (OSAS). Participants were paid 100 euros for the experiment. A power analysis was performed calculating the sample size needed to correlate the 2 studied tests: a sample of 30 subjects gave a statistical power equal to 90% with an alpha of 0.05 and a statistical correlation of r = 0.5.

Sleep Schedules

Patients were instructed to maintain a regular sleep-wake schedule during the 3 days preceding each experimental session. No stimulants of any kind were allowed during the study.

During the PSG and MWT sessions, patients were monitored in the laboratory from 20:00 to 17:00 the next day and were in bed from 23:00 to 07:00.

Before the simulated driving session, patients slept at home and were instructed to spend at least 8 hours in bed from 23:00 to 07:00.

Maintenance of Wakefulness Test

As recommended by AASM practice parameters, four 40-minute MWT trials were completed at 10:00, 12:00, 14:00, and 16:00. The room was shielded from external light, and the only light source was positioned behind the patient’s head. Room temperature was tuned according to the patient’s comfort level.

An experienced sleep technologist performed the MWT. Electroencephalogram (C4/A1, O2/A1), electromyogram, and electrooculogram were recorded according to the recommendations of Rechtschaffen and Kales. Prior to each trial, the patients were asked if they needed other adjustments for comfort. Instructions to the patients were: “Please sit still and remain awake for as long as possible. Look directly ahead, and do not look directly at the light.” Patients were not allowed to use artificial strategies to stay awake such as slapping the face or singing.

Data were recorded and manually analyzed in 30-second epochs using the Alice data acquisition system (Respironics, Murrysville, PA, USA). Sleep latency on the MWT was defined as the first appearance of 1 epoch of any sleep stage (1, 2, 3, 4, or REM). Patients who did not sleep during a trial were assigned a value of 40 minutes. Patients were video monitored during the whole test. The mean sleep latency of the 4 MWT trials was then calculated.

Driving Simulation

We used the Divided Attention Steering Simulator (DASS, Sto-wood Scientific Instruments, Oxford, UK) based on a tracking task (Figure 1). The software reproduces a winding road shown as lines on the screen, and the task requires using the steering wheel to keep the front of the car in the middle of the road and not go over the edge of the road. The steering wheel was a computer game type (Grandprix 1, Thrustmaster) and was fixed to a table. The DASS has been used in previous studies to examine sleepy drivers and patients with OSAS.17,24-26

The computer program sampled the lateral deviation from the center of the road at 10 Hz. If the driver was unable to hold the car between the edges of the road for 15 seconds, the drive stopped automatically. The simulated driving session lasted 60 minutes.

The software calculates the mean deviation from the center of the road and the standard deviation of this difference. This standard deviation from the center of the road (SDS) was the studied variable.

The driving simulation took place in a semidark and sound-attenuated laboratory room. In order to reduce any learning effect, each patient first performed two 10-minute training sessions. Patients were tested on the driving simulator from 12:00 to 13:00.

Data Processing and Analyses

Group data are expressed as means [±SD], and P <0.05 was considered as significant.

Pearson correlations were computed between subjective sleepiness scores, polysomnographic data, MWT scores, and driving performance (SDS).

According to the normative data of the MWT,7 we classified the patients into 3 groups, defined by their mean MWT scores: 0-19 min (sleepy), 20-33 min (alert), and 34-40 min (fully alert). A one-way analysis of variance (ANOVA) was conducted to investigate the effects of MWT mean sleep latency groups on dependent variables. Post hoc tests (Bonferroni) were conducted if ANOVA was significant.

RESULTS

Patients

Thirty male patients with untreated OSAS were recruited (mean age = 51 ± 8 years, range 34-62 years). Mean body mass index (BMI) was 29 ± 3 kg/m² (range 24-37). Patients slept of mean of 387 ± 48.6 minutes during the night prior to MWT. The
mean apnea/hypopnea index (AHI) was 43.3 ± 24/hr (range 14-96) and the mean microarousal index was 35 ± 15/hr (range 16-70). The mean ESS score was 13.5 ± 4.6 (range 3-22). The mean MWT sleep latency of our patients was 28 ± 10 minutes. There was no significant difference between mean sleep latencies during the 4 MWT trials (respectively, MWT\textsubscript{10h} = 28 ± 14.3, MWT\textsubscript{12h} = 28 ± 13.5, MWT\textsubscript{14h} = 26 ± 14.0 and MWT\textsubscript{16h} = 31.6 ± 11.5 minutes [ANOVA, F\textsubscript{3,29} = 0.134, NS]). Classification of our patients into 3 groups according to their mean MWT scores indicated that 23.3% of the patients were sleepy (mean MWT score = 13.3 ± 3 min), 33.3% were alert (mean MWT score = 26 ± 4 min), and 43.4% were fully alert (mean MWT score = 38.3 ± 2 min). Table 1 presents the clinical and polygraphic characteristics of the 3 groups of patients.

Factors Affecting MWT Scores

The mean sleep latency on the MWT correlated with BMI (r = -0.452, p <0.05), AHI (r = -0.360, p <0.05), and age (r = -0.358, p <0.05), but not with the microarousal index (r = -0.251, NS), total sleep time (r = 0.054, NS), or ESS (r = -0.191, NS).

We found a significant difference between MWT groups for BMI (ANOVA, F\textsubscript{2,29} = 4.396, p <0.05); patients from the sleepy group (mean BMI = 31.5) had a higher BMI than patients from the fully alert group (mean BMI = 27.4, p = 0.02).

A significant difference between MWT groups for AHI was also found (ANOVA, F\textsubscript{2,29} = 8.023, p <0.01), patients from the alert group (mean AHI = 60.1/hr) having a higher AHI than patients from the fully alert group (mean AHI = 27.6/hr, p = 0.002). There was significant difference between MWT groups for age (ANOVA, F\textsubscript{2,29} = 5.118, p <0.05), patients from the alert group (mean age = 56.2 years) were significantly older than patients from the fully alert group (mean age = 47.0 years, p = 0.05) (Table 1).

Driving Performance and MWT Scores

Mean MWT scores were inversely correlated with SDS on the driving simulator (r = -0.513, p <0.01). A significant effect of MWT groups (sleepy, alert, fully alert) on SDS was found (ANOVA, F\textsubscript{2,29} = 5.861, p <0.01) (Figure 2). Post hoc tests indicated that patients from the sleepy group (mean SDS = 0.9) had significantly higher SDS than patients from the fully alert group (mean SDS = 0.35, p = 0.006).

Driving Performance and Subjective sleepiness, BMI, and Polysomnographic Data

Simulated driving performance (SDS) was not correlated with subjective sleepiness (ESS score), BMI, AHI, microarousal index, or total sleep time (respectively, r = 0.251, NS; r = 0.250, NS; r = 0.313, NS; r = 0.354, NS and r = 0.056, NS).

DISCUSSION

Our study is one of the first to test the relationship between driving ability and the objective measurement of sleepiness (MWT) in patients with untreated obstructive sleep apnea. Studies on driving fitness of OSA patients have mainly used simulators, because of safety, low cost, and ease of data collection. A recent study also showed that driving simulators can provide comparable information to real driving tests in sleep-deprived healthy participants.\textsuperscript{24}

Our findings show that BMI and AHI are the main predictors of objective daytime alertness in patients with OSAS, confirming previous results obtained on larger populations of patients with untreated OSAS.\textsuperscript{25} As previously shown,\textsuperscript{26} we also found that aging tended to decrease the sleep latency on the MWT from fully alert (34–40 min) to alert (20–33 min).

Clinical and epidemiological studies\textsuperscript{6,7,30} have shown that patients with OSAS have impaired steering performance compared to controls,\textsuperscript{26} and that being sleepy at the wheel is a major risk factor for accidents in drivers with OSAS.

Our findings show that mean MWT scores are correlated to simulated driving performance (SDS) in untreated OSAS patients. Fully alert patients on the MWT clearly have better performances than sleepy patients.

In a previous study\textsuperscript{25} using the same simulator, alert normal

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**Table 1**—Subject characteristics (mean ± SD) in the 3 mean sleep latency groups on the Maintenance of Wakefulness Test (MWT).

<table>
<thead>
<tr>
<th>Mean sleep latency groups on the MWT</th>
<th>Number of patients</th>
<th>Age, y (range)</th>
<th>Body mass index (BMI), kg/m²</th>
<th>Apnea/hypopnea index (AHI), events/hr</th>
<th>Mean arousal index, events/hr</th>
<th>Total sleep time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleepy (0-19 min)</td>
<td>7</td>
<td>51.7 ± 5.5</td>
<td>31.5 ± 2.5</td>
<td>48.3 ± 18.2</td>
<td>39.4 ± 15.8</td>
<td>436.3 ± 40.8</td>
</tr>
<tr>
<td>Alert (20-33 min)</td>
<td>10</td>
<td>56.2 ± 7.1</td>
<td>29.1 ± 3.1</td>
<td>60.1 ± 28.8</td>
<td>37.7 ± 19.6</td>
<td>362.7 ± 35.0</td>
</tr>
<tr>
<td>Fully alert (34-40 min)</td>
<td>13</td>
<td>47.0 ± 7.2</td>
<td>27.4 ± 3.0</td>
<td>27.6 ± 9.7</td>
<td>30.1 ± 8.6</td>
<td>386.0 ± 51.0</td>
</tr>
</tbody>
</table>

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**Figure 2**—Standard Deviation from the center (SDS) on driving simulator (mean ± SD) in the 3 mean sleep latency groups on the Maintenance of Wakefulness Test (MWT).

*P <0.05
control subjects had similar standard deviation from the centerline (0.30 ± 0.42) as our subjects from the very alert group. Sleep-deprived and fatigued drivers had an SDS that was midway between that of the 2 other groups (0.7 ± 1.42).

From our results, it can probably be safely stated that subjects with a MWT score above 34 minutes have optimal performance, and that subjects whose score is under 19 are clearly impaired. For the median group, whose MWT score is between 20 and 33 minutes, the situation is unclear: their driving performance is not significantly different from either of the 2 other groups. Considering that on other points (AHI, microarousal index) they appear quite similar to the more seriously affected group, one would tend to have rather negative expectations of their driving ability. However, since sleepiness at the wheel is still the best measure to predict driving risk, self-reported sleepiness should also be assessed before making decisions. This relies on a truthful, subjective assessment by the driver talking to a physician, though deceit cannot be excluded, especially from drivers dependent on their driving licenses for their jobs.

Selection biases of this study included the ability to perform on a driving simulator and the absence of comorbid pathologies or treatment that could interfere with the driving test or the MWT. In the future, it would be worth confirming our findings in female patients with OSAS, and comparing MWT scores to real driving impairment. Further studies on larger and different populations (female, other sleep disorders, older patients) will reinforce the validity of the MWT as a predictor of driving risk.

Simulated driving tests in addition to MWT, could provide valuable information to clinicians about the fitness of patients with OSAS to drive, but we still need to be cautious in interpreting these tests because of a lack of normative data. Real driving studies should also confirm these preliminary results in order to provide optimal testing conditions for the evaluation of fitness to drive.

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REFERENCES